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A Quantitative Analysis of the Effectiveness of Contiguous, Graphemic and Phonological Interventions on Measures of Reading and Spelling Acquisition

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ABSTRACT

Although research has established that phonological awareness is a predictor of future reading skill, the effects of variant vs. contiguous presentations of grapheme-phoneme correspondences as part of a teaching program have not been examined. A variant presentation is one in which there is a mismatch between the letter and sound or sound and letter correspondences and a contiguous representation is one in which there is a consistent match between the letter and sound information. Three 10 hour interventions were designed to determine the effects of two variant and one contiguous presentation of grapho-phonological information on five measures of reading and four measures of spelling.The Contiguous intervention class significantly (p<0.05) outperformed both the Grapheme and Phoneme intervention classes in reading regular words, and spelling exception words and nonwords. This suggests that the presentation of contiguous grapho-phonological information contributes to reading and spelling outcomes more than variant presentations.

INTRODUCTION

Recent research tends to indicate that orthographic and phonological information independently contribute to the acquisition of reading and spelling skill (Bryant & Bradley, 1985; Byrne, Fielding-Barnsley, & Ashley, 2000; Coltheart, Rastle, Perry, Langdon, and Ziegler, 2001; Grainer & Ferrand, 1994; Stanovich & West, 1989; Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995). Liberman (1997) argues that these two sources of information have different sources. The orthography of language has a cultural genesis whereas phonology has a biological one. Written language has been formed by the conventions and traditions of cultural development. The selection and assignment of graphemes to the sublexical phonemes, or pictures or characters to lexical units is essentially an arbitrary process that occurred in the development of the literary environments of many and varied human cultures (de Saussure, 1972). The different written forms of language developed their own frequently occurring patterns that characterize their particular script. These scripts may remain relatively pure and isolated from foreign elements or they may incorporate and absorb various extraneous patterns. Those texts that developed within their own traditions and conventions tended to remain simple and transparent and have shallow, predictable and invariant correspondences between the distinctive phonology and orthography of that language. Texts that incorporated a mixture of phonologies and orthographies tended to become opaque, and to have a deep orthography consisting of

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complex and variant spelling patterns. The English language has incorporated words from other languages into its written and spoken vocabulary and that has modified its phonology and orthography (Henry, 1988; Seidenberg & McClelland, 1989).

Spoken language on the other hand, seems to be a capacity peculiar to humans and transmitted biologically. Humans have a propensity to understand the linguistic gestures of others and naturally to acquire the ability to give and receive verbal communications. Such communication can often take place in spite of incomplete phonological information. The basic unit of phonological transmission is the word and the phonology of each word consists of an indistinguishable blend of sounds. The task of teaching spelling and reading skills for an alphabetic script comprises parsing the blended sounds in words into phonemes and then assigning graphemes to them. Thus the articulation of speech is acquired naturally whereas the parsing of words into phonemes and the conversion of phonemes into graphemes is learnt (Liberman, 1997; Perfetti, 1992).

The alphabetic principle is the strategy of isolating phonemes in words and mapping them to graphemes. Share (1995) argues that the acquisition of phonological recoding and the alphabetical principle acts as a self teaching mechanism that empowers readers to identify novel words and writers to spell spoken words. Given that readers are exposed to a multitude of novel words in English texts it is necessary that readers acquire this self teaching mechanism to enable them to quickly recognize and phonologically recode new items.

The understanding that verbal language and speech is usually acquired and communicated naturally has created anticipation for some educationists that it will be processed effortlessly when reading and writing. Research, on the other hand, indicates that the process of analyzing the phonemes within the utterances of lexical units is difficult and is learnt. Morais (1987) and Morais, Bertelson, Cary and Alegria (1986) studied ex-illiterate and illiterate adult Portuguese and Read, Yun-Fei, Hong-Yin, and Bao-Qing (1986) studied literate traditional Chinese and Chinese literate in phonetically coded pin yin, and both sets of results indicated that students who have acquired a phonetic written code could also analyse words into syllables, rhymes and phonemes whereas students who had not learnt a phonetically coded script were relatively unaware of sublexical units. Liberman (1997) points out that this realization has formed the basis of reading and spelling research over the last two decades.

Research by Elkonin (1973), Bruce (1964 cited in Chew, 1997; Goswami & Bryant, 1990) and Liberman, Shankweiler and colleagues (Liberman & Shankweiler, 1979; Liberman & Shankweiler, 1985; Liberman, Shankweiler, Fischer, & Carter, 1974) established that children require instruction to be able to parse words into the various sublexical units. Elkonin (1973) and Bruce (1964 cited in Chew, 1997) researched phonemic awareness which is the fine tuned process of parsing each consonant and vowel in a syllable or word (e.g., /t/-/w/-/i/-/s/-/t/) whereas phonological awareness is the coarser process of identifying sublexical units like onsets (the initial consonant or consonant clusters e.g., /tw/); rimes (the vowel and final consonant or consonants e.g., /ist/); anti-bodies (the initial consonant or consonants and vowel e.g., /twi/) or the coda (the final consonant or consonants e.g., /st/) of a syllable.
Bryant and Bradley (1985) and Bryant, MacLean, Bradley, and Crossland (1990) instructed children on the identification of coarse sublexical units by having them recognize similar rhyme patterns from words that rhyme and the identification of phonemes from word alliteration. Their research was a longitudinal study and indicated that children who learnt to identify phonemes and spelling patterns from this training out performed a control group over several years in certain measures of reading acquisition.

Further research by Goswami, Bryant, Mead and Treiman introduced the sublexical units of the onset or the initial consonants of one syllable words and the rime or the remainder of the sounds in a syllable after the onset. Their research indicated that instruction in onset and rime contributed to children learning how to parse phonemes in words, identify frequent spelling patterns and transfer this learning by analogy to novel spelling sequences (Goswami & Bryant, 1990; Goswami 1991, 1993, 1995, & 1999; Goswami & Mead, 1992; Treiman, 1985).

The prospect that children could learn new words by analogy from rhymes, rime bodies and onsets rather than a strict one to one letter-sound correspondence raised hopes that learning could be based on frequent and consistent sublexical patterns. Some theorists went on to propose that learning occurs through a single psychological route that statistically analyses these frequent and consistent patterns irrespective of whether or not the letter-sound correspondences are regular or follow rule-like grapheme-phoneme conventions (Glushko, 1979; Harm & Seidenberg, 1999; Jared, McRae & Seidenberg, 1990; Plaut, McClelland, Seidenberg, & Patterson, 1996; Seidenberg & McClelland, 1989; Seidenberg, Waters, Barnes, & Tahenhaus, 1984).

Research by Ehri and Wilce (1985, 1987) included a training intervention consisting of analogous consonant-vowel-consonant (CVC) words to transfer (CVC) words; compared to control (CVC) words to transfer (CVC) words and the results indicated that beginner readers who processed a full analysis of the relationship between the visual cues of the orthographic information and the phonological cues of the spoken pronunciation of the words performed better with the transfer tasks than those beginners that did not make this connection. The process of connecting both sources of information aided the long term memorization of words. Later research by Ehri and Robbins (1992) indicated that this process of learning by the full analysis of and correspondence between orthographic and phonological cues operated both at the sublexical level of rime units and phonemic units (see also Muter, Hulme, Snowling & Taylor, 1998). Ehri's understanding (1995, 1997) and longitudinal studies by Byrne, Fielding-Barnsley and colleagues established that phonemic awareness or the parsing of words into their constituent phonemes is not sufficient by itself, but that the full development of the alphabetic principle by the transparent and clear juxtaposition of phonemic and graphemic information is required for the acquisition of literacy (Byrne, 1991; Byrne, 1992; Byrne, 1993; Byrne, 1996; Byrne & Fielding-Barnsley, 1989; Byrne & Fielding-Barnsley, 1991; Byrne & Fielding-Barnsley, 1993; Byrne, Fielding-Barnsley, & Ashley, 1996; Byrne, et al., 2000).

This research reflects a growing acceptance that beginner readers benefit from direct instruction in developing phonemic awareness and the alphabetic principle. The aim of the present study is to investigate the nature of three different presentations of phoneme to grapheme correspondences within the context of an intervention instructing infant students in phonemic awareness (Bourne, 2002). In the Graphemic intervention children were instructed in the different phonemes associated with the 72 most prevalent graphemes according to the Spalding and Spalding (1969) approach to literacy. The graphemic intervention used words that contained the same graphemes representing different phonemes.

In the Phonemic intervention children were instructed in the different graphemes associated with the most prevalent phonemes and this material was selected from the spelling dictionary of the Lamond and Whiting (1992) approach to literacy. The phonemic intervention used words that contained the same phonemes represented by different graphemes.

In the Contiguous intervention children were instructed in the official and traditional grapheme-phoneme correspondences that maintain consistent patterns of phoneme to grapheme correspondences taken from Brand's (1994) approach to teaching literacy. A contiguous presentation of material occurs when two modalities converge simultaneously to achieve a multi-sensory unit. In the contiguous intervention both auditory and visual information were presented consistently without conflict or variance between the phonemic and graphemic information.

The questions addressed in this study were,
1. Are the Grapheme or Phoneme interventions more beneficial than the contiguous intervention for improving reading/spelling and listening comprehension skills?
2. Does the pattern of effects for the three interventions vary across the different measures of reading and spelling skills (regular words, exception words, non-words, standard reading and spelling tests and listening comprehension)?

METHOD

Participants

The sample consisted of 81 children from three grade two classes in a denominational school in Sydney. Their age range was 6 years to 8 years and 5 months with *M*= 7 years 1 month and *SD* = 4.70 months. There were 37 boys and 44 girls.

Research Design

The study had three phases. In phase 1 the participants were pre-tested, in phase 2, the interventions were administered and in phase 3 post-testing was carried out.

Measures

Reading: The Waddington Reading (WR) test (Waddington, 1988) was administered as a pretest. This is a modified cloze reading test with a reported KR20 reliability of .97. An alternate form of this test was constructed that adhered to criteria specified in Waddington's (1988) manual and administered as a post test. To assess the parallel forms' reliability of the alternate Waddington (1988) Reading and Spelling tests, the alternate Coltheart regular, exception and nonword reading and spelling tests, were all trialed with 64 grade 3 children who were not involved in the intervention study. The results indicated a high parallel forms reliability for all the tests that varied from .83 to .97 (see Table 1.)

Word reading: The Coltheart Reading test (Coltheart & Leahy (1996) contained 90 items that were randomly presented to the children on flash cards. The 90 items consisted of 30 regular words, 30 exception words and 30 nonwords. Coltheart and Leahy (1996) have normed this test on 420 Australian students.

Reading Posttest: A 90-word parallel form of the Coltheart and Leahy (1996) test was also developed to minimise test-retest effects. The regular and exception words were taken from Carroll, Davies and Richman's (1971) *American Heritage Word Frequency List.* The regular (30) and exception (30) words were matched for frequency, number of syllables, number of letters and regularity (see Table 1).

The Listening Comprehension Pre and Post Tests: Listening comprehension was included as a measure of comprehension separate from decoding (Aaron, 1989; Gough & Tunmer, 1986; Nicholson, 1986). Two forms of this test were collated by Brigance (1983) and consisted of a series of short passages of prose followed by 5 comprehension questions. The passages ranged through nine grade levels of difficulty.

Table 1: Reliability Analysis of the Dependent Measures

Dependent Measure	Parallel Forms	Cronbach's α	
	r_{xx}	Pretest	Posttest
Reading Regular Word	0.89	0.89	0.92
Reading Exception Word Pretest	0.96	0.83	0.89
Reading Non-Word Pretest	0.81	0.91	0.91
Spelling Regular Word	0.92	0.91	0.90
Spelling Exception Word	0.90	0.92	0.92
Spelling NonWord	0.91	0.86	0.84
Waddington Reading	0.98	0.88	0.87
Waddington Spelling	0.97	0.96	0.96

Spelling test (30Regular Word, 30 Exception Words and 30 Nonwords: The same construction procedures as those used above for the reading tests were used to create parallel forms of spelling tests (see Table 1).

Waddington (1988) Spelling (WS) Test. The WS test was administered to the participants as a pretest. This test is normed on Australian students, with a reported KR20 reliability of .95. A variant Waddington Spelling posttest was constructed. It consisted of words that were matched with the original test on the following criteria: on frequency according to *The American Heritage: Word frequency list* by Carroll, et al. (1971) on number of letters, on number of syllables, on type of phoneme to grapheme correspondence, and other specified criteria outlined in Waddington's (1988) manual of Diagnostic reading and spelling tests (see Table 1).
The word reading tests (i.e., the 90 words) and the listening comprehension test were administered individually, and the other tests were administered in class groups. All tests were administered by the researcher.

Procedures

Interventions
The interventions were derived from the principles underlying three different approaches to presenting grapheme-phoneme relationships.

The Contiguous Intervention. The Contiguous intervention presented words where the graphemic unit consistently represented the same phoneme. A selection of words was taken from the Brand (1994) program, where the graphemic units carried the same phonemic content. For example, in lesson 16, the students were given the following words to sort according to the sound of the underlined letters:- h<u>air</u>, t<u>ou</u>ch, w<u>a</u>s, y<u>ou</u>ng, w<u>a</u>sp, p<u>air</u>, c<u>ou</u>ntry, st<u>air</u>s, c<u>ou</u>ple, d<u>ou</u>ble, squ<u>a</u>sh. The target letters were underlined and the defining characteristic that the children sorted was the words that contained the same grapho-phonological information.

The Phoneme Intervention. The Phoneme intervention demonstrated to children the range of different graphemes that could be used to represent a single phoneme in the English language. A selection of material for the Phoneme intervention was taken from the Sound Dictionary of the Lamond and Whiting (1992) program, where words of different graphemic units were grouped according to their common sound (i.e., phonemic unit). For example, in lesson 19, the students were given the following words to sort according to the sound of the underlined letters:- h<u>or</u>se, s<u>ore</u>, br<u>oa</u>d, s<u>oar</u>, p<u>our</u>, d<u>oor</u>, w<u>ar</u>, ch<u>al</u>k, p<u>aw</u>, f<u>au</u>lt, s<u>ure</u>, th<u>ough</u>t. The target letters were underlined and the defining characteristic that the children sorted was the different graphemes that represented the same phoneme.

The Grapheme Intervention. The Grapheme intervention demonstrated to the children the range of different phonemes that a single grapheme could represent in the English language. A selection of material was taken from the Spalding and Spalding (1969) program that illustrated how a single graphemic unit could represent different phonemes. For example, the students were given the following words in Lesson 17 to sort according to the different sounds of /oo/:- h<u>oo</u>p, b<u>oo</u>k, d<u>oo</u>r, sn<u>oo</u>ze, sh<u>oo</u>k, p<u>oo</u>r, shamp<u>oo</u>, b<u>oo</u>rish, g<u>oo</u>dness, w<u>oo</u>. The target letters were underlined, and the children sorted the words according to the different sounds these letters represented.

Design of the Instruction Program

The interventions were designed for student-centered teaching where the children were encouraged to engage in discovery learning (Gaskin, Ehri, Cress, O'Hara & Donnelly, 1996). In each lesson, the children were given four tasks. The work-sheets for each of the interventions consisted of the same exercises and instructions, and only differed in the selection of words introduced with each lesson. The duration of the intervention was two half-hour lessons per week for 10 weeks. The worksheets provided concrete feedback to the experimenter of the students' progress. The students worked in pairs of competent and poorer readers. The first pair of students to complete the sort of the experimental stimuli was asked to present their sort to the rest of the class after checking with the experimenter. The experimenter modelled the instructions, and identical instructions, modelling and peer collaboration was implemented in each of the interventions.

The first task required the children to sort words according to a specified criterion, the sound of the letters underlined in each of a group of twelve words. The words were scripted onto separate cards and the children when given verbal and written prompts on how to complete the task. For the second and third exercise the students were given written and verbal prompts on how to count the number of syllables and on how to identify onset and rimes in the words. In the fourth exercise the children were instructed on how to fully analyse each word into its constituent sounds.

In the fifth exercise the students were provided with a list of consonants and consonant blends on the one hand, and a group of rimes to which they could add the consonantal onset, on the other. The children were rewarded with a tally and a stamp for the number of words they made from the onsets and rimes. The material for this exercise was partly developed from the research of Stanback (1991 & 1992) who has compiled lists of rime patterns from a sample of 17,602 frequency-based words.

The students were rewarded with stamps during the interventions, and a pencil and a ball point pen for their participation in the program. Rewards were identical across the three experimental conditions.

RESULTS

To compare posttest scores for students in the Phoneme, Grapheme, and Contiguous intervention conditions, scores were grouped into two conceptual sets (reading and spelling achievement), and separate MANCOVAs performed on scores in the two sets. In each case, corresponding pretest measures were used as concomitant variables. Univariate ANCOVAs were applied to assess the effects of the two factors on individual dependent measures. Stepdown analyses (Roy & Bargmann, 1958 as cited in Stevens, 1992) were also performed for correlated measures within each set. The Bryant-Paulson procedure (Bryant & Paulson, 1976 cited in Stevens, 1992), which is an extension of Tukey's WSD (Tukey, 1953 cited in Stevens, 1992) procedure for random concomitant variables, was used for all post-hoc comparisons of marginal means. All significant univariate outcomes were accompanied by effect size estimates based on the partial eta squared statistic (η^2).

Assumptions for Uni-Multivariate Analysis of Variance.
Screening procedures for the three sets of scores suggested adequate conformity to univariate and multivariate analysis of variance assumptions. Mahalanobis distances, calculated separately for each of the three cells of the design, indicated no multivariate or univariate outliers (ps > 0.05), and all tests for heterogeneity of variance and dispersion matrices were nonsignificant (ps > 0.05). Assumptions of univariate and multivariate normality were judged to be tenable.

Reading Outcomes

Pretest Equivalence.
Mean pretest scores on the tests for regular words, exception words, nonwords, listening comprehension (LC) and the Waddington Reading (WR) tests are shown in Table 2. To determine whether pretest scores differed significantly across the three experimental conditions, a one-way MANOVA was performed for pretest scores on the five tests. This indicated no significant multivariate effect for condition ($V = 0.15$, approximate $F(10,144) = 1.21$, $p = 0.29$). Univariate tests on the regular word, exception word, non-word, WR, and LC measures were also nonsignificant (all ps > 0.10).
Assumptions for Covariance Analysis.
With internal consistency reliabilities over .83 for scores on the exception word, regular word, and non-word tests (see Table 1), and a KR-20 reliability estimate of 0.97 for the WR reading test, pretest scores on these measures were considered to be adequately reliable to use as covariates. Tests for heterogeneity of regression hyperplanes across the three cells of the design were nonsignificant in all multivariate, univariate, and stepdown analyses (all ps > 0.10), indicating that use of the pooled within-cells regression coefficients to adjust cell means was tenable.
The multivariate association between combined pretest and composite posttest scores on the five measures was significant ($V = 1.62$, approximate $F(25,350) = 6.73$, $p < 0.001$), with univariate regression analyses indicating strong relationships between combined pretest scores and achievement on the regular words ($F(5,70) = 57.74$, $p < 0.001$), exception words ($F(5,70) = 95.11$, $p < 0.001$), nonwords ($F(5,70) = 46.90$, $p < 0.001$), WR ($F(5,70) = 16.88$, $p < 0.001$) and LC ($F(5,70) = 12.99$, $p < 0.001$) tests. Thus, use of the combined pretests as covariates produced a significant reduction in posttest error variance.

Reading Outcomes.

Observed means, adjusted means, and standard deviations for scores on the five posttests are also shown in Table 2. Based on the Pillai-Bartlett criterion, the main effect for condition on combined posttest scores approached significance at the 0.05 level ($V = 0.22$, approximate $F(10,134) = 1.66$, $p = 0.10$). Since a significant degree of overlapping variance was found between scores on the set of posttest measures (Bartlett's $\chi^2(10) = 42.82$, $p < 0.001$), both univariate and stepdown Fs were used to assess the effects of the conditions on the five measures separately.

Given that one of the major goals of the three interventions was to increase reading achievement, the three word reading tests (i.e., of regular words, exception words, and nonwords) were entered prior to the WR and LC tests in the stepdown analysis. Since regular word reading is presumed to incorporate both orthographic and phonological processes, the regular word test was entered prior to the exception and non-word tests, while the latter two tests were assigned equal priority and analysed immediately after the regular word test (using an Bonferroni-adjusted α level of 0.025). The WR test, which assesses both sentence reading and comprehension, was in turn entered prior to the LC test.

The univariate ANCOVAs indicated a significant effect on regular words ($F(2,70) = 4.56$, $p = 0.01$, partial $\eta^2 = 0.12$) and a marginally significant effect on the nonwords ($F(2,70) = 2.69$, $p = 0.08$, $\eta^2 = 0.07$). All other univariate effects were nonsignificant (all $Fs(2,70) < 1.02$, $ps > 0.36$). The effect on the nonwords was also not significant at stepdown (stepdown $F(2,68) = 1.99$, p = 0.16) indicating that the univariate effect found on this measure was already accounted for in its overlap with the regular word test. The pattern of adjusted means for the regular words test is shown in Figure 1. The significant effect favoured the Contiguous intervention, while the lowest scores were recorded in the Phoneme intervention. Bryant-Paulson qs indicated that on each dependent measure, the Contiguous intervention students significantly outperformed those in Phoneme intervention condition ($q = 5.66$, $p < 0.05$). However, there were no significant differences between the Phoneme and Grapheme or between the Grapheme and Contiguous interventions, although the latter difference did approach significance at the 0.05 level ($q = 3.26$, $p < 0.10$).

Spelling Outcomes

Pretest Equivalence

Mean pretest scores on the regular word, exception word, nonword and WS spelling tests are shown in Table 3. To determine whether pretest scores differed significantly across the three experimental conditions, a one-way MANOVA was performed for pretest scores on the four tests. This indicated a significant multivariate effect for condition ($V = 0.30$, approximate $F(8,146) = 3.24$, $p = 0.002$). Univariate tests indicated no significant univariate effects ($F(2,75) < 1.23$, $ps > 0.30$), however, the effect for WS was significant at stepdown ($F(2,72) = 12.84$, $p < 0.001$). To determine whether this was responsible for the significant multivariate effect, the WS pretest was removed and the MANOVA performed again. This analysis indicated no significant overall effect for class ($V = 0.05$, approximate $F(6,148) < 1$). Given that the pretest differences appeared to have resulted from differences on the WS pretest, data from this test was not used in the analysis as a covariate.

Table 2 Observed Means (M_{ob}) Adjusted Means (M_{adj}) and Standard Deviations (SD) for Scores on the Pre- and Posttest Reading of Regular Word, Exception Word, and Non-word Tests, the Waddington Reading Test and Listening Comprehension Test (n=81)

Class		Reading Regular Words			Reading Exception Words			Reading NonWords			Waddington Reading Test			Listening Comprehension		
		M_{ob}	M_{adj}	SD	M_{ob}	M_{adj}	SD	M_{ob}	M_{adj}	SD	M_{ob}	M_{adj}	SD	M_{ob}	M_{adj}	SD
Phoneme	Pre	22.07		7.55	14.67		5.41	17.19		8.54	38.56		5.19	4.70		1.81
Condition	Post	22.96	22.93	7.08	18.30	18.14	6.70	21.00	21.09	8.32	41.30	40.68	5.19	6.85	6.60	1.77
Grapheme	Pre	22.00		6.25	14.56		3.90	16.37		7.32	37.22		5.29	3.70		1.61
Condition	Post	23.37	23.34	5.19	17.96	18.01	5.60	19.30	19.61	7.10	40.67	41.09	6.02	5.74	6.01	2.28
Contiguous	Pre	22.33		5.58	13.97		4.65	17.92		6.52	37.83		6.62	4.58		2.20
Condition	Post	25.13	25.13	4.65	18.25	18.36	5.43	22.42	22.00	5.18	40.21	40.40	7.65	6.21	6.18	1.91

Note: For each of the reading tests the score was calculated on the number of correct responses. For the listening comprehension test the score was calculated at a grade level (at least 3 out of 5 correct answers to comprehension questions)

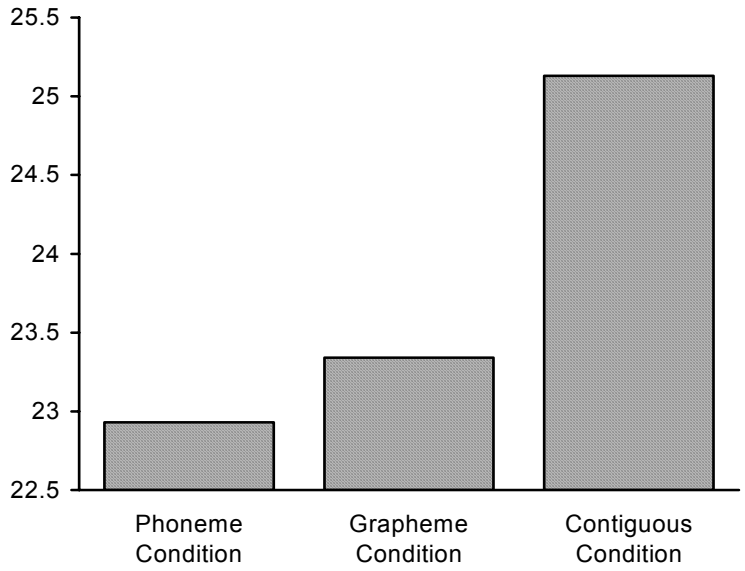

Figure 1: Adjusted Reading Posttest Means on the Regular Word Reading Test for Students in the Phoneme, Grapheme and Contiguous Intervention Conditions

Assumptions for Covariance Analysis.
Similar conditions applied to the spelling analysis as to the reading. When the same tests were carried out, it was found that the multivariate association between combined pretest and composite posttest scores on the three measures was significant ($V = 1.13$, approximate ($F(9,216) = 14.53$, $p < 0.001$), with univariate regression analyses indicating strong relationships between combined pretest scores and achievement for the regular words ($F(3,72) = 52.17$, $p < 0.001$), exception words ($F(3,72) = 79.13$, $p < 0.001$), and nonwords ($F(3,72) = 31.37$, $p < 0.001$). This indicated that the use of the combined pretests as covariates produced a significant reduction in posttest error variance.

Spelling Outcomes.

Observed means, adjusted means, and standard deviations for scores on the four posttests are also shown in Table 3. Based on the Pillai-Bartlett criterion, the main effect for condition on combined posttest scores was significant at the 0.05 level ($V = 0.24$, approximate $F(6,142) = 3.16$, $p = 0.01$). Since a significant degree of overlapping variance was found between scores on the set of posttest measures (Bartlett's $\chi^2(3) = 35.97$, $p < 0.001$), both univariate and stepdown Fs were used to assess the effects of the conditions on the four measures separately.

The univariate ANCOVAs indicated a significant effect on the exception words and non-words ($F(2,72) = 7.24$, $p = 0.001$, partial $\eta^2 = 0.17$; $F(2,72) = 5.87$, $p = 0.004$, $\eta^2 = 0.14$), but no significant difference on the regular words ($F(2,72) = 1.32$, $p = 0.27$). The effects on the exception words and nonwords remained significant or marginally significant at stepdown (stepdown $F(2,71) = 5.80$, $p = 0.005$; stepdown $F(2,70) = 2.79$, $p = 0.07$). The pattern of adjusted means for the exception word and nonword tests is shown in Figures 2 and 3. As indicated, in both cases, the significant effect favoured the Contiguous intervention, while the lowest scores were recorded in the Grapheme intervention. Bryant-Paulson qs indicated that on the exception words measure, the Contiguous intervention students significantly outperformed those in both the Phoneme and Grapheme interventions ($q = 4.38$, $p < 0.05$; $q = 6.24$, $p < 0.05$, respectively). There

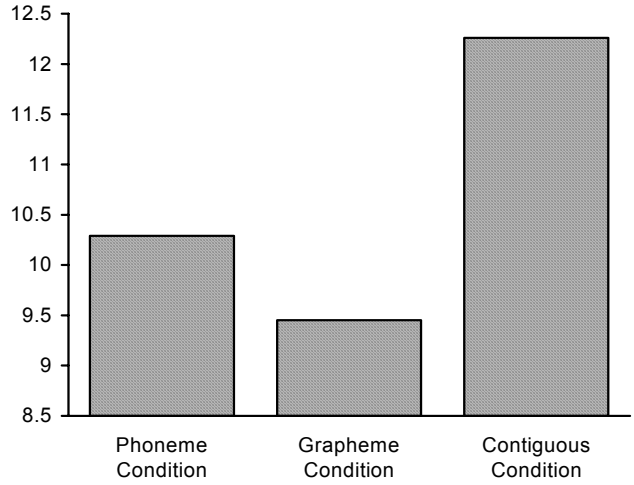

Figure 2: Adjusted Spelling Posttest Means on the Exception Word Test for Students in the Phoneme, Grapheme and Contiguous Intervention Conditions

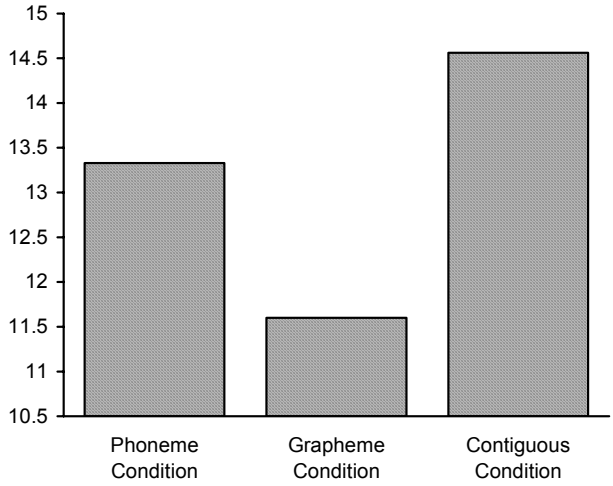

Figure 3: Adjusted Spelling Posttest Means on the Nonword Test for Students in the Phoneme, Grapheme and Contiguous Intervention Conditions

was no significant difference between the latter two interventions. On the nonwords measure, the only significant difference was between the Contiguous and Grapheme interventions ($q = 5.28$, $p < 0.05$). The other two differences were not significant (qs $\leq$ 3.09, ps > 0.10).

One major aim of the research was to determine if there were significant differences between the three experimental conditions on the five reading tests. Significant differences on the regular word test would suggest the superiority of the Contiguous intervention over the Grapheme and Phoneme interventions. Similarly, significant differences between the three experimental conditions were obtained on two of the three spelling tests (the exception and nonword tests) again suggesting the superiority of the Contiguous intervention over the Grapheme and Phoneme interventions.

Table 3 Observed Means (M_{ob})Adjusted Means (M_{adj}) and Standard Deviations (*SD*) for Scores on the Pre- and Post Test Spelling of Regular Word, Exception Word, and Non-word Tests, and the Waddington Spelling Test (*n*=81).

Class		Spelling Regular Words			Spelling Exception Words			Spelling NonWords			Waddington Spelling Test		
		M_{ob}	M_{adj}	SD	M_{ob}	M_{adj}	SD	M_{ob}	M_{adj}	SD	M_{ob}	M_{adj}	SD
Phoneme	Pre	11.63		5.65	6.78		5.21	10.70		6.18	39.85		17.37
Condition	Post	14.30	14.28	5.06	10.26	10.37	5.72	13.56	13.38	4.79	45.04	45.00	15.11
Grapheme	Pre	11.81		4.76	7.07		4.69	10.52		3.95	37.11		13.36
Condition	Post	13.93	14.25	4.42	9.67	10.16	5.14	11.78	12.09	4.79	45.15	46.44	11.96
Contiguous	Pre	10.96		4.39	7.33		4.50	10.04		4.30	43.46		11.69
Condition	Post	14.58	14.27	3.87	12.08	11.49	5.14	14.17	14.02	4.44	46.46	45.20	12.70

Note: For each of the Spelling Tests the score was calculated on the number of correct responses.

DISCUSSION

The improved performance of the students who received the contiguous intervention compared to those that received the variant graphemic and phonemic interventions suggests that the simultaneous presentation of visual and auditory material is a key to this aspect of literacy learning. Conversely, the presentation of variant or mismatched visual and auditory material does not appear to contribute as much to learning. Learning seems to be maximised when similar visual and auditory information is matched and is invariant. Words that sound alike are sometimes spelt alike and sometimes spelt differently. Words are sometimes spelt the way that they sound, and sometimes spelt in ways that conform to orthographical, morphological and semantic constraints. The contiguous presentation of grapho-phonological information honours the different constraints on the spelling and pronunciation of words, and promotes the associative learning of exemplars of similar words and discourages the juxtaposition of dissimilar or variant spellings of words.

The results of this research may have indicated that learning took place during the contiguous presentation of graphemic and phonemic units whether or not they were the major or minor letter-sound correspondences specified by Venezky (1970); the regular or irregular words defined by Coltheart (1978); the consistent or inconsistent and frequent or infrequent words in Seidenberg, et al., (1984) and Seidenberg and McClelland's, (1989) research and computer modeling. Previous research has revolved around the role of the place of decoding and spelling rules in learning to read and spell, whereas this research has focused on the role of similar patterns of grapho-phonological information.

The increased benefit of the contiguous presentation to the reading of regular words, the spelling of exception words and the spelling of nonwords indicated that both the lexical and nonlexical processes of reading were developed during the course of the intervention. The effectiveness of the contiguous presentation was across each of the categories of words that activate both the visual (exception words) and the auditory (regular and nonwords) processing of words. Most models of reading acquisition acknowledge that reading involves lexical or phonological processes that are auditory in nature , nonlexical or orthographical processes that are visual in nature and semantic processes that include contextual, morphological and grammatical information (Adams, 1990; Coltheart, Curtis, Atkins, & Haller, 1993; Seidenberg & McClelland, 1989). The contiguous intervention out performed the other interventions in facilitating the dual development of the phonological and orthographical processors.

The research assessment tasks required the students to transfer learning from the interventions to the test material. The interventions did not teach to the assessment tasks but rather administered normative tests as both pretest and posttest. This implied that the study contained implicit transfer training tasks that are a strong measure of learning.
Research by Ehri and Wilce (1985), Goswami and Bryant (1990), Bowey (1996) and longitudinal studies by Byrne et al., (2000) in phonological and phonemic awareness have established that the matching and connecting of phonological and graphological information is critical in learning to read. The present research extends this understanding to include the contiguous matching and the minimization of variance between the two sources of information as ways of maximizing learning.
The Connectionists models of reading have concentrated on the effect of consistent patterns of sublexical spelling units on reading acquisition (Plaut, 1997; Plaut, et al., 1996; Seidenberg & McClelland, 1989; Seidenberg et al., 1984; Zorzi, Houghton, & Butterworth, 1998a & 1998b). On the other hand, the Dual Route Modelers of reading acquisition have

focused on the effects of regularity, serial processing and the rules of converting graphemes to phonemes (Coltheart , 1978, Coltheart, et al., 1993; Coltheart, Langdon, & Haller, 1996; Coltheart, Rastle, K., Perry, C., Langdon, R., & Ziegler, 1999; Coltheart et al., 2001; Rastle & Coltheart, 1999). The present research indicates that the contiguous presentation of auditory and visual information also contributes to learning. The contiguous presentation of multi-sensory information has also been observed in other educational domains to benefit learning (Mayer, 1997).

The acquisition of reading and spelling requires that children develop the counter-intuitive skills of isolating graphemes in words, phonemes from the stream of speech and the ability to contiguously match graphemes with phonemes (and/or phonemes with graphemes). The main objective of reading is to comprehend the material. The development of the subskills needed to read therefore come at the cost of redirecting attention from comprehension to the sub-components of lexical units (Byrne 1996). The present research has confirmed that direct instruction in these subskills does contribute to reading and spelling outcomes.

Further research into the contiguous presentation of grapho-phonological information would determine the reliability of the present observations. This research was conducted with grade 2 children and in normal classroom settings, while further experimentation could ascertain if the same results could be obtained with randomised samples and other age groups. The addition of a control group would also determine under what conditions the effects of the contiguous presentation of letter-sound relationships improve learning.

This research supports the contiguous presentation of graphemic and phonemic relationships in preference to the concurrent presentation of either phonological or orthographic variance. The contiguous intervention was found to be more facilitative of literacy acquisition than the variant interventions that may have been partially inhibitive (Adams, 1990; Beck & McCaslin, 1977).

REFERENCES

Aaron, P.G., (1989) *Dyslexia and Hyperlexia.* Dordrecht: Kluwer.

Adams, M. J. (1990). Beginning to read: Thinking and learning about print. Massachusetts: MIT Press.

Beck, I. L., and McCaslin, E. S. (1977). *An analysis of dimensions that affect the development of code-breaking ability in eight beginning reading programs.* U.S.A.: U.S. Department of Health, Education and Welfare. National Institute of Education.

Bourne, R. J. (2002). Two Studies on the Effectiveness of Contiguous, Graphemic and Phonological Interventions on Measures of Reading and Spelling. M.Phil Ed. Diss. Sydney: University of Sydney.

Bowey, J. (1996). Phonological recoding of nonword orthographic rime primes. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22,* 1, 117-131.

Brand, V. (1994). *Spelling made easy*. Herfordshire: Egon.

Brigance, A. H. (1983). *Comprehensive inventory of basic skills*. Australia: Hawker Brownlow Education.

Bryant, P. E., and Bradley, L. (1985). *Children's reading problems: Psychology and education.* London: Basil Blackwell Publication.

Bryant, P. E., MacLean, M., Bradley, L., and Crossland, J. (1990). Rhyme and alliteration, phoneme detection, and learning to read. *Developmental Psychology, 26,* 3, 429-438.

Byrne, B. (1991). The role of phonological awareness in reading acquisition. *Australian Journal of Reading, 14,* 2, 133-139.

Byrne, B. (1992). Experimental psychology and real life: The case of literacy acquisition. In J. Alegria, D Holender, J. J. de Morais., and M. Radeau (Eds.), *Analytic Approaches to Human Cognition* (pp. 169-182). New York: Elsevier Science Publishers.

Byrne, B. (1993). Learning to read in the absence of phonemic awareness? A comment on Cossu, Rossini, and Marshall (1993). *Cognition, 48,* 285-288.

Byrne, B. (1996). The learnability of the alphabetic principle: Children's initial hypotheses about how print represents spoken language. *Applied Psycholinguistics, 17,* 401-426.

Byrne, B., and Fielding-Barnsley, R. (1989). Phonemic awareness and letter knowledge in the child's acquisition of the alphabetic principle. *Journal of Educational Psychology. 81*, 3, 313-321.

Byrne, B., and Fielding-Barnsley, R. (1991). Evaluation of a program to teach phonemic awareness to young children. *Journal of Educational Psychology, 83*, 451-455.

Byrne, B., and Fielding-Barnsley, R. (1993). Evaluation of a program to teach phonemic awareness to young children. A 1-year follow up *Journal of Educational Psychology*, *85*, 1, 104-111.

Byrne, B., Fielding-Barnsley, R., and Ashley, L. (1996). What does a child bring to the task of learning to read? A summary of the New England reading acquisition projects. *Australian Journal of Psychology, 48,* 3, 119-123.

Byrne, B., Fielding-Barnsley, R., and Ashley, L. (2000). Effects of preschool phoneme identity training after six years: Outcome level distinguished from rate of response. *Journal of Educational Psychology, 92,* 4, 659-667.

Carroll, J. B., Davies, P., and Richman, B. (1971). *American heritage: Word frequency list.* Boston: Houghton Mifflin.

Chew, J. (1997). Traditional phonics: what it is and what it is not. *Journal of Research in Reading, 20, 3*, 171-183.

Coltheart, M. (1978). Lexical access in simple reading tasks. In G. Underwood, (Ed.), *Strategies of information processing* (pp.151-261). London: Academic Press.

Coltheart, M., and Leahy, J. (1996). Assessment of lexical and nonlexical reading abilities in children: Some normative data. *Australian Journal of Psychology, 48,* 3, 136-140.

Coltheart, M., Curtis, B., Atkins, P., and Haller, M. (1993). Models of reading aloud: Dual-route and parallel distributed-processing approaches. *Psychological Review, 100*, 4, 589-608.

Coltheart, M., Langdon, R., and Haller, M. (1996). Computational cognitive neuropsychology and acquired dyslexia. In B. Dodd, R. Campbell., and L. Worrall. (Eds.), *Evaluating theories of language: Evidence from disordered communication* (pp. 1-29). San Diego: Singular Pub.

Coltheart, M., Rastle, K., Perry, C., Langdon, R., and Ziegler, J. (1999). *DRC: A dual route cascaded model of visual word recognition and reading aloud* (manuscript in preparation). Department of Psychology, Macquarie University, Sydney NSW 2109 Australia.

Coltheart, M., Rastle, K., Perry, C., Langdon, R., and Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review, 108, 1,* 204-256.

de Saussure, F. (1972). *Course in general linguistics.* (C. Bally and A. Sechehaye (Eds), A Riedlinger (Collaborator), R. Harris, (trans). London: Duckworth.

Ehri, L. C. (1987). Learning to read and spell words. *Journal of Reading Behaviour, 19*, 1, 5-31.

Ehri, L. C. (1995). Phases of development in learning to read words by sight. *Journal of Research in Reading, 18,* 2, 116-125.

Ehri, L. C. (1997). Sight word learning in normal readers and dyslexics. In B. A. Blachman (Ed.), *Foundations of reading acquisition and dyslexia: Implications for early intervention* (pp. 163-189). Hillsdale, NJ: Erlbaum.

Ehri, L. C., and Robbins, C. (1992). Beginners need some decoding skill to read words by analogy. *Reading Research Quarterly*, *27,* 1, 13-26.

Ehri, L. C., and Wilce, L. S. (1985). Movement into reading: Is the first stage of printed word learning visual or phonetic? *Reading Research Quarterly, 22,* 163-178.

Ehri, L. C., and Wilce, L. S. (1987). Does learning to spell help beginners learn to read. *Reading Research Quarterly, 22, 1,* 47-65.

Elkonin, D. B. (1973). USSR. In John Dowling (Ed.) Comparative reading: Cross-national studies of behavior and processes in reading and writing (pp.551-579). New York: MacMillan.

Gaskin, I. W., Ehri, L. C., Cress, C., O'Hara, C., and Donnelly, K. (1996). Procedures for word learning: Making discoveries about words. *The Reading Teacher, 50,* 4, 312-327.

Glushko, R. J. (1979). The organisation and activation of orthographic knowledge in reading words aloud. *Journal of Experimental Psychology: Human Perception and Performance*, *5,* 4, 674-691.

Goswami, U. (1991). Learning about spelling sequences: The role of onsets and rimes in analogies in reading. *Child Development, 62,* 1110-1123.

Goswami, U. (1993). Toward an interactive analogy model of reading development: Decoding vowel graphemes in beginning reading. *Journal of Experimental Child Psychology, 56,* 443-475.

Goswami, U. (1995). Phonological development and reading by analogy: What is analogy, and what is it not? *Journal of Research in Reading, 18,* 2, 139-145.

Goswami, U. (1999). Causal connections in beginning: the importance of rhyme. *Journal of Research in Reading, 22,* 3, 217-240.

Goswami, U., and Bryant, P. (1990). *Phonological skills and learning to read.* Hillsdale, NJ: Erlbaum.

Goswami, U., and Mead, F. (1992). Onset and rime awareness and analogies in reading. *Reading Research Quarterly, 27, 2,* 153-162.

Gough, P. B. & Tunmer, W.E., (1986) Decoding, Reading and Reading disability, *Remedial and Special Education, 7,* 6-10.)

Grainer, J., and Ferrand, L. (1994). Phonology and orthography in visual word recognition: effects of masked homophone primes. *Journal of Memory and Language, 33,* 218-233.

Harm, M. W., and Seidenberg, M. S. (1999). Phonology, reading acquisition, and dyslexia: insights from connectionists models. *Psychological Review, 106,* 3, 491-528.

Henry, M. K. (1988). Beyond phonics: Integrated decoding and spelling instruction based on word origin and structure. *Annals of Dyslexia, 38,* 258-275.

Jared, D., McRae, K., and Seidenberg, M. S. (1990). The basis of consistency effects in word naming. *Journal of Memory and Language, 29*, 687-715.

Lamond, J. and Whiting, P. R. (1992). *Discovering reading through sound.* University of Sydney: The Evelyn McCloughan Children's Centre.

Liberman, A. M. (1997). How theories of speech affect research in reading and writing. In B. A. Blachman (Ed.), *Foundations of reading acquisition and dyslexia: Implications for early intervention* (pp. 3-19). Hillsdale, NJ: Erlbaum.

Liberman, I. Y., and Shankweiler, D. (1979). Speech, the alphabet, and teaching to read. In L. B. Resnick and P. A. Weaver (Eds), *Theory and practice of early reading* (pp. 109-132). New Jersey: Erlbaum.

Liberman, I. Y., and Shankweiler, D. (1985). Phonology and the problems of learning to read and write. *RASE, 6*, 6, 8-17.

Liberman, I. Y., Shankweiler, D., Fischer, F. W., and Carter, B. (1974). Explicit syllable and phoneme segmentation in the young child. *Journal of Experimental Child Psychology, 18,* 201-212.

Mayer, R. E. (1997). Multimedia learning: Are we asking the right questions? *Educational Psychologist, 32, 1,* 1-19.

Morais, J. (1987). Segmental analysis of speech and its relation to reading ability. *Annals of Dyslexia, 3,* 126-141.

Morais, J., Bertelson, P., Cary, L., and Alegria, J. (1986). Literacy training and speech segmentation. *Cognition, 24,* 45-64.

Muter, V., Hulme, C., Snowling, M., and Taylor, S. (1998). Segmentation, not rhyming, predicts early progress in learning to read. *Journal of Experimental Child Psychology, 71,* 3-27. (A corrected version of the 1997 article of the same title and authors.)

Nicholson, T. (1986) Taking the guessing out of reading. *Reading Psychology, 2, 14,* 7-10.

Perfetti, C. A. (1992). *Challenging the myths: What the research really says about reading and reading disability.* Proceedings of the 1992 New South Wales Conference on Learning Difficulties, Sydney, Australia, 39-70.

Plaut, D. C. (1997). Structure and function in the lexical system: Insights from distributed models of word reading and lexical decision. *Language and Cognitive Processes, 12, 5/6,* 765-805.

Plaut, D. C., McClelland, J. L., Seidenberg, M. S. and Patterson, K. (1996). Understanding normal and impaired word reading: Computational principles in quasi-regular domains. *Psychological Review,* 103, 1, 56-115.

Rastle, K., and Coltheart, M. (1999). Serial and strategic effects in reading aloud. *Journal of Experimental Psychology: Human Perception and Performance, 25,* 482-503.

Read, C., Yun-Fei, Z., Hong-Yin, N., and Bao-Qing, D. (1986). The ability to manipulate speech sounds depends on knowing alphabetic writing. *Cognition, 24,* 31-44.

Seidenberg, M. S., and McClelland, J. L. (1989). A distributed, developmental model of words recognition and naming. *Psychological Review, 96,* 523-568.

Seidenberg, M. S., Waters, G. S., Barnes, M. A., and Tahenhaus, M.K. (1984). When does irregular spelling or pronunciation influence word recognition? *Journal of Verbal Learning and Verbal Behaviour, 23,* 383-404.

Share, D. L. (1995). Phonological recoding and self-teaching: *sine qua non* of reading acquisition. *Cognition, 55,* 151-218.

Spalding, R. B. and Spalding, T. (1969). *The writing road to reading.* New York: William Morrow.

Stanback, M. L. (1991). Syllable and rime patterns for teaching reading: Analysis of frequency-based vocabulary of 17, 602 words. Ed.D. Diss., New York: Teachers College, Columbia University.

Stanback, M. L. (1992). Syllable and rime patterns for teaching reading: Analysis of a frequency-based vocabulary of 17,602 words. *Annals of Dyslexia, 42,* 196-221.

Stanovich, K. E., and West, R. F. (1989). Exposure to print and orthographic processing. *Reading Research Quarterly, 24, 4,*402-429.

Stevens, J. (1992). *Applied multivariate statistics for the social sciences*. New Jersey: Lawrence Erlbaum Assoc. Pub.

Treiman, R. (1985). Onsets and rimes as units of spoken syllables: Evidence from children. *Journal of Experimental Child Psychology, 39,* 161-181.

Treiman, R., Mullennix, J., Bijeljac-Babic, R., and Richmond-Welty, E. D. (1995). The special role of rimes in the description, use, and acquisition of English orthography. *Journal of Experimental Psychology: General, 124,* 2, 107-136.

Venezky, R. L. (1970). *The structure of English orthography.* The Hague: Mouton.

Waddington, N. J. (1988). *Diagnostic reading and spelling tests.* Ingle Farm: Waddington Educational Resources.

Zorzi, M., Houghton, G., and Butterworth, B. (1998a). The development of spelling-sound relationships in a model of phonological reading. *Language and Cognitive Processes, 13, 2/3,* 337-371.

Zorzi, M., Houghton, G., and Butterworth, B. (1998b). Two routes or one in reading aloud? A connectionist dual-process model. *Journal of Experimental Psychology: Human Perception and Performance, 24,* 4, 1131-1161.

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