A Novel Means to Examine Response to Spelling Treatment

Introduction

Literate adults have stored memory for spellings of specific words, as well as knowledge of sound-to-letter correspondences that allow them to generate plausible spellings for unfamiliar words and nonwords. A dual-route model of written language processing posits that these skills reflect distinct but interactive processes referred to as *lexical* and *non-lexical* routes, respectively. Irregular words (such as "choir") that do not follow conventional letter-sound correspondences are necessarily processed via a lexical route, whereas nonwords (such as "shurb") are decoded by non-lexical grapheme-phoneme conversion. Regular words (such as "flake") can be read or spelled via either a lexical or non-lexical route.

In a recent examination of a dual-route model, Coltheart and colleagues (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Castles, Bates, & Coltheart, 2006) proposed that regular word reading accuracy could be predicted by reading performance on lists of irregular words and nonwords. Specifically, they proposed that the proportion of irregular words, or p(IRREG) , and the proportion of nonwords, or p(NWD), that a person can accurately read provide relatively pure estimates of the competency of the lexical and non-lexical routes. Because dual-route theory posits that either route can process regular words, reading accuracy for these items, or p(REG), should be predictable from p(IRREG) and p(NWD) by the following formula:

$$p(REG) = p(IRREG) + [1 – p(IRREG)] \times p(NWD)$$

For example, if a patient obtains reading scores of 60% correct for irregular words and 40% correct for nonwords, then p(REG) = .60 + [1 – .60] x .40). Thus, it is predicted that this individual should be able to read 60% of regular words by a lexical strategy, and reading accuracy for the remaining 40% of regular words will be determined by the functional capacity of the non-lexical route, reflected by nonword reading scores. Thus, the dual-route equation predicts a reading score of 76% (60% + 16%) correct for regular words.

Coltheart and colleagues (Coltheart et al., 2001; Castles et al., 2006) applied this prediction equation to the reading data obtained from young normal readers, children with developmental dyslexia, and children with brain damage due to stroke (total n = 2246), and observed high correlations between predicted and observed regular word reading scores (ranging from +.825 to +.980). We recently tested whether such predictions hold for reading, and also for spelling, in 33 adults with acquired alexia and agraphia. We found a high correlation between predicted and observed performance for reading (r = .915) and spelling (r = .924). These findings provided support for dual-route theories of written language processing, and prompted the present investigation in which we examined the clinical utility of the prediction equation to study response to spelling treatment in individuals with acquired agraphia.

Methods

Eight individuals with aphasia due to left hemisphere stroke participated in this study (5 male; 3 female). They ranged in age from 43 to 67 years of age (mean = 59.5) and had an average of 15 years of education (range = 12 – 19). Time post onset of aphasia ranged from 5 months to 13.5 years (mean = 6.9 years), and aphasia severity as estimated by the Aphasia Quotient from the Western Aphasia Battery ranged from 70.6 to 98.4 (mean = 82.91).

Single word reading and spelling were assessed using controlled lists of stimuli that included 40 regular words, 40 irregular words, and 20 nonwords. For the group, spelling was more impaired

than reading (51.5% correct for spelling; 81.1% correct for reading), and was the focus of the treatment described here.

The nature of the spelling treatment was determined by the agraphia profile for each participant, and followed a continuum from lexical to phonological to interactive treatment. Lexical treatment involved training spelling of specific words that served as key words to assist in recall of sound-to-letter correspondences during subsequent phonological treatment. Phonological treatment was directed toward re-establishing sound-letter and letter-sound correspondences for 20 consonants and 10 vowel sounds. Interactive treatment was implemented with individuals who had relatively preserved (or re-established) sound-letter correspondence abilities. Interactive treatment involved a problem-solving approach in which participants were trained to use phonological knowledge to generate phonologically plausible spellings to evaluate on the basis of residual orthographic knowledge (lexical check), and to use an electronic speller as an external aid to check spellings.

For each participant, pre-treatment and post-treatment spelling of regular words was examined relative to predicted performance calculated on the basis of the actual spelling performance on irregular words and nonwords using the prediction equation described above.

Results

As shown in Figure 1, a comparison of pre- and post-treatment performance demonstrated significant improvement in spelling regular words (average gain of 12.12%; sd = 5.25%) and irregular words (average gain of 12.37%; sd = 7.03). Nonword spelling improved by an average of 15.62% (sd = 18.98), a difference that was not quite significant at .05 level due to considerable variance across participants. A scatterplot of predicted versus observed spelling of regular words is shown in Figure 2, with pre-treatment values indicated with triangles and post-treatment values indicated with circles. Improved performance by individual participants is illustrated by the upward shift of circles in relation to triangles. The overall convergence of values toward the 45º line visually demonstrates the high correlation between predicted and observed scores. Predicted scores accounted for 92.9% of the variance in actual performance at pre-treatment and 86.1% after treatment. Symbols above the 45º line indicate spelling that exceeded predicted performance, whereas symbols below the line indicated spelling performance below predicted performance.

Discussion

Participants in this study demonstrated significant improvement in spelling performance for untrained items following behavioral treatment for spelling. Group results also demonstrated that spelling of regular words was predicted with a high level of accuracy on the basis of lexical knowledge (estimated by irregular word spelling) and phonological knowledge (estimated by nonword spelling). It was somewhat surprising that the accuracy of the prediction equation was better for pre- compared to post-treatment data. We assume that concurrence between predicted and observed spelling performance suggests that individuals are making maximal use of lexical and non-lexical abilities, and that was the case for most of the participants in this study. However, Figure 2 shows that two individuals performed below expectation on regular word spelling (based on their irregular word and nonword spelling). This can be illustrated by the participant denoted in Figure 2 by red symbols. He had the following scores prior to treatment: regular words = 40%, irregular words = 3%, and nonwords = 45%, and predicted spelling of regular words = 47% (7% more than actual performance). Following treatment, regular words =

50%, irregular words = 10%, and nonwords = 75%, and his predicted performance for regular words was 78% (28% better than actual performance). These scores demonstrated that, although this participant showed marked improvement in phonological spelling ability for nonwords, he was not fully applying the knowledge to the spelling of regular words. Therefore the next phase of treatment for this individual should involve increased use of non-lexical spelling abilities when spelling regular words. Thus, the prediction equation provided insight regarding the use of lexical and nonlexical spelling abilities in a way that was not clearly evident otherwise. In sum, the quantitative information provided by the prediction equation served to complement the observed performance data, and warrants further exploration of its value relative to cognitive changes in response to treatment.

References

Castles, A., Bates, T.C., & Coltheart, M. (2006). John Marshall and the developmental dyslexias. *Aphasiology*, 20, 871-892.

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review*, 108, 204-256.

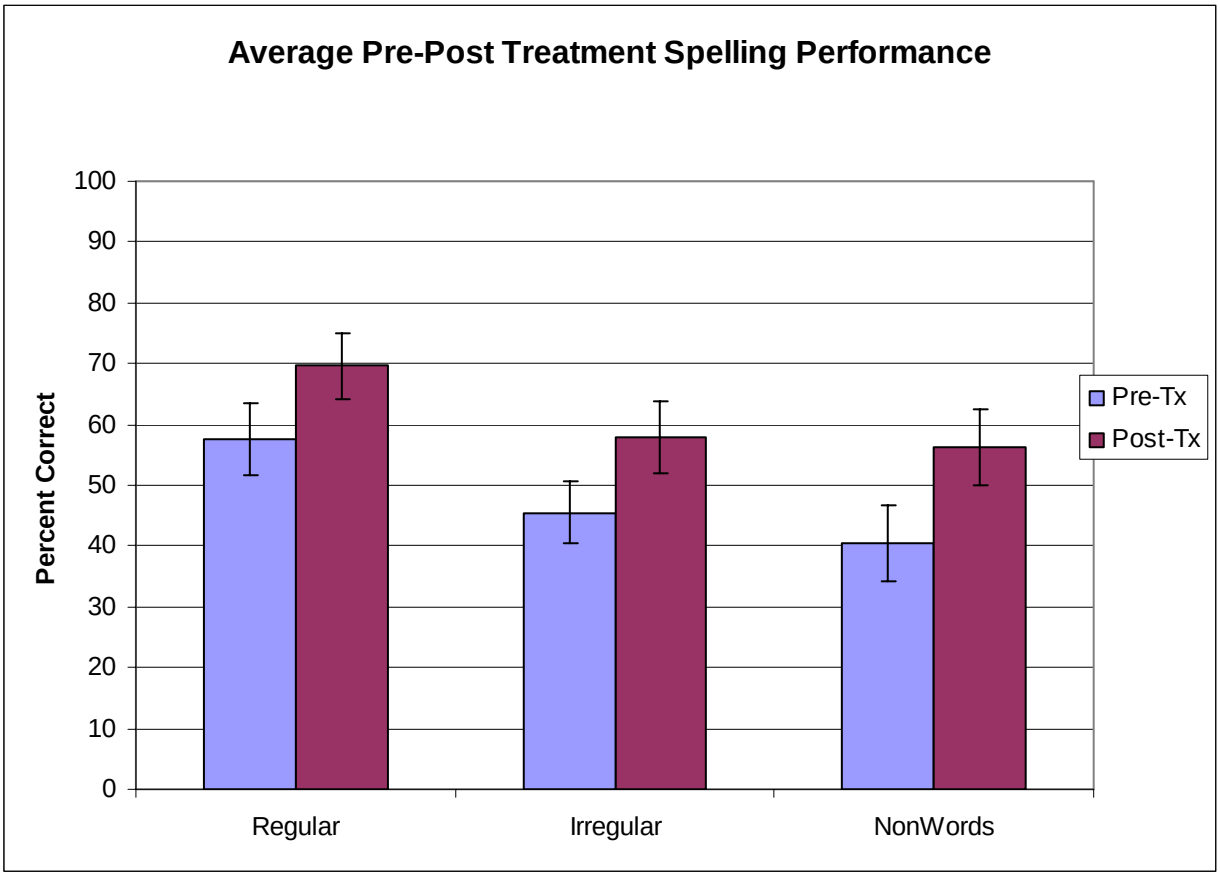
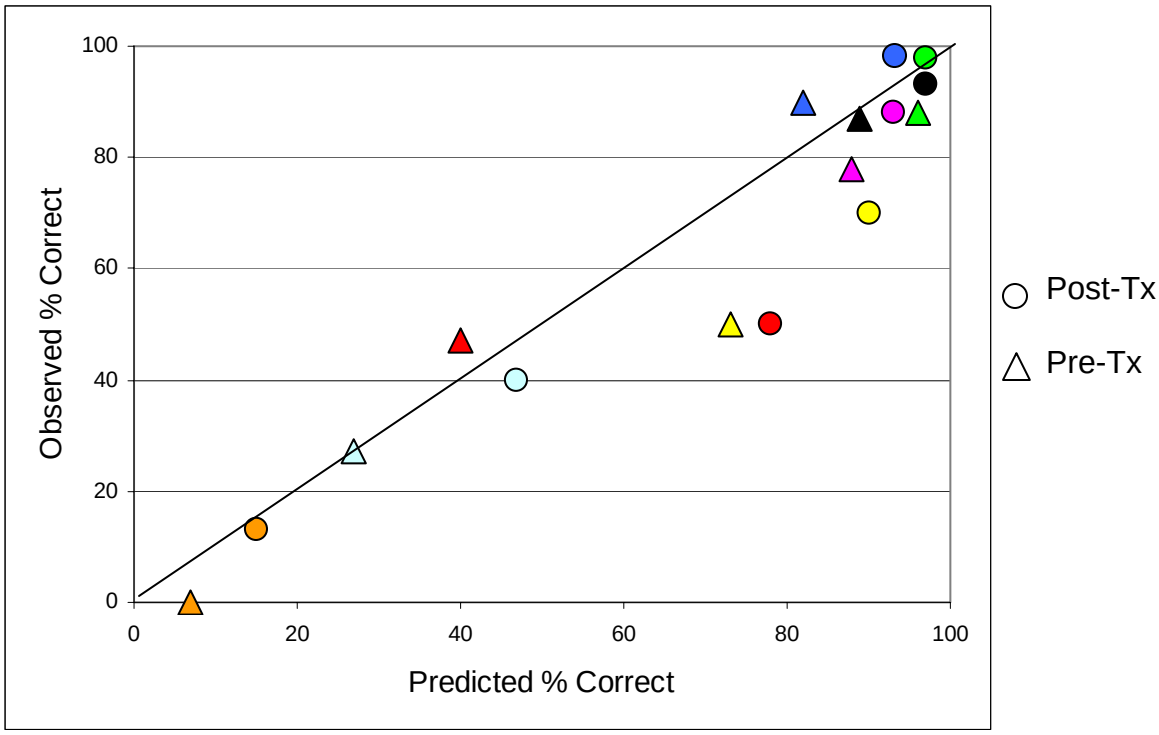


Figure 1. Average pre- and post-treatment spelling of regular words, irregular words, and nonwords by a group of eight individuals with acquired impairment of language. Vertical bars indicate standard error of the mean.



Scatterplot reflecting pre- and post-treatment spelling performance of 8 individuals (each indicated by a different color). The 45 degree angle line indicates convergence of predicted and observed spelling of regularly spelled words. Predicted spelling of regular words is based on actual spelling of irregular words and nonwords (see text for details).