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Research Article

Influence of Linguistic and Nonlinguistic Variables on Generalization and Maintenance Following Phonomotor Treatment for Aphasia

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Purpose: Although phonomotor treatment shows promise as an effective intervention for anomia in people with aphasia, responses to this treatment are not consistent across individuals. To better understand this variability, we examined the influence of 5 participant characteristics—age, time postonset, aphasia severity, naming impairment, and error profile—on generalization and maintenance of confrontation naming and discourse abilities following phonomotor treatment.
Method: Using retrospective data from 26 participants with aphasia who completed a 6-week phonomotor treatment program, we examined the relationships between participant characteristics of interest and change scores on confrontation naming and discourse tasks, measured pretreatment, immediately following treatment, and 3 months following treatment.
Results: Although the participant characteristics of aphasia severity and error profile appeared to predict generalization to improved confrontation naming of untrained items and discourse performance, a post hoc analysis revealed that no one characteristic predicted generalization across participants at 3 months posttreatment.
Conclusions: Response to phonomotor treatment does not appear to be influenced by aphasia and anomia severity level, error profile, participant age, or time postonset. Other factors, however, may influence response to intensive aphasia treatment and are worthy of continued exploration.

Aphasia is an acquired language disorder that affects approximately one third of stroke survivors (McClung, Gonzalez Rothi, & Nadeau, 2010) and is associated with lower quality-of-life ratings and poorer functional outcomes (Ellis, Simpson, Bonhila, Mauldin, & Simpson, 2012; Laska, Hellblom, Murray, Kahan, & Von Arbin, 2001). Stroke-related damage to cortical networks limits language processing at the levels of phonology, syntax, and lexical semantics, resulting in variable receptive and expressive language abilities. Anomia, or naming difficulty, is a regular and devastating consequence of damage in the left hemisphere that results from either incorrect or incomplete engagement of semantic or phonological information (Nadeau, 2001; Roth, Nadeau, Hollingsworth, Cimino-Knight, & Heilman, 2006). Due to its prevalence, various treatments for anomia have been developed, aimed to improve production of words trained in therapy, maintain those improvements over time, and generalize improvements to untrained words. This type of generalization has remained an elusive yet important outcome for many aphasia therapies. In short, aphasia treatment generalization is the ultimate indication of a successful therapy because it is evidence that the effect of treatment reached beyond the rehearsed trained words and affected novel language use.

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In a hallmark meta-analysis of phonological, semantic, and mixed treatment approaches, Wiseburn and Mahoney (2009) noted that few aphasia therapies have shown evidence of generalization to untrained words, and many more have shown evidence of acquisition and maintenance of words that are trained in treatment. This meta-analysis also reported differences in response to language treatment despite evidence of overall efficacy. The authors attributed these differences to the influence of intraindividual (e.g., type of lesion, age, prestroke depression) and extraindividual (e.g., psychosocial support, presence of supportive caregiver) characteristics. To date, however, the impact of these characteristics on treatment outcomes is not well understood and is often analyzed post hoc rather than as the primary focus of investigation. Not only is understanding the impact of individual characteristics important in discerning the efficacy of a specific language intervention, but it is also important to consider how to best allocate treatment in today's health care climate. Aphasia therapy requires a significant commitment of time and resources. Given this, predicting treatment response would be a powerful tool in identifying participants who may most benefit from any given therapy. In addition, the impact of individual characteristics could also inform expectations of patients and their families. To this end, the purpose of this study was to retrospectively determine whether five linguistic and nonlinguistic individual characteristics predict posttreatment generalization and maintenance with 26 persons with aphasia (PWA) who completed phonomotor treatment. These characteristics (described below) were selected due to prior evidence of their potential to influence treatment response.

Phonomotor Treatment

Phonomotor treatment has been developed through a series of phase I and phase II trials, and was specifically designed to promote generalization and maintenance of improvements in expressive language ability (Kendall, Conway, Rosenbek, & Gonzalez-Rothi, 2003; Kendall, Nadeau, et al., 2006; Kendall, Oelke, Brookshire, & Nadeau, 2015; Kendall, Rodriguez, Rosenbek, Conway, & Gonzalez-Rothi, 2006; Kendall, Rosenbek, Heilman, Conway, Klenberg, Gonzalez Rothi, & Nadeau et al., 2008). This intensive, phonologically based protocol uses a multimodal approach to rebuild and strengthen phonological networks required for whole language knowledge and use (see Kendall et al., 2015, for a complete description). Intensive language therapy is associated with positive outcomes in patients with aphasia (Bhogal, Teasell, & Speechley, 2003; Denes, Perazzolo, Piani, & Piccione, 1996; Wenke et al., 2014). Furthermore, phonological processing is a core language function that drives the decoding and production of sounds. During therapy, participants are taught phonemes and phoneme sequences using multimodal input (e.g., auditory, motor, orthographic, tactile-kinesthetic, and conceptual), modified from the Lindamood Phoneme Sequencing Program for Reading, Spelling, and Speech (LiPS; Lindamood & Lindamood, 1998) and based on Nadeau's (2001) parallel-distributed processing model of phonology. This treatment aims to strengthen neural connectivity underlying knowledge of phonemes with the immediate goal of increasing the ability to produce phonological word forms given input from the substrate for semantic knowledge.

Evidence for improvement in naming trained items following phonological interventions is widely supported in the literature (Lorenz & Ziegler, 2009; Miceli, Amitrano, Capasso, & Caramazza, 1996; Wiseburn & Mahoney, 2009), though evidence for generalization has been mixed (Miceli et al., 1996; Nettleton & Lesser, 1991). Results from phonomotor treatment trials, however, provide strong evidence of generalization (Kendall et al., 2015). Specifically, participants who have received phonomotor treatment show evidence of generalized improvement in naming of untrained items and evidence of generalized improvements in discourse, reading, and quality-of-life indicators (Brookshire, Conway, Hunting Pompon, Oelke, & Kendall, 2014; Kendall et al., 2003, 2008, 2015; Kendall, Nadeau, et al., 2006).

Characteristics Related to Treatment Response

Although results of phonomotor treatment trials are promising, what remains to be known is who responds best to this type of treatment. In general, varied reports have emerged from studies that have examined individual patient characteristics and their predictive value in recovery and response to treatment. Intraindividual characteristics with a higher degree of support in the literature include initial severity of impairment, severity of impairment within different language domains (e.g., phonology, auditory comprehension), cognitive abilities (e.g., memory, attention, executive functions), pre- or postmorbid depression, and lesion characteristics (e.g., volume, location; Charidimou et al., 2014; El Hachioui et al., 2013; McClung et al., 2010; Watila & Balarabe, 2015). Although extraindividual characteristics reflect a largely neglected area of study compared with intraindividual characteristics, some are reportedly predictive of treatment response, including presence of a supportive and emotionally stable caregiver; familial, community, and social supports; and presence and quality of language rehabilitation (McClung et al., 2010; Watila & Balarabe, 2015). Intraindividual characteristics with evidence of mixed predictive value include age, gender, time postonset, multilingualism, handedness, occupational, educational, and socioeconomic status (McClung et al., 2010; Nettleton & Lesser, 1991; Persad, Wozniak, & Kostopoulos, 2013; Watila & Balarabe, 2015).

Aphasia research aimed at identifying patient characteristics that predict response to anomia treatment is challenged by the nature of the population: Sample sizes are generally small and participants are heterogeneous on factors such as lesion characteristics and familial support, yet tend to be homogeneous on factors such as multilingualism and socioeconomic status. Furthermore, the complex interaction between stroke characteristics (e.g., lesion site and size), aphasia characteristics (e.g., severity of impairment),

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individual characteristics (e.g., depression), and extra-ndividual characteristics (e.g., social support) clouds our understanding of the impact of any one characteristic in isolation from others. In addition, studies examining characteristics that predict response to anomia treatment are highly susceptible to limited statistical power by exploring a multitude of factors within a limited sample size. Whereas multiple regression analysis would help delineate unique influences of each characteristic in an ideal situation where sample size is large, such a comprehensive analysis is not possible with the typical sample sizes in treatment studies in aphasia. These challenges, however, do not preclude the importance of exploring specific characteristics that influence individual treatment response.

In this study, five patient characteristics that relate to aphasia treatment outcomes were examined: nonlinguistic characteristics of age and time postonset as well as the linguistic characteristics of pretreatment severity of aphasia, severity of anomia, and number of naming errors (profile of phonologic or semantic errors). Whereas cognitive abilities (e.g., memory, attention, executive functions), presence of pre- or postmorbid depression, and psychosocial support have emerged as hypothesized predictors of treatment success, the current study did not include these variables, given that they were not within the parameters of the original treatment study.

Nonlinguistic Characteristics

Age. Treatment aimed at restoring access to impaired language networks relies on brain alterations or changes, commonly referred to as *neuroplasticity*. Whereas evidence from both animal and human models have dispelled the myth of the aging brain as incapable of cortical reorganization (Kempermann, Gast, & Gage, 2002; Park & Reuter-Lorenz, 2009), what remains disputed is the neuroplastic potential of older versus younger participants, especially given the effects of confounding personal or environmental variables. Many treatment efficacy studies have looked at the relationship between age and language outcomes, with mixed results. In a number of aphasia treatment studies, younger participants were linked to greater improvement compared with older participants (Lendram, McGuirk, & Lincoln, 1988; Marshall, Tompkins, & Phillips, 1982; van de Sandt-Koenderman et al., 2008). In other aphasia treatment studies, participant age did not emerge as a predictor of response to treatment (Code, Torney, Gildea-Howardine, & Willmes, 2010; Persad et al., 2013; Pickersgill & Lincoln, 1983; Seniow, Litwin, & Lesniak, 2009). Varied research methodologies, as well as other confounding variables, complicate the understanding of age and treatment response, and warrant continued exploration of the circumstances under which age may be a potent predictor of recovery.

Time postonset. Although there is evidence that early language intervention may capitalize on periods of spontaneous recovery and maximize functional recovery following stroke (Basso, Capitani, & Vignolo, 1979; Kirmess & Maher, 2010; Laska et al., 2001), many studies illustrate the potential of patients to demonstrate neuroplastic change and language gains during the chronic phase (e.g., 12 or more months postonset; Basso et al., 1979; Meinzer et al., 2004). Specifically, in a study by Meinzer et al. (2004), one of two intensive language training programs was provided to 28 people with chronic aphasia (M = 43.78 months postonset). Participants engaged in either language exercises or a functional communication intervention, each provided for 3 hr/day for 10 consecutive days, with the goal of improving production of spoken words. Posttest results showed improvement in language function for both groups of participants, regardless of treatment type or months postonset. In addition, imaging of each participant's perilesional area revealed that the posttreatment change in brain activity correlated with change in language function. In a separate literature review, McClung et al. (2010) found evidence that restorative therapy may be effective any time after the first few days following stroke and for years later (see also Cramer, 2008; Kendall, Nadeau, et al., 2006). More work is needed to better understand the pattern of recovery following stroke and intervention timing that affect success in treatment.

Linguistic Characteristics

Severity of aphasia. Even when PWA are equated for degree of language impairment, their response to treatment can vary widely depending on a number of other factors. Beyond identifying initial severity, there is variability in the direction of this relationship. Some studies found an advantage for participants with milder aphasia (Code et al., 2010; Eoute, 2010; Kiran, 2016), others found an advantage for more severe aphasia (Laska et al., 2001; Robey, 1998), and some showed mixed results within their sample (Persad et al., 2013). For example, in an analysis of intensive aphasia therapy programs by Persad et al. (2013), pretreatment aphasia severity appeared to relate to gains on some specific outcome measures (i.e., the Western Aphasia Battery–Aphasia Quotient score [WAB-AQ]; Kertesz, 1982), but not to clinical improvement in general. The authors interpreted findings linking severity to treatment response as evidence of improvement for participants in the acute and not chronic phase of aphasia. In a separate study, Code et al. (2010) tracked the progress of eight participants with chronic aphasia during a 1-month, intensive treatment program. The group, as a whole, experienced significant improvement. Individual response to treatment varied with a general trend of participants with milder aphasia making greater progress. Interestingly, the oldest and most impaired individual made the most progress overall, thus highlighting the complexity of factors that contribute to success.

Severity of anomia. Consistent with findings that general language impairment is related to treatment outcomes, severity of lexical retrieval impairment is also associated with functional language gains following treatment. For example, Conroy, Sage, and Lambon Ralph (2009) followed seven participants who participated in anomia treatment. Baseline confrontation naming abilities were significantly correlated with response to treatment. Similarly, Lambon Ralph, Snell, Fillingham, Conroy, and Sage (2010) found

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that naming performance was highly correlated to therapy gain both immediately after therapy and at follow-up. Seniow et al. (2009) found that baseline language abilities predicted language outcomes following treatment. Specifically, baseline naming accuracy was the strongest predictor of improvement; individuals with less severe baseline impairment in naming experienced greater gains following treatment. These results suggest that residual lexical retrieval skills support success in anomia treatment.

Naming error profile. Analyses of speech errors have long been used to understand the underlying structures and processes of language for typical speakers as well as to understand the nature of impairment in PWA (Martin, Roach, Brecher, & Lowery, 1998; Martin, Schwartz, & Kohen, 2006; Nickels & Howard, 1994, 1995). Whereas a number of studies have examined how error profiles evolve as a result of treatment (Kendall, Pompon, Brookshire, Minkina, & Bislick, 2013; Kiran & Johnson, 2008; Kiran & Thompson, 2003; Minkina et al., 2015), error profiles also provide information regarding the underlying nature of impairment (Dell, Schwartz, Martin, Saffran, & Gagnon, 1997). For example, a greater number of semantic errors may indicate a person with aphasia has impaired access to the lemma level of word retrieval, whereas a greater number of phonological errors may indicate impaired access and retrieval at the phonological level (Dell et al., 1997). On the basis of Dell's interactive activation model, these levels of language are interconnected and bidirectional, meaning language processing spreads over multiple levels—bottom-up, top-down, from phonological to lemma to conceptual/semantic and back again (Dell, 1986; Dell & O'Seaghdha, 1992). Thus, therapies addressing language at the phonological level (e.g., phonomotor treatment) are believed to spread to other linguistic levels and to promote change at all levels. Although little is understood about the influence of pretreatment error profile on treatment success, there is some support to explore this linguistic characteristic as a predictor. For example, results of Lambon Ralph et al. (2010) found that degree of phonological impairment was predictive of gains following phonologically based anomia treatment in 33 PWA.

Current Aims

The purpose of this study is to investigate whether several individual characteristics predict generalization and maintenance of language abilities in response to phonomotor treatment. Using data from 26 PWA who previously completed phonomotor treatment (see Kendall et al., 2015), we retrospectively examined nonlinguistic (i.e., age, months postonset) and linguistic characteristics (i.e., aphasia severity, confrontation naming ability, error profile) and their relationship to lexical retrieval and discourse ability immediately and 3 months following treatment, a common time point to assess treatment maintenance (Kendall et al., 2008). Two research questions were posed. First, do any of the characteristics of interest predict generalization to improved naming of untrained words, either immediately or 3 months following treatment? Second, do any of the characteristics of interest predict generalization to discourse abilities, either immediately or 3 months following treatment?

Method

Participants

Phonomotor treatment was provided to 26 individuals with acquired aphasia in the context of a single-group design with repeated testing (Kendall et al., 2015). PWA were recruited through the VA Puget Sound Health Care System and the University of Washington Aphasia Registry and Repository. PWA were 6 or more months postonset of left hemisphere stroke, documented by brain computed tomography (CT) or MRI scan and/or report. To be included in the study, participants had to demonstrate aphasia with anomia and phonologic processing impairment. Presence of aphasia was defined using the criteria of McNeil and Pratt (2001): impaired language reception or expression caused by left hemispheric damage that results in impaired processing and loss of access to language representation that affects all levels of language. Receptive and expressive language skills, including presence of anomia, were characterized by performance on the WAB-AQ (Kertesz, 1982) and the Boston Naming Test (BNT; Kaplan, Goodglass, Weintraub, & Segal, 1983). Phonological impairment was assessed using the Standardized Assessment of Phonology in Aphasia (Kendall et al., 2010). It should be noted that cutoff scores were not strictly used in determining study eligibility. In cases where participants performed the above criterion on one or more of the aforementioned assessment batteries but demonstrated anomia on nonstandardized naming probes and/or in conversational discourse, clinical judgment was exercised in the process of determining study inclusion. Individuals were excluded if they exhibited severe apraxia of speech (AOS). Specifically, presence and severity of AOS and was determined by three speech-language pathologists (SLPs) using participant data from discourse production, repetition of words and nonwords, and naming tasks. Presence of AOS was confirmed via the observation of the following characteristics: slowed speaking rate (prolonged sounds and/or intersegment durations), sound distortions, distorted substitutions, and prosodic abnormalities (McNeil, Robin, & Schmidt, 2009). Additional exclusion criteria included severe dysarthria (Duffy 2013), major depressive disorder or other psychiatric illness, degenerative neurological disease, chronic medical illness, or severe and/or uncorrected impairment in vision or hearing.

The inclusion and exclusion criteria led to 26 participants (11 women, 15 men) with aphasia who ranged in age from 26–78 years (M = 56 years, SD = 14.5 years) and whose time postonset was 8–211 months (M = 47.5 months, SD = 53.3 months). Initial severity of aphasia, measured by the WAB-AQ (Kertesz, 1982) ranged from 37.6–96.1 points (out of 100 points; M = 78.68, SD = 16.53). Initial severity of anomia, measured by the BNT (Kaplan et al.,

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1983), ranged from 1–57 (out of 60 points; M = 34.35, SD = 18.11). Please see Table 1 for participant descriptive statistics.

Assessment Procedures for Characteristics of Interest

Nonlinguistic characteristics of age and time postonset (in months) were collected using a pretreatment intake questionnaire. Linguistic characteristics were assessed at several times points: pretreatment, 1 week immediately posttreatment, and 3 months posttreatment. Aphasia severity was assessed using the WAB-AQ (Kertesz, 1982), and confrontation naming ability was assessed using the BNT (Kaplan et al., 1983). Linguistic error data were gathered by coding incorrect responses made by participants during pretreatment confrontation naming of real and nonword stimuli created in the lab (described below in Outcome Measures). Errors were coded using six predetermined categories of errors: semantic-related, phonological, semantic-unrelated, mixed, omission, and neologism (see Minkina et al., 2015, for more detailed information on the error-coding scheme used).

Outcome Measures

In the present study outcome measures consisted of (a) accuracy of confrontation naming response and (b) correct information units (CIUs; Nicholas & Brookshire, 1992), in percentage and per minute, during a discourse task. The confrontation naming task included 42 trained and 41 untrained words, created using the Medical Research Council Psycholinguistic Database (Coltheart, 1981). Stimuli were characterized by low phonotactic probability and high neighborhood density (stimuli development is described in Kendall et al., 2015). Three data points (representing a 3-day test sequence within 1 week) were averaged to reduce the effects of test–retest variability on statistical analysis of outcomes.

Discourse language samples were collected and audio-recorded by the administering research SLP during an in-person interview. The research SLP posed questions to the participant about their medical problems, daily activities, and mood (i.e., “What illnesses or medical problems do you have?,” “How has your stroke affected your life?,” and “Describe a typical day.”). Participants answered the question until they felt they had sufficiently answered the prompt; in other words, the research SLP did not probe

Table 1. Participant demographics and test scores.

Pt	Age (years)	Sex	Ed level (years)	Duration postonset (months)	WAB-AQ (out of 100)	BNT (out of 60)	SAPA (correct out of 151)	Confrontation naming 83 nouns (% correct)	Repetition 145 nonwords (% correct)	AOS presence & severity
1	49	M	16	21	87.5	37	96	82	62	None
2	26	M	16	45	94.2	57	128	90	93	None
3	48	M	13	16	94.6	52	131	87	97	None
4	27	M	13	17	51.1	44	74	68	84	None
5	67	F	14	162	84.5	36	94	85	35	None
6	53	M	19	81	63.9	13	64	35	60	None
7	63	M	16	15	37.6	1	53	6	25	None
8	64	M	20	52	76.3	9	80	31	40	None
9	57	F	14	38	52.6	5	61	31	74	None
10	47	F	16	11	84.6	50	123	87	97	None
11	62	M	15	29	96.1	57	115	92	90	None
12	74	F	18	8	91.3	51	105	84	85	None
13	30	F	14	14	50.8	5	50	43	28	Moderate
14	60	F	18	65	59.5	15	81	40	54	None
15	57	M	16	24	82.0	31	102	58	84	None
16	72	M	18	211	69.8	34	76	42	57	None
17	67	M	16	104	81.1	56	103	83	52	Moderate
18	68	M	23	14	92.0	57	109	89	64	Mild
19	33	F	15	31	78.2	31	65	52	77	None
20	70	M	16	10	94.7	43	114	76	86	None
21	45	F	12	14	85.2	22	124	51	97	None
22	78	M	13	41	90.2	46	105	68	79	None
23	61	F	16	15	95.0	50	110	89	79	Mild
24	67	M	15	20	86.6	18	124	70	98	None
25	61	F	18	155	92.0	32	109	61	69	Moderate
26	51	F	13	22	74.3	41	96	79	84	Moderate
AVE	**56**	**N/A**	**16**	**48**	**78.7**	**34.3**	**95.8**	**65.4**	**72.2**	
SD	**15**	**N/A**	**3**	**53**	**16.5**	**18.1**	**24.1**	**23.8**	**22.0**	

Note. Pt = participant; Ed = education; WAB-AQ = Western Aphasia Battery–Aphasia Quotient; BNT = Boston Naming Test; SAPA = Standardized Assessment of Phonology in Aphasia; AOS = apraxia of speech; AVE = average; N/A = nonapplicable (Table reprinted from Kendall et al., 2015, from the *Journal of Speech, Language, and Hearing Research,* http://jslhr.pubs.asha.org/).

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with additional questions and was restricted to head nods and other nonverbal indicators that she was listening to participants' responses. After language samples were collected, graduate students used computerized language analysis (CHILDES; MacWhinney, 2000) to transcribe the samples.

Treatment Procedure

The phonomotor treatment protocol and primary outcomes from the phonomotor treatment trial using this sample (*N* = 26) have been reported previously (Kendall et al., 2015). All participants received 60 hr of phonomotor treatment (1-hr treatment sessions, 2 consecutive sessions/day, 5 days/week for 6 weeks) provided by a certified research SLP who received special training in delivery of phonomotor treatment.

Data Analysis

Outcome measures—confrontation naming and discourse task performance—were administered prior to treatment, immediately following treatment, and 3 months after treatment completion. Change scores on outcome measures were derived by subtracting pretreatment scores from (a) immediate posttreatment and (b) 3 months posttreatment (see Table 2). Relationships between nonlinguistic characteristics (i.e., age, months postonset), linguistic characteristics (i.e., WAB-AQ, BNT, number of semantic and phonologic errors), and outcome measures (i.e., confrontation naming and discourse abilities) were initially explored using Pearson's correlation coefficient to quantify the strength of associations between variables. Correlations of interest were identified and used to guide simple linear regression analyses. Although multiple regression analysis would have been an ideal tool to determine the overall contribution of the group of predictors and the relative unique contribution of each predictor to the total variance explained in outcome measures, sample size for this study was not adequate to complete this type of analysis (Wilson VanVoorhis & Morgan, 2007).

Results

Correlations

The following correlations, organized by research question, were statistically significant ($p < .05$; multiple comparison corrections were not used—see Perneger, 1998; see Table 3). Immediately following treatment, there was a negative correlation between untrained words and WAB-AQ ($r = -.395$). Three months following treatment, change scores for confrontation naming of untrained words were positively correlated with the number of phonological errors ($r = .45$). Immediately following treatment, change in percentage CIUs was negatively correlated with WAB-AQ ($r = -.409$). Change in CIUs per minute was positively correlated with number of semantic errors ($r = .536$). See Table 1 for complete correlation results.

Regression

Predictors of interest (i.e., WAB-AQ, number of phonological errors, and number of semantic errors) were converted to standard scores prior to conducting regression analyses. Simple linear regressions were conducted with the significantly associated variables to describe further the quantitative relationship between patient characteristics and treatment outcome measures (see Table 4). Results showed that a 1-*SD* increase in pretreatment WAB-AQ was predictive of a 3.20-item decrease in immediately posttreatment naming change score on untrained items. In other words, individuals with higher pretreatment WAB-AQs demonstrated smaller gains in untrained confrontation naming accuracy immediately posttreatment than individuals with lower pretreatment WAB-AQs. A 1-*SD* increase in pretreatment WAB-AQ was also predictive of a 0.05% decrease in CIU percentage change immediately posttreatment. In other words, individuals with higher pretreatment WAB-AQs demonstrated smaller gains in CIUs than those with lower pretreatment WAB-AQs. A 1-*SD* increase in the number of pretreatment semantic errors was predictive of a 6.58 CIU increase in CIU per minute change score immediately following treatment. In other words, individuals with a higher number of pretreatment semantic errors had larger increases in CIUs per minute immediately posttreatment than those with fewer pretreatment semantic errors. Last, a 1-*SD* increase in the number of pretreatment phonological errors was predictive of a 3.40-item increase in 3 months maintenance confrontation naming change score for untrained items. In other words, individuals with a higher number of pretreatment phonological errors showed larger gains in confrontation naming of untrained items 3 months posttreatment compared with pretreatment. See Table 2 for complete regression results.

Discussion

The purpose of this study was to investigate whether individual characteristics can predict posttreatment language performance following phonomotor treatment, a phonologically based treatment that has demonstrated efficacy and generalization for PWA (Kendall et al., 2015). Both nonlinguistic (i.e., age, time postonset) and linguistic (i.e., severity of aphasia, anomia, and error profile) characteristics were evaluated to determine whether they predict posttreatment lexical retrieval accuracy and discourse ability. Initial analyses revealed two out of the five individual characteristics—aphasia severity and linguistic errors—were related to treatment generalization either immediately or 3 months posttreatment. Results of a post hoc analysis, however, indicate that no one characteristic appears to predict generalization and maintenance of treatment gains across participants. These results suggest these particular individual characteristics may not relate to PWA's response to phonomotor treatment.

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Table 2. Individual change scores for immediately post and 3 months posttrained real word naming, untrained real word and nonword naming, and discourse measures, including percentage CIUs and CIUs per minute.

	Trained real word naming		Untrained real word naming		Discourse: CIUs percentage		Discourse: CIUs per minute	
Pt	**Imm**	**3 mo**	**Imm**	**3 mo**	**Imm**	**3 mo**	**Imm**	**3 mo**
1	11.93	11.10	4.85	1.60	–1.17	—	7.60	—
2	7.92	7.90	2.40	4.00	–11.77	—	0.98	—
3	7.93	4.80	8.10	2.40	13.80	7.27	14.24	10.09
4	15.83	7.10	12.99	2.40	–4.87	3.09	10.75	17.39
5	5.58	7.20	–10.60	0.00	7.46	9.13	–9.42	6.28
6	25.44	22.30	9.75	1.60	9.43	–2.29	3.93	2.37
7	32.50	10.30	5.70	–1.60	18.20	17.71	17.73	16.41
8	46.07	10.40	13.79	2.40	5.70	–2.25	19.15	–15.45
9	27.76	8.70	3.24	1.60	31.78	29.64	–13.64	-0.21
10	13.50	13.50	5.70	3.70	16.72	16.29	10.60	5.13
11	4.71	6.30	–0.04	1.60	0.01	–6.97	9.45	0.00
12	9.71	8.30	4.90	7.30	–3.19	4.48	1.85	1.13
13	50.70	49.10	31.68	33.10	5.38	4.30	–2.90	4.86
14	30.94	43.65	4.88	16.26	—	—	—	—
15	15.11	12.70	12.16	14.63	11.61	0.00	18.06	7.63
16	13.48	3.97	1.63	4.88	28.18	7.64	38.18	4.62
17	20.63	19.67	13.05	11.38	–8.00	5.61	5.72	5.70
18	0.95	2.38	4.08	9.75	–3.00	–7.30	4.37	6.01
19	34.89	22.22	–1.67	–1.63	14.00	3.80	21.54	24.13
20	–1.55	2.38	5.71	3.25	18.48	22.26	12.31	28.36
21	23.00	14.29	2.39	8.13	–16.42	–0.15	9.29	–1.58
22	15.06	14.68	–0.86	–0.82	–5.65	6.60	–13.62	6.18
23	11.09	13.49	11.42	8.13	0.78	15.41	–3.61	11.33
24	19.01	4.77	–4.08	4.06	–3.00	–1.00	6.34	-3.75
25	7.16	2.38	–6.49	–5.63	–6.93	–5.50	–0.44	0.21
26	23.01	19.05	2.45	4.88	–1.08	11.87	0.22	21.60

Note. A negative change score means there was a decrease in words named compared to pretreatment; a negative percentage means there was a decrease in CIUs compared with pretreatment. CIUs = correct information units; Pt = participant; Imm = immediately post, 3 mo = 3 months post. Em dashes indicate data not available.

Table 3. Correlation matrix for variables of interest.

									Confrontation naming				Discourse/CIU			
Variables of interest	***M***	***SD***	**Age (years)**	**MPO**	**Phon error**	**Sem error**	**WAB**	**BNT**	**Train imm**	**Unt imm**	**Train 3 mo**	**Unt 3 mo**	**CIU % imm**	**CIU min imm**	**CIU % 3 mo**	**CIU min 3 mo**
Age (years)	56.12	14.50	—	0.30	–.22	.16	–.26	.07	–.31	–.36	–.33	–.21	.14	–.05	.04	–.26
MPO	47.50	53.25		—	.14	.25	–.03	–.05	–.11	–.36	–.12	–.21	.16	.14	–.14	–.22
Phon errors	3.38	4.88			—	–.35	–.25	–.25	.35	.36	.40*	.45*	–.03	–.38	.03	–.16
Sem errors	10.54	6.06				—	–.26	–.43*	.34	–.049	.19	–.06	.24	.54**	–.06	.04
WAB	78.68	16.53					—	.72**	–.69*	–.40*	–.47*	–.23	–.41*	–.10	–.30	–.10
BNT	34.35	18.11						—	–.77**	–.21*	–.41*	–.16	–.37	–.05	–.14	.26
Naming: Train, imm	18.17	13.07							—	.51**	.69**	.38	.16	.09	.03	–.21
Naming: Unt, imm	5.27	8.10								—	.54**	.73**	.05	.10	.03	–.01
Naming: Train, 3 mo	13.18	11.41									—	.70**	–.04	–.18	–.01	.06
Naming: Unt, 3 mo	5.28	7.56										—	–.09	–.06	–.09	–.08
CIU: %, imm	0.05	0.12											—	.33	.61**	.21
CIU: Min, imm	6.75	11.55												—	–.19	.12
CIU: %, 3 mo	0.06	0.09													—	.43*
CIU: Min, 3 mo	6.89	9.77														—

Note. MPO = months postonset; Phono error = phonological errors; Sem error = semantic errors; WAB = Western Aphasia Battery; BNT = Boston Naming Test; Train = trained; Unt = untrained; imm = immediate post; 3 mo = 3 months post; CIU = correct information unit.

*$p < .05$, **$p < .01$.

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Table 4. Simple linear regression: Statistically significant results only.

Task and predictor	R^2	R^2 adj	*F*	*b*	*SE*	*t*	β
Immediate posttreatment change scores							
Naming, trained							
WAB-AQ	.47	.45	21.591**	−8.99	1.94	−4.65**	−.69
BNT	.59	.57	33.99**	−10.00	1.72	−5.18**	−.77
Naming, untrained							
WAB-AQ	.16	.12	4.44*	−3.20	1.52	−2.11*	−.40
Discourse, CIUs per minute							
Semantic errors	.29	.26	9.28**	6.58	2.16	3.05**	0.54
Discourse, CIUs per percentage							
WAB-AQ	.17	.13	4.62*	−0.05	0.02	−2.15*	−0.41
Three-month posttreatment change scores							
Naming, trained							
Phonological errors	.16	.12	4.49*	4.53	2.10	2.12*	0.40
WAB-AQ	.22	.18	6.61*	-5.30	2.06	−2.57*	−0.47
BNT	.17	.14	4.90*	−4.70	2.12	−2.21*	−0.41
Naming, untrained							
Phonological errors	.20	.17	6.11*	3.40	1.38	2.47*	0.45

Note. WAB-AQ = Western Aphasia Battery Aphasia Quotient; BNT = Boston Naming Test; CIUs = correct information units.
*$p < .05$, **$p < .01$.

Nonlinguistic Characteristics as Predictors

Whereas conclusive evidence in the extant literature demonstrates that the aging brain does not repair itself as quickly as the younger brain (Crosson et al., 2015; Kleim & Jones, 2008), age did not emerge as a predictor of treatment responsiveness in the current study. This result is consistent with previous work (Code et al., 2010; Persad et al., 2013; Pickersgill & Lincoln, 1983; Seniow et al., 2009).

Similarly, time postonset did not emerge as a predictor of treatment response, mirroring the results of Meinzer et al. (2004) and McClung et al. (2010) and supporting the hypothesis that neuroplastic potential is not limited to patients who have more recently endured stroke. For example, Kendall, Rodriguez, et al. (2006) reported on a participant with aphasia who was 54-years poststroke at time of treatment and made statistically significant gains in expressive and receptive language abilities following phonomotor treatment. Although discussion continues about the optimal time to begin aphasia treatment following stroke (Carod-Artal, Medeiros, Horan, & Braga, 2005; Huang, Chung, Lai, & Sung, 2009), this study contributes to the body of evidence that PWA respond to therapeutic intervention regardless of time postonset. It is important to note that age and time postonset are often considered confounding variables. Given the range of age and time postonset in PWA included in the present study, this may explain these nonsignificant results.

Aphasia Severity as a Predictor

Aphasia severity was predictive of an inverse response to treatment generalization immediately following treatment. In other words, participants with more severe impairment tended to show greater treatment response to untrained naming items (in addition to trained naming items) immediately following treatment compared with participants having less severe impairment. This finding is similar to those of Laska et al. (2001) and Robey (1998) and fits within the conclusions of Kiran (2016), reflecting the idea that these participants may have had more "room to grow" relative to participants with milder impairment. Some studies have addressed treatment response differences between participants with severe impairment and those with mild by using adjusted change scores in the analyses (e.g., see Lambon Ralph et al., 2010; Seniow et al., 2009); however, this type of analysis has been reported to induce bias (Glymour, Weuve, Berkman, Kawachi, & Robins, 2005). For example, when adjusted change scores were used in the present study's analysis, small gains appeared substantially inflated for participants with milder impairment, making clinical interpretation of these results challenging.

The negative relationship between impairment severity and treatment response contrasts with several related anomia treatment studies that describe a positive relationship between pretreatment naming ability and posttreatment response. For example, Conroy et al. (2009) found participants with more mild impairment had greater treatment response after administering a noun and verb naming treatment. Lambon Ralph et al. (2010) and Seniow et al. (2009) also reported a positive, predictive relationship between naming ability and response to a phonologically based treatment—namely, a "conventional training" involving semantic, phonological, and syntactic levels of language. One interpretation of this particular finding in the present study is that phonomotor treatment is useful for participants with more severe naming impairment, potentially because it aims to reestablish connections between the building blocks of language (phonemes). However, it is important to note that treatment response for participants with milder impairment is difficult to capture due to

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potential ceiling effects. In other words, individuals with mild or minimal aphasia do not have as many opportunities for improvement on the outcome measures compared with individuals with more moderate to severe deficits. In addition, it is important to recognize that regression to the mean may have been a factor in the finding that individuals with more severe impairment demonstrated greater gains in untrained and trained confrontation naming accuracy immediately posttreatment (see Barnett, van der Pols, & Dobson, 2004, for more on the regression to the mean phenomenon).

The predictive capacity of aphasia severity on treatment generalization was not maintained when tested 3 months following treatment. Overall, whereas group data (Kendall et al., 2015) demonstrated generalization of confrontation naming immediately following treatment and 3 months later, these improvements appear to be unrelated to the individual participant's aphasia severity.

The finding that individuals with more impairment showed greater generalization immediately posttreatment compared with those with less impairment—and that this association did not hold up 3 months posttreatment, at least for untrained items—may reflect the extent to which participants engaged the linguistic network in their daily lives after completing the treatment. For example, individuals who began treatment with more severe linguistic deficits may have led more isolated lives and may interact in less enriched linguistic environments compared with individuals with milder deficits (Parr, 2007; see also Kleim & Jones, 2008). Thus, individuals with more severe deficits may have fewer opportunities to engage their linguistic network, potentially contributing to a loss of gains achieved during treatment.

It is important to note that the majority of participants in this study would be classified as having a milder form of aphasia. Future work with a wider range of aphasia severities will continue to help clarify the potential influence of aphasia severity on treatment response.

Semantic and Phonological Errors as Predictors

Given phonomotor treatment's emphasis on rebuilding phonological networks, it is logical to hypothesize that an individual's linguistic errors may be predictive of response to aphasia treatment. Study results show a greater number of semantic errors are predictive of improved discourse performance, as measured by CIUs per minute immediately posttreatment. Semantic errors are believed to occur when engagement of a semantically related word form is greater than the target word form (Dell, 1986; Dell & O'Seaghdha, 1992). When discourse and naming are retested 3 months after treatment completion, however, participants' pretreatment semantic errors do not emerge as predictive. Results also show that the greater the phonological impairment, the greater improvements in confrontation naming for both untrained and trained stimuli immediately following treatment. A study by Hickin, Best, Herbert, Howard, and Osborne (2002) reports a similar finding: The participant who reportedly demonstrated the most phonological impairment made the greatest gains through that study's phonological treatment. One interpretation of this result is that phonomotor treatment directly addresses phonological impairment; marked gain in phonological ability is a logical consequence of treatment. (We found it interesting that the study of the evolution of errors in this sample did not reveal a change in proportions of errors—for example, a decrease of phonological errors—from pre- to posttreatment; see Minkina et al., 2015.) We found contrasting findings, however, in the study by Lambon Ralph et al. (2010), who reported a positive, though not substantial, relationship between baseline phonology and response to treatment. In addition, the present study's participants demonstrated generalization in performance to untrained items at 3 months posttreatment, suggesting the phonological networks have strengthened and are beginning to respond with the correct patterns of engagement necessary for the target item. Furthermore, and keeping with the principles of neuroplasticity (Kleim & Jones, 2008), continued practice in everyday life during and following treatment may further strengthen the phonological network and the interactive networks across linguistic levels (Kendall et al., 2008; McClung et al., 2010).

The discussion of these study findings has an additional, interesting facet that is based on one participant's treatment response. After reviewing individual data (see Table 1) and noting Participant 13's drastically significant gains following treatment relative to her peers, we were motivated to conduct a post hoc analysis. This participant's results alone were greater than 3 *SD*s above the mean for all confrontation naming change scores and would therefore be considered by some as outlying data and eligible for exclusion. After excluding this participant's data, reanalyzed group results did not yield changes in the findings reported above. However, results of the excluded participant suggest that an individual with extremely pronounced phonological impairment—like the reported findings of Hickin et al. (2002)—may respond especially well to phonomotor treatment. Specifically, Participant 13's performance was characterized by substantially more phonological relative to semantic errors, frequent phonemic paraphasias, and also concomitant AOS—impairments that may especially improve with phonomotor treatment. However, two patient characteristics may have contributed to her substantial response to treatment. First, this participant's stroke occurred during the postpartum period, and the prognosis for recovery from these types of strokes is relatively good (Ducros, 2012; Preter, Tzourio, Ameri, & Bousser, 1996). Second, this participant was quite young (30 years old) at the time of the study, and therefore age may have also contributed to her substantial gains in following treatment (Crosson et al., 2015; Kleim & Jones, 2008)—even though age was not an emergent predictor in this study.

Limitations

Despite the fact that data were available for 26 participants (a moderately large sample size in the realm of

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aphasia research), the sample was not large enough to use multiple linear regression (Watila & Balarabe, 2015), a seemingly ideal tool to examine the five individual characteristics of focus in the present study. Instead, this study was limited to the use of simple linear regression that only had the predictive power to examine one isolated factor in relation to one isolated outcome measure at a time.

When examining the predictive power of patient characteristics, there is added value in completing both group and case-series analyses in order to best examine the complex dynamics at play. Although group analyses are useful to capture trends within a select sample of a specified population, this type of analysis may also "wash out" important individual differences. For example, Code et al. (2010) reported group trends that showed an advantage for patients with more mild impairment, yet in individual analyses, the oldest individual with the most impairment experienced the most gains overall. Whereas the current study included only group analyses, future studies would benefit from including both types of analyses, providing a more detailed description of relationships between individual factors and outcome measures.

Future Directions

Whereas this study represents some of the individual factors that may affect treatment outcomes, there are a number of other factors worthy of examination, including cognitive abilities, presence of depression, chronic stress, and family/caregiver support. With regard to cognitive abilities, previous research has reported that PWA demonstrate impairments in short-term memory, working memory, and attention (Hula & McNeil, 2008; Hunting Pompon, McNeil, Spencer, & Kendall, 2015; Martin & Reilly, 2012; Murray, 2012). Several studies have reported that cognitive abilities—reasoning, problem-solving, attention, working memory, visual recall, and recognition memory—may be predictive of treatment outcomes (Fillingham, Sage, & Lambon Ralph, 2006; Lambon Ralph et al., 2010; Seniow et al., 2009). More evidence is necessary to understand the specific interaction between these extralinguistic cognitive factors, linguistic performance, and its rehabilitation.

Pre- and Postmorbid Depression

A few studies have considered pre- and postmorbid depression and found a relationship between depression and treatment outcomes. Depressive symptoms following stroke are common, often have a chronic course, and are associated with greater stroke severity and functional impairment (Berg, Palomäki, Lehtihalmes, Lönnqvist, & Kaste, 2003). Williams, Rittman, Boylstein, Faircloth, and Haijing (2005) found that prestroke depression is often overlooked in the literature, yet it is a significant predictor of recovery in aphasia. Stroke-related depression has emerged as an important consideration in stroke rehabilitation, and should be explored as a potential predictor of response to aphasia treatment.

Chronic Stress

Interesting neuropsychological evidence has more recently emerged about the impact of chronic stress on the structure and function of the brain, particularly in regions central to learning (Davidson & McEwen, 2012; Russo, Murrough, Han, Charney, & Nestler, 2012). Many PWA experience chronic stress and therefore may not be able to capitalize on their treatment efforts. A study of chronic stress in aphasia is currently under way by author Hunting Pompon and colleagues, with the aim of furthering our understanding of the impact of this psychosocial factor on rehabilitation outcomes.

Presence of Support

Caregiver support is also often overlooked in studies that identify predictors of response to treatment. Yet, the presence of a supportive caregiver has a proven impact on recovery and quality of life following stroke (McClung et al., 2010; Visser-Meily et al., 2006). The presence of a supportive caregiver has been associated with the maintenance of communicative competence; PWA may retain the ability to spontaneously participate in a socially interactive context utilizing discourse and pragmatic strategies even if their use of language is restricted (Blonder, 2000). The "supportive" caregiver distinction is crucial; the quality of communicative interactions and support from this caregiver matters more than his or her mere presence. Without supportive qualities, a caregiver may actually hinder the recovery process (Manzo, Blonder, & Burns, 1995; Thompson, Sobolew-Shubin, Graham, & Janigian, 1989).

The therapeutic alliance between patient and clinician may also influence a patient's response to treatment. A clinician who works with a patient in an empathetic, supportive way is more likely to adopt a personalized approach to treatment, discuss and set mutual goals, and maintain open and honest communication. These aspects of the treatment relationship engender trust on the part of the patient and his or her family and improve treatment adherence (Davidson & Worrall, 2011). These aspects of the therapeutic relationship reportedly influence the patient's response to treatment (Manning, 2010).

Future studies will benefit from examining the presence of a caregiver, the quality of the support the caregiver facilitates (see Holland, Frattali, & Fromm, 1999; Carlsson, Hartelius, & Saldert, 2014), and the impact of the therapeutic alliance between patient and clinician. These types of supportive relationships have a number of benefits, and the related impact on PWA treatment outcomes is worthy of further exploration.

Conclusion

PWA's response to phonomotor treatment appears to be uninfluenced by severity levels, error profile, participant age, and time postonset in this sample of 26 individuals with chronic aphasia. Given the broad variability in response to aphasia treatment, however, the overarching question remains unanswered: Who responds best to

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phonomotor or other anomia treatments, and who would be better served by an alternate therapy or approach? Continued study of factors that may affect treatment outcomes is clearly warranted. PWA make significant expenditures of time, effort, and financial resources to improve language abilities, and yet some do not make the same gains in treatment as others. It is essential to continue to investigate the factors which affect treatment response to build upon the efficacy of current treatments, capitalize on the strengths of our patients, improve our prescriptive specificity, and define new directions for adjuvant treatments for aphasia.

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