Background

Phonology is a sub-field of linguistics concerned with patterning of sounds in language and is a medium by which sound information is mapped onto higher levels of language such as words. Impaired phonologic processes in adult aphasia have been linked to reading (de Partz, 1986; Kendall et al, 1998, 2003; Conway et al, 1998), language comprehension (Blumstein, 1998; Milberg et al, 1988), speech production (Nadeau, 2000; Kendall et al, 2003; Kendall et al, 2008; Browman and Goldstein, 1992) and working memory (Baddley and Hitch, 1974; Friedman et al, 2000) dysfunction. While there are existing measures to determine the severity of and change in semantic and syntactic impairments, there is no standardized measure of phonologic deficits for adults with aphasia. The long-term goal of this research is to develop a valid and reliable impairment level measure of phonology in aphasia that is sensitive in detecting clinical change and will differentiate between patterns of phonologic dysfunction. The focus of this abstract, is to 1) outline procedures regarding item development for 3 domains (or subtests) of this assessment: reading, repetition and perception; and 2) present psychometric properties of these items from data collected from individuals with aphasia.

Methods

Item response theory (IRT) formed the basis for development using the following procedures: 1) theory of phonology in aphasia was identified (Nadeau, 2001); 2) three constructs within the theory were delineated (reading, perception, repetition); 3) items were developed for each construct employing psycholinguistic principles thought to be relevant to performance (e.g. frequency, length, etc); 4) professionals in the field reviewed the items; 5) items were revised; 6) data were collected from individuals with aphasia; 7) IRT statistics were generated for each of the 3 constructs to answer research questions directed toward the integrity of the items.

Item Development

<u>Construct #1 Reading:</u> 69 items across 4 categories (*real words, nonwords, words with irregular orthography, pseudohomophones*) were constructed. Real words (1-5 syllables) were nouns controlled for number of graphemes and phonemes, frequency, and complexity. Frequency was equated within and

across categories (Thorndike-Lorge). Irregular real word (1-3 syllables) nouns were divided into high and low frequency groups (Thorndike-Lorge). Pseudohomophones were real words converted using Thorndike-Lorge to determine the written word frequency. Nonword items (1–3 syllables) were created by combining consonants and vowels based on frequency (Shriberg & Kent, 1982). The sum of all biphone probabilities and average biphone probability were determined.

Construct #2 Repetition and Parsing/Blending: 113 items across 6 categories (*real and nonword repetition, parsing and blending real and nonwords*) were constructed. Real word and nonword repetition items were divided into 1- 3 syllable words. Phonotactic probability and frequency (Kucera & Francis, 1982) were controlled within and across all categories. Parsing and blending noun items were divided into 6 groups based on the division of the word for parsing or blending: compound words, 2-syllable non-compound words, onset-rime, body-coda, and individual phonemes. Phonotactic probability and frequency (Kucera & Francis, 1982) were controlled within and across all categories.

Construct #3 Perception: 216 items across 4 categories (*real and nonword rhyme, lexical decision, minimal pairs*) were constructed. Nonword items were created using high- and low-frequency phoneme 1- and 2-syllable combinations. Foils were created so participants could not identify a pattern of rhyming. Rhyming pairs were created by changing the initial phoneme only. Lexical Decision items from the real and nonword rhyme tasks were used for the lexical decision task and were divided by syllables (1-2). Each syllable group was divided into high- (2-3 phonemes) and low- (5-6 phonemes) frequency items. Phonotactic probability was controlled across and within syllable categories. Minimal pair items contained the same vowel and followed either CV or VC patterns.

Data Collection

Subject recruitment: Individuals with aphasia (N=50 reading construct, N=47 repetition and perception constructs) were recruited from the VA RR&D Brain Rehabilitation and Research Center, Gainesville, Florida and the University of Washington, Speech and Hearing Clinic, Seattle, Washington (Table 1). Inclusion criteria were a single left hemisphere stroke (documented by CT or MRI imaging data) at least 6 months prior to enrollment in this study resulting in aphasia as determined by standardized testing (Western Aphasia Battery)(Kertesz, 1982). Individuals were excluded if their primary language was not

English, or if they had refractory depression or other psychiatric illness, neurological illnesses, chronic medical illness, or severe sensory deficits.

Experimental Task: Tasks and stimuli were randomized and presented with ISI of 8.0 seconds on a Dell Lattitude X1 Laptop. For the reading task, participants were asked to read each word aloud. Verbal responses were recorded digitally for subsequent analysis. Repetition and perception stimuli were recorded by a male speaker using a Marantz Digital Audio Recorder. Patient responses for repetition were recorded digitally for subsequent analysis.

Analysis

Subject responses were scored for accuracy (defined as no phonemic, semantic or verbal paraphasias). Distortions were scored as correct. Data were analyzed using WINSTEPS Rasch analysis (Bond & Fox, 2001;Linacre, 2005; 1994).

Results/Discussion

#1) How well do the phonological data fit the Rasch measurement model? Our results show that the data fit the model reasonably well. The infit mean square residuals (MNSq) and point measure correlations for Construct #1 (reading) showed 0 misfit. Construct #2 (perception) showed 2% misfitting items and Construct #3 (repetition, parsing/blending) showed 0.9% misfit items. Frequency of point measure correlations that fell below 0.3 was 8.6% (reading), 19.4% (perception) and 5% (repetition, parsing/blending).

#2) Is the hypothesized hierarchical structure empirically validated by the actual hierarchy in individuals with aphasia? The results show that the hypothesized hierarchy matched the IRT generated hierarchy for reading and perception; however there was a mismatch of 2 stimuli type within the construct of repetition and parsing/blending. More specifically, it was predicted that nonword parsing would be easier than real word blending . It turned out that all non-word processing (parsing and blending) was more difficult, and that within word class, blending was more difficult than parsing.

3) How well does item hierarchy differentiate phonologic dysfunction in individuals with aphasia? The results show that individuals with phonologic dysfunction are reasonably differentiated with this item bank. Number of distinct person ability strata was 6.39 (reading), 4.77 (perception) and 5.40 (repetition, parsing/blending). Cronbach's alpha was .98 (reading), .93 (perception) and .97 (repetition, parsing/blending). Person separation was 4.54 (reading), 3.33 (perception), 3.80 (repetition, parsing/blending). With regard to floor and ceiling effects, the results showed 0 (reading), 4.3% ceiling and 2% floor (perception) and 9% (repetition, parsing/blending). Intra-rater reliability was conducted on 100% of each participant's responses and inter-rater reliability was completed on 25% of each participant's responses. Intra-class correlations were calculated. Intra-rater reliability was 99% and inter-rater reliability 96%.

Limitations: While Rasch analysis is robust to sample size limitations, the present sample is relatively small (n= 47-50) which could influence the stability of our item calibrations. Furthermore, while this study investigated fit to the Rasch model, fit to other IRT models (e.g., 2-parameter) should also be investigated. Finally, further studies should investigate the unidimensionality of the overall construct of phonology and its subcategories (e.g. confirmatory factor analysis). Future directions of research to further standardize this measure include studies of test-retest reliability and analysis and interpretation of the normal control data that have already been collected.

Table 1: Patient demographics. Average and (standard deviation) for age, months post onset, education, Western Aphasia Battery, AQ and Boston Naming Test performance.

Construct	Age	Months post onset	Education	Western Aphasia Battery AQ	Boston Naming Test
Repetition, Parsing/Blending and Perception N=47	62 (11)	69 (62)	15 (2.9)	73.8 (22.3)	30.6 (17.4)
Reading N=50	67.3 (10.1)	84.2 (42.2)	13.4 (3.0)	77.0 (23.2)	31.5 (19.8)

Table 2: IRT results for reading, repetition and perception constructs for the SAPA

Construct	Fit to model % items misfit (expectation <5%)	Floor and/or ceiling effect (expectation <5%)	Point measure correlation (% of items < .30)	Person separation reliability (strata) (Person separation strata expectation >2.0)	Cronbach's alpha (expectation ≥ .70)
READING ALOUD N=69 items N=50 aphasics	0	0	8.6	4.54 (6.39)	.98
PERCEPTION N=216 items N=37 aphasics	2%	Ceiling = 4.3% Floor = 2%	19.4	3.33 (4.77)	.93
REPETITION, PARSING, BLENDING N=113 items N=37 aphasics	0.9%	Floor = 9%	5	3.80 (5.40)	.97

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