

Disentangling noun and verb production in aphasia: Evidence from item response theory

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Abstract ID: 204

Event: SoA 2025 Copenhagen posters

Topic: Clinical and experimental work on aphasia and related disorders

Introduction and aims

Word production requires the rapid integration of multiple cognitive processes, where associative representations are generated (semantic processing) and mapped to a lemma (lexical processing) with its associated grammatical markers (morphosyntactic processing) and phonemic forms (phonological processing) (Dell et al., 1997). Deficits in word production have been extensively studied in aphasia as a means of understanding this underlying architecture; however, there is contention in the literature as to whether the cognitive processes involved in word production differ as a function of word class, with noun and verb production being of particular interest. Although noun-verb dissociations have been reported in the literature (Caramazza & Hillis, 1991), recent literature suggest that these dissociations may be the byproduct of measurement issues related to the tests used (Casilio, Fergadiotis et al., 2025). Item response theory (IRT) is a modern measurement framework that has previously been used to obtain precise scores for both noun and verb production tests in aphasia (Fergadiotis et al., 2015, 2023). Here, we extend this work to evaluate the dimensionality of two common noun and verb production tests in a large and diverse sample of individuals with aphasia. Our aims were to (1) test whether response probabilities on both tests simultaneously are best modeled as varying along one or two dimensions, and (2) explore the effect of relevant person covariates on person-level IRT scores.

Method

Binary item responses on the short form of the Boston Naming Test (BNT), a test of noun production, and Verb Naming Test (VNT), a test of verb production, were extracted from an archival dataset (MacWhinney et al., 2011) of 107 participants with chronic aphasia (Table 1; see our prior work for additional details).

Person covariates of interest were also extracted. These included overall aphasia severity, indexed as the Aphasia Quotient of the Western Aphasia Battery—Revised (WAB-R AQ); and (2) relevant behaviors from connected speech, given that language produced in naturalistic contexts is highly sensitive to a range of deficit patterns (Casilio, Kasdan et al., 2025). Connected speech behaviors included the following transcription-based metrics, as averaged across five standardized elicitation tasks (MacWhinney et al., 2011): percentage of nouns produced, percentage of verbs produced, percentage of word-level errors, and

percentage of utterance-level errors.

To address our first aim, we specified two Rasch IRT models in a generalized linear mixed effects framework: (1) a random-item unidimensional model, where verb and noun production are treated as productively requiring the same set of underlying cognitive processes; and (2) a random-item two-dimensional model, where verb and noun production are treated as productively requiring two distinct yet correlated combinations of underlying cognitive processes.

Then, using the best-fitting model, we explored the effect of first overall aphasia severity and then additionally connected speech on person-level IRT scores.

Results

All models converged to an admissible solution.

The two-dimensional IRT model demonstrated a better fit to the data (Table 2); however, the person-level IRT scores for each were correlated at .90 (Figure 1, Table 3).

The two-dimensional IRT model with the WAB-R AQ covariate was a substantially better fit to the data than the two-dimensional IRT model without any covariates (Table 2). WAB-R AQ was significantly predictive of person-level IRT scores ($p < .001$) and reduced the correlation between the two to .60 (Figure 2, Table 4).

The model that additionally included the four connected speech covariates yielded an even better fit (Table 2). Here, percentage of nouns produced ($p < .001$), word-level errors ($p < .001$), and utterance-level errors ($p = .019$) were significantly associated with person-level IRT scores (Table 5). There was no significant association with person-level IRT scores and the percentage of verbs produced ($p = .192$). In combination, the addition of the connected speech variables reduced the correlation between the two to .44 (Figure 3, Table 5).

Discussion

Noun and verb production in aphasia, as measured on the BNT and VNT, can productively be treated as two distinct yet highly correlated dimensions. Thus, obtaining scores from both likely yields minimal additional unique information for most people with aphasia, aligning with prior work (Casilio et al., 2025).

The shared covariance between person-level IRT scores on the BNT and VNT was explained by both aphasia severity and connected speech. These findings have two important implications. First, the person covariates that were significantly associated with the person-level IRT scores were reflective of noun production, as evidenced by the substantially larger reduction in random effect variance for the BNT as compared with the VNT (Tables 4, 5). This suggests that the cognitive processes overlapping with both noun and verb production

(i.e., lexical-semantic and phonological processing) (Casilio et al., 2025) were those driving the shared covariance. Thus, disentangling any unique contribution of noun and verb production is likely contingent on holding lexical-semantic and phonological processing constant.

Second, the inclusion of relevant person covariates reduced the correlation between the person-level IRT scores by more than half. Such scores may potentially be useful in future research on verb and noun production in aphasia that incorporates other forms of evidence (e.g., lesion information). More broadly, these findings speak to the utility and flexibility of IRT for addressing complex questions of cognitive processing.

In conclusion, as shown through a series of IRT models, verb and noun production in aphasia appears to rely on two distinct yet highly correlated sets of cognitive processes. However, disentangling the two, at least at the group level, is necessitated on controlling for person covariates likely reflective of processes (lexical-semantic, phonological) shared between both tests.

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