Phonological Rehabilitation of Alexia and Anomia in an Individual with Aphasia

Left hemisphere stroke often results in aphasia characterized by anomia and alexia. Research has shown that treatment focused at the level of the phoneme and phoneme sequences improves anomia (Kendall et al., 2006; Kendall et al., 2008) and phonological/deep alexia (Conway et al., 1998; Kendall et al.,1998; Kendall et al., 2003). These findings are theoretically supported by a model of phonology in aphasia (Nadeau, 2001) and a multimodal model of phonological processing and reading (Alexander & Slinger, 2004).

Nadeau's parallel distributed model of phonology (2001) states that phonologic representations are stored as patterns of connectivity within and between auditory association, articulatory motor, orthographic and semantic/conceptual domains. Phonologic knowledge within each domain is represented as connection strengths between each unit. During learning, the strengths of the connections are gradually adjusted so that a pattern of activity involving the units in one domain elicits the correct pattern of activity in the units of another domain resulting in widespread generalization. After stroke, remaining phonologic representations and domain connections serve as the foundation for improving word retrieval deficits. This is the fundamental hypothesis that motivates phonological rehabilitation of anomia in aphasia. Support for this hypothesis originates from studies of language acquisition in children. Children first learn various phonological sequences of their language (Gathercole, 1995; Gathercole & Martin, 1996), and then assemble these sequences into combinations and associate them with concepts, enabling word comprehension and production. If this principle of language development also applies to language redevelopment after brain injury, it suggests two possibilities: (1) that effective retraining of phonemes may generalize to all words containing the trained phoneme sequences; and (2) that once given an adequate repertoire of phonological sequence knowledge, individuals with aphasia should continue to enhance existing but inadequate connections between the substrate for concept representations and the substrate for phonological sequence knowledge after therapy. Additionally, training some phonological sequences may generalize to other phonological sequences (e.g., through shared distinctive features and motor programming sequences). This language redevelopment may best be accomplished through a multi-modal approach.

Alexander and Slinger's (2004) multimodal model of phonological processing and reading identifies sensory, cognitive, and motor inputs that may respond to intensive treatment and support development of phoneme perception and production, phonological processing and reading. The model suggests that a multimodal treatment approach can focus on developing individuals' explicit awareness of distinct sensorimotor and metalinguistic features of phonemes. Explicit awareness can be trained via association tasks for each phoneme. Such explicit awareness can provide in-depth perception and production skills for phonemes and a basis for retraining sublexical phonological processing and indirect route reading. In fact, Alexander (1991) and her colleagues (Torgesen et al., 1999; Torgesen et al., 2001) report that a multimodal treatment can successfully remediate phonological deficits in children with dyslexia, as well as prevent these deficits in children at risk for dyslexia. This is noteworthy because key characteristics of dyslexia are also seen in phonological alexia, i.e. impaired phonological processing and indirect route reading. Therefore, an intensive multimodal treatment may be a viable approach to rehabilitate phonological and indirect route reading deficits associated with phonological alexia.

The data presented in this abstract are from a single subject who is participating in a larger group treatment for multi-modal phonological rehabilitation of anomia in aphasia (Kendall & Nadeau, VA RR&D Merit Review Grant). This individual is interesting because he exhibited a high level anomia, phonological alexia and left-handedness. To that end, the following specific aims were addressed:

Specific Aim #1: Assess immediate response to treatment.

Specific Aim #2: Assess generalization to untrained stimuli and word retrieval abilities.

Specific Aim #3: Assess generalization to reading abilities.

Specific Aim #4: Determine maintenance of treatment effects 3 months later.

Methods

<u>Participant</u>: The participant is a monolingual English speaking, left-handed, 26 year old male who suffered a left intracranial hemorrhage and subdural hematoma with subsequent resection of the left anterior temporal lobe 45 months prior to this study. He completed 16 years of education prior to the stroke. At enrollment in the current study, he presented with a mild aphasia, impaired phonological processing, phonological alexia and no apraxia of speech. His Western Aphasia Battery (WAB; Kertesz, 1982) score was 94.2/100 and his Boston Naming Test (BNT; Goodglass et al,, 1983) score was 57/60. Phonological alexia was determined by impaired ability to read non- words aloud (50% accurate) compared to real words (95% accurate) on the Standard Assessment of Phonology in Aphasia (SAPA; Kendall et al., 2010).

<u>Design</u>: The larger phase II study is a pre- post-group design. Data presented here include results of pre- and post-treatment probes and standardized tests. Outcome measures were collected one week prior to therapy, immediately post treatment, and 3 months later.

<u>Treatment program:</u> Therapy consisted of sixty, 1-hour treatment sessions, 2 sessions/day, 5 days/week for 6 weeks. The treatment program consisted of two stages. Stage 1 trained all English phonemes in isolation and Stage 2 trained 1 and 2 syllable real and non-words. In Stage 1, each phoneme was trained by teaching motor descriptions, perceptual discrimination, production, and grapheme to phoneme correspondences. Stage 2 was an extension of Stage 1 and included combinations of various phonemic sequences. Training progressed from simple one syllable to complex one and two syllable real and non-words.

<u>Stimuli</u>: Stimuli consisted of phonemes in isolation and 1-2 syllable real and non-words. Stimuli were comprised of words with low phonotactic probability and high neighborhood density. All stimuli were phonotactically legal in English.

Results

See Table 1 for illustration of results described below.

Specific Aim #1 addressed immediate response to treatment as measured by performance on the SAPA and trained real and non-word stimuli. Results showed performance on the SAPA improved from 85% accurate pre-treatment to 92% accurate immediately post-treatment. This improvement is approximately three standard deviations above standardized group norms. Performance on trained non-word repetition and trained real word confrontation naming significantly improved ($p = .0002$, $p = .0006$ respectively).

Specific Aim #2 addressed generalization to untrained stimuli and word retrieval abilities. Performance on untrained non-word repetition significantly improved ($p = .0149$). Performance on untrained real word naming improved from 91% accurate pre-treatment to 94% accurate immediately post-treatment, however, this increase was not significant ($p>.05$).

Specific Aim #3 addressed generalization to reading abilities. Results showed performance on the Woodcock Reading Mastery Test-Revised (WRMT-R) improved from standard score of 90 pre-treatment to 104 immediately post-treatment. This improvement is approximately one standard deviation above standardized group norms (standard deviation =15).

Specific Aim #4 addresses maintenance of treatment effects 3 months later. All outcome measures will be administered in February 2011.

Discussion

The results from this study indicate that multi-modal treatment focused at the level of the phoneme and phoneme sequences can improve an underlying impairment in phonology in an individual post-stroke. Generalization to word retrieval for untrained items was improved; however, not significantly. With regard to reading abilities, effects of treatment generalization were demonstrated. These findings from a single, high-level, left-handed individual, lend support to the notion that improvement in phonology and phonologic sequences can indeed activate conceptual semantics and orthographic representations. Three month follow up testing will reveal what treatment effects have been maintained.

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Table 1. Pre and Post Treatment Standardized Outcome Measures.

	Aim 1 Treatment response			**Aim 2 Generalization to lexical function**		**Aim 3 Generalization to reading**
	Standardized Assessment of Phonology in Aphasia (SAPA) % accurate and raw score	Trained nonword repetition % accurate and SEM	Trained real word confrontation naming % accurate and SEM	Untrained nonword repetition % accurate and SEM	Untrained real word confrontation naming % accurate and SEM	Woodcock Reading Mastery Tests-Revised (WRMT-R) Standard scores and SEM
Pre-treatment	85 (128/151)	94 (0.8)	90 (1.4)	92 (2.85)	91 (2.7)	90 (2)
Immediately Post-treatment termination	92 (139/151)	100 (0.0)	98 (0.0)	99 (.79)	94 (2.75)	104 (2)
P value for t-test of pre-treatment and immediately post-treatment	**+**Approximately 3 standard deviations above group norms (std dev = 3.68)	.0002	.0006	.0149	.2489	**+**Approximately 1 standard deviation above group norm (std dev = 15)
3-months post treatment (Specific Aim #4)	*	*	*	*	*	*

* Subject completed treatment November 2010. Three-month follow-up data will be collected in February 2011.
+T-tests will be calculated for SAPA and Woodcock scores after the 3 months post treatment testing is completed.
Standardized Assessment of Phonology in Aphasia (SAPA; Kendall et al., 2010)
Woodcock Reading Mastery Tests-Revised (WRMT-R; Woodcock, 1987)