Noun and Verb Production and Comprehension in Stroke-Induced and Primary Progressive Aphasia: An Introduction to the *Northwestern Naming Battery*

Introduction

Stroke-induced aphasia can selectively impair production of nouns and verbs. Research has shown that individuals with nonfluent, Broca's aphasia with agrammatism often have more difficulty producing verbs than nouns, whereas fluent aphasic individuals (i.e., those with anomic aphasia) exhibit the reverse pattern (Miceli, Silveri, Villa, & Caramazza, 1984; Zingeser & Berndt, 1990; Berndt, Mitchum, Haendiges, & Sandson, 1997; Kim & Thompson, 2000, 2004). Similarly, individuals with primary progressive aphasia (PPA) demonstrate dissociations in noun/verb naming. Non-fluent PPA patients often have disproportionately impaired verb naming, whereas fluent PPA patients present with more difficulty producing nouns (Bak and Hodges, 2003; Hillis et al., 2004, 2006). Whereas, some researchers have shown that aphasia can also impair comprehension of nouns and verbs (Miceli, Silveri, Nocentini, and Caramazza, 1988), subsequent studies have shown that comprehension and production are independent of one another (Berndt et al., 1997; Kim and Thompson, 2000).

In addition to dissociations between grammatical classes, stroke-induced agrammatic aphasic speakers' verb production deficit is influenced by verb argument structure (Dragoy & Bastiaanse, 2009; De Bleser and Kauschke, 2003; Thompson, Shapiro, Li, & Schendel, 1995; Thompson, Lange, Schneider, & Shapiro, 1997; Kim & Thompson, 2000). The effects of argument structure on verb production in PPA have not been investigated, but it can be hypothesized that patients with agrammatic PPA (i.e., progressive nonfluent aphasia) may show patterns similar to those seen in stroke-induced agrammatic aphasia due to similarities with regard to affected brain tissue (Gorno-Tempini et al., 2004; Mesulam et al., 2009) as well as recent data suggesting parallel syntactic deficits in the two disordered populations (see Weintraub et al., 2009).

Several published tests are available for assessing word class deficits in neurologically impaired patients; however, none adequately examine both production and comprehension of nouns and verbs. The *Northwestern Naming Battery* (NNB; Thompson and Weintraub, in preparation for publication), however, was designed to provide a comprehensive assessment of noun and verb production and comprehension. The test examines production and comprehension of pictured objects (nouns) of different semantic categories and actions (verbs) including verbs with one-, two-, and three-arguments. The stimuli in the NNB are controlled for word frequency and visual complexity. A subset of these items are designed for testing noun/verb ratios for naming (n = 32) and comprehension (n = 22). That is, they were further frequency matched with one another.

The present study used the NNB to test naming and auditory comprehension of nouns and verbs in individuals with stroke-induced aphasia and PPA. In both domains we also tested for verb argument structure effects. In addition, we examined the external validity of the NNB by comparing scores derived from the NNB with those from published, standardized tests (i.e., the *Boston Naming Test* (BNT; Kaplan, Goodglass, & Weintraub, 1983), the *Boston Diagnostic Aphasia Examination* Action Naming subtest (BDAE; Goodglass, Kaplan and Barresi, 2001), and the *Western Aphasia Battery-Revised* (WAB-R; Kertesz, 2007)).

Method

Participants

Fifty-two stroke-induced aphasics (33 nonfluent, 19 fluent), 28 individuals with PPA (10 agrammatic; 14 logopenic; 4 semantic), and 28 healthy controls participated in this study. All participants were native, monolingual English speakers who each passed hearing and vision screenings. The fluency rating and aphasia quotient (AQ) obtained from the WAB-R were used to determine each stroke participant's aphasia classification. The PPA participants were classified based on neurological examination, clinical presentation, and test performance.

Stimuli and Procedures

Single word naming and comprehension were tested using the NNB's Confrontation Naming and Auditory Comprehension subtests, respectively. To assess argument structure effects, the verb stimuli used in these subtests included intranstive, one-argument verbs and transitive, two- and three-argument verbs. The stimuli were matched for frequency based on the CELEX Database (Baayen, Piepenbrock, & van Rijn, 1993). Black and white, and colored, line drawings were used to depict the stimuli, which were normed using undergraduate and graduate students from Northwestern University.

Results and Discussion

Control participants performed at ceiling across all conditions and were excluded from further analyses. Nonfluent, agrammatic stroke-induced aphasic participants had greater production accuracy for nouns as compared to verbs ($t(32) = 4.22$, $p = .000$); however, stroke-induced anomic aphasic participants did not demonstrate a significant difference between word classes ($t(18) = -0.31$, $p = .763$). Similarly, the agrammatic PPA participants had greater production accuracy for nouns than verbs ($t(9) = 4.29$, $p = .002$), which was not demonstrated for the logopenic PPA participants ($t(13) = 0.68$, $p = .504$). There were no significant differences in either participant group for comprehension of nouns and verbs. With regard to argument structure, our stroke-induced agrammatic participants had greater accuracy for intransitive verbs than transitive verbs ($F(1, 50) = 16.77$, $p = .000$). Similar results were found for PPA-G participants ($F(1, 22) = 18.76$, $p = .000$).

Due to the small number of semantic PPA participants (PPA-S) and the variability in their performance, a non-parametric chi-square test was used to analyze their data. In assessing production by lexical type, three out of four participants showed a significant difference, with verbs produced with greater accuracy than nouns (PPA-S1 ($\chi^2(1, N = 1) = 10.66$, $p = .000$), PPA-S3 ($\chi^2(1, N = 1) = 8.96$, $p = .003$), and PPA-S4 ($\chi^2(1, N = 1) = 12.70$, $p = .000$). In assessing comprehension by lexical type, only one subject demonstrated a significant difference – with better verb comprehension as opposed to noun comprehension (PPA-S1: $\chi^2(1, N = 1) = 12.69$, $p = .000$). No significant differences were observed for analyses by transitivity in either condition. That is, PPA-S participants did not display significant differences in production or comprehension of intransitive versus transitive verbs.

With regard to external validity, there were significant positive correlations between the NNB Confrontation Naming subtest (both nouns and verbs) and scores derived from the WAB Naming subtest (Stroke: $r = .814$, $p = .01$; PPA: $r = .875$, $p = .01$). Further, NNB noun naming scores were positively and significantly correlated with BNT scores for both participant groups (Stroke: $r = .874$, $p = .01$; PPA: $r = .870$, $p = .01$). In addition, the same correlations were significant for both stroke-induced aphasia groups (Nonfluent ($n = 30$): $r = .905$, $p = .01$; Fluent ($n = 15$): $r = .819$, $p = .01$) as well as for the two PPA patient groups (Agrammatic ($n = 10$): $r = .914$, $p = .01$; Logopenic ($n = 14$): $r = .872$, $p = .01$). Comparing NNB verb naming scores to

scores on the Action Naming subtest of the BDAE also showed a significant positive correlation for the stroke aphasic participants (Stroke: r = .757, p = .01). Finally, scores on the Auditory Comprehension subtest of the NNB also correlated positively for both groups with scores derived from the Auditory Comprehension subtest of the WAB (Stroke: r = .522, p = .01; PPA: r = .705, p = .01).

These findings indicate that the NNB is useful for assessing word class naming deficits in both stroke-induced and PPA patient populations. Hence, clinicians can confidently use it to evaluate comprehension and production of both word classes using a single measure. Administration of the NNB can also provide data detailing the source of patients' naming deficits that may be used to develop intervention strategies.