## A cognitive psychometric model for assessment of picture naming errors

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The latent abilities required for word production in aphasia can be measured using a cognitive model of the picture naming process. A multinomial processing tree (MPT) characterizes the latent decisions that must be made when naming a picture, and the assumed decision points are motivated by a two-step theory of word retrieval in which errors can occur during selection of a word and/or its corresponding sounds. The model further assumes that the success of internal processing depends either on the ability of the participant, the difficulty of the item, or an interaction. We fit the model to 63,875 naming responses (365 patients, 175 items each) collected at 2 different research hospitals, in Philadelphia, PA (n=275) and Columbia, SC (n=90). To assess the model's predictions on the picture naming task (i.e., internal validation), we compared it with several other pattern recognition and prediction models with similar numbers of parameters, including artificial neural networks and individual modes with limited error correction at the item-level. The MPT model had the highest accuracy (67.7%) for predicting which of 8 response types a participant would produce on a given item, and unlike the pattern recognition models, it predicted all of the response types at least once. This provides evidence that our psychological assumptions are improving our understanding of the processes that generate this data. To assess external validity, we examined the relationship between the estimated parameters and other psychological tests. The model's word selection ability correlated with other tasks of word processing, and the model's phoneme selection ability correlated with other speech production tasks; similarly, lexical difficulty correlated with word frequency, while phonological difficulty correlated with word length and the number of similar sounding words. We also examined neurological imaging and found that lexical abilities were associated with damage to the superior temporal gyrus, while phonological abilities were associated with damage to insular cortex and the superior longitudinal fasciculus. An online platform allows researchers and clinicians to obtain ability estimates and percentiles from item-level picture naming data using the model.

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