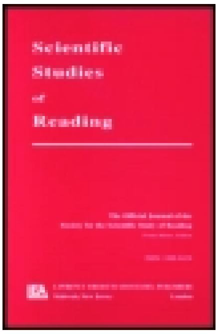

Scientific Studies of Reading
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/hssr20

Predictors of Spelling Ability in Children With Down Syndrome

Lisa Lim [a], Joanne Arciuli [a], Susan Rickard Liow [b] & Natalie Munro [a]
[a] University of Sydney
[b] National University of Singapore
Published online: 17 Dec 2013.

Scientific Studies of Reading, 00:1–19, 2013

ISSN: 1088-8438 print/1532-799X online
DOI: 10.1080/10888438.2013.862247

Routledge
Taylor & Francis Group

Predictors of Spelling Ability in Children With Down Syndrome

Lisa Lim and Joanne Arciuli
University of Sydney

Susan Rickard Liow
National University of Singapore

Natalie Munro
University of Sydney

This study examined whether there are processing differences between children with Down syndrome (DS; $n = 22$; 7 years 8 months to 13 years 10 months) and typically developing children (TD; $n = 22$; 6 years 6 months to 10 years 10 months), matched for receptive vocabulary. The TD children performed better on tests of nonverbal intelligence (matrices), phonological awareness (sound deletion), and phonological short-term memory (digit span), as well as spelling accuracy (30 single words). Separate regression analyses revealed that nonverbal intelligence and phonological awareness were the best predictors of spelling accuracy for TD children, whereas receptive vocabulary and phonological short-term memory were the best predictors for children with DS. An examination of spelling errors suggested that although children with DS do use some phonological awareness during spelling, deficits in short-term memory appear to limit success. The implications of these results for intervention studies are briefly discussed.

Proficient reading and writing skills are important for social, academic and vocational success, and for quality of life (Buckley, 2001). There is a growing body of research on reading development in children with Down syndrome (DS; see Lemons & Fuchs, 2010, for review), but much less is known about their spelling acquisition. In this study, we examined the cognitive and linguistic processes that underpin spelling attempts made by children with DS compared to those made by typically developing (TD) younger children. Specifically, we addressed the question of whether children with DS use the same cognitive and linguistic processes during spelling as TD children. The answer to this question has implications for clinicians, educators, and researchers who seek to optimize literacy development in children with DS. Before describing the design of the present study, previous research on spelling acquisition in TD children and in children with DS is briefly summarized.

Correspondence should be sent to Lisa Lim, 83 Thong Soon Green, Singapore 787389. E-mail: llim3413@uni.sydney.edu.au

SPELLING ACQUISITION IN TD CHILDREN

Phonological awareness has been shown to be a significant predictor of spelling ability. Phonological awareness abilities include blending, segmenting, and deletion, and the manipulation of different units at word level (such as "sun" and "flower" in *sunflower*), syllable level (such as "bee" in *beetle*), and phoneme level (such as /b/ in *bat*; see Gillon, 2004). The spelling errors of young TD children often reflect this kind of phonological knowledge (Caravolas, Hulme, & Snowling, 2001; Nation, 1997; Otaiba et al., 2010; Treiman, 1993; Treiman, Zukowski, & Richmond-Welty, 1995). In their kindergarten years, many TD children attempt to spell words using their knowledge of letter names, such as "you" as "u" or "see" as "c" (Bourassa & Treiman, 2001). Some beginners also spell words phonetically, such as "queen" spelt as "kwin" (Bosman & Van Orden, 1997). These kinds of spelling errors suggest that children employ phonological knowledge in their initial spelling attempts (Ehri, 2000). Performance on phonological awareness tasks, such as sound identification and sound deletion, are thus strong predictors of spelling achievement in TD school-aged children (Caravolas et al., 2001; MacDonald & Cornwall, 1995).

Strattman and Hodson's (2005) study of 75 children (aged 7 years 2 months to 9 years 2 months) revealed that the ability to manipulate phonemes accounted for more variance in spelling ability than any of the other predictors they examined. Nation and Hulme (1997) studied the spelling ability of 75 TD children from Year 1 to Year 4. Children were assessed on phonological awareness skills (rhyme categorisation, alliteration, onset-rime, and phoneme segmentation) and spelling. Their results showed that phoneme segmentation was the strongest predictor of spelling ability. Another study by MacDonald and Cornwall (1995) followed 24 TD children from preschool (5 to 6 years of age) to adolescence (16 to 17 years of age). These children were assessed on phoneme deletion skills as well as the spelling of single words. The authors found that early phoneme deletion skills significantly predicted spelling ability 11 years later.

Vaessen and Blomert (2013) investigated the role of phonological awareness, letter-sound matching skills, and rapid automatized naming in reading and spelling outcomes for 1,284 Dutch TD children from first grade to sixth grade. Of interest, although the relative importance of these variables changed over the course of children's literacy development, results indicated that only two of these variables were important for spelling (phonological awareness and letter-sound matching skills) and that the relative contribution of these variables remained stable over the course of children's development.

Although phonological awareness is very important for spelling, other skills are needed for accuracy in English. As Tunmer, Herriman, and Nesdale (1988) pointed out, the influence of phonological awareness on spelling achievement should be viewed in the context of other cognitive and linguistic variables that can affect literacy development. These variables include letter-sound correspondences (Muter, Hulme, Snowling, & Taylor, 1998; Treiman, 1993), spoken language abilities including vocabulary (Muter, Hulme, Snowling, & Stevenson, 2004), and phonological short-term memory (Caravolas et al., 2001; Muter & Snowling, 1998). For example, the child's working memory capacity for holding and manipulating different letter combinations or alternatively rote-learning sequences of letters is critical for inconsistently spelled words such as "yacht," "sword," or "orchid" (Kessler & Treiman, 2003). Consequently, children need to develop a range of cognitive and linguistic strategies in addition to phonological awareness in order to become proficient spellers.

SPELLING ACQUISITION IN CHILDREN WITH DS

Difficulties with reading and spelling acquisition are common in children with DS and often limit academic progress and vocational opportunities (Bochner, Outhred, & Pieterse, 2001). For example, Byrne, MacDonald, and Buckley (2002) examined the literacy skills of 24 school-aged children with DS enrolled in a mainstream school. Children with DS showed lower spelling scores when compared with TD children matched for reading age. Although previous studies have shown that phonological awareness is the most important predictor for spelling acquisition in TD children, it is not clear how children with DS acquire spelling skills. Thus, it is important to examine the contribution of phonological awareness skills to predicting spelling achievement relative to other relevant cognitive and linguistic skills.

POSSIBLE PREDICTORS OF SPELLING ACQUISITION IN CHILDREN WITH DS VERSUS TD CHILDREN

The literature on spelling development suggests that phonological awareness, phonological short-term memory, receptive vocabulary, and nonverbal intelligence are important variables to explore when comparing the performance of children with DS with that of TD children. Each of these predictors is described next.

Phonological Awareness

A review of the link between reading ability and phonological awareness by Lemons and Fuchs (2010) indicated that children with DS have weaker phonological awareness skills than their TD peers. This is not to say that children with DS do not benefit from interventions targeting phonological awareness; rather, Lemons and Fuchs's review of the effect of phonological awareness interventions on reading suggested that gains may be limited in magnitude when compared with TD peers and may not extend to all individuals with DS. Kennedy and Flynn (2003) carried out phonological awareness intervention with three children with DS (ages 6 years 11 months, 8 years 4 months, and 8 years 10 months). The intervention took place twice weekly, for 4 weeks, and consisted of alliteration, initial phoneme detection, rhyme identification and spelling of consonant-vowel-consonant (CVC) and CVCC real words. Immediately following phonological awareness intervention, results showed significantly improved spelling scores, with two children spelling the majority of the first and last sounds of a word accurately. Van Bysterveldt (2009) assessed 10 children with DS (ages 5 years 5 months to 6 years) over 20 weeks of phonological awareness training involving letter-sound correspondence, phoneme matching games, and storybook reading. Children were assessed on their ability to spell five words (*train, chips, sun, cat,* and *dinosaur*). The data revealed that three children successfully generalized their phonological awareness knowledge to their spelling attempts. Clearly, additional research with a larger set of stimuli would be useful in determining the relative contribution of phonological awareness at the phoneme level to spelling in children with DS.

Phonological short-term memory. Phonological short-term memory is known to be impaired in children with DS. The review by Naess, Halaas Lyster, Hulme, and Melby-Lervag

(2011) reported that, on average, children with DS were around 1 *SD* below TD peers on measures of phonological short-term memory but that they exhibited significant variability. Seung and Chapman's (2000) study of older children and young adults with DS (ages 9 years 8 months to 24 years 3 months) revealed digit spans of between 3 and 5 numbers, that is, at least 2 digits less than average. Others have reported even lower digit spans—between one and three numbers among children 6 to 14 years of age (Conners, Rosenquist, Arnett, Moore, & Hume, 2008).

Although phonological short-term memory seems to vary considerably in the population of children with DS, it may be an important predictor of their spelling (Laws, 1998). Phonological short-term memory would contribute to long-term storage of orthographic representations, but it could also play a role during the process of spelling by "holding together" the sequences of sounds or letters that make up a word. It is this temporary storage that is identified as a support to spelling (Gathercole, 1999; Jarrold & Baddeley, 2001). A negative impact of weak phonological short-term memory capacity would be errors involving additions or omissions, errors concerning the ordering of letters (e.g., reversal errors), and errors where the response is shorter than the target. Errors at the beginning of a word may be less likely than errors in other parts of the word (e.g., children may be able to provide the correct first letter but find the remainder of the word more challenging). Reduced phonological short-term memory abilities may have an adverse effect on learning and rehearsal of sounds in a word as it is being spelled, thereby affecting spelling acquisition in the longer term (Gathercole, 1999).

Receptive vocabulary. Having prior knowledge of a word's meaning may assist an individual in selecting the appropriate word to spell, particularly for similar sounding words. For example, when asked to spell the word *hear* in the given context, "I hear you clearly," a child with a better understanding of word meanings would be likely to spell the word as "hear" rather than "here" (Burt & Fury, 2000). The literature suggests that vocabulary can be affected in DS. Cardoso-Martins, Peterson, Olson, and Pennington (2009) found that receptive vocabulary, as assessed by the Peabody Picture Vocabulary Test–III (Dunn & Dunn, 1997) correlated with word spelling ability in children with DS, suggesting lexical-semantic processing is important. However, children with DS are known to achieve lower scores on the Peabody Picture Vocabulary Test (Dunn & Dunn, 1981), when compared to younger TD children matched for mental age on the Stanford Binet (Caselli, Monaco, Trasciani, & Vicari, 2008; Terman & Merrill, 1964).

Nonverbal intelligence. There is considerable heterogeneity in terms of cognitive impairment among individuals with DS, with impairment ranging from mild (i.e., IQ scores of 50 to 70) to severe (i.e., IQ scores of 20 to 35; The American Academy of Pediatrics Committee on Genetics, 2001). Severe cognitive deficits are likely to adversely affect literacy acquisition, including spelling proficiency (Laws & Gunn, 2002). The inclusion of a test of nonverbal intelligence provides information on the child's processing and reasoning capacity.

OBJECTIVES OF THE CURRENT STUDY

It is not known whether the relative contribution of cognitive and linguistic processes underpinning spelling is similar in children with DS versus TD children. Certainly, children with DS appear to demonstrate poorer spelling outcomes relative to TD children. Moreover, there is reason to believe that the relative contribution of processes might be different in children with DS given previous research that has highlighted lower receptive vocabulary, weak phonological awareness, limited phonological short-term memory, and variable nonverbal intelligence in this population. We investigated the relative contribution of predictors of spelling accuracy in children with DS versus TD children with similar receptive vocabulary ability. We also looked at the nature of errors as spelling attempts can sometimes reveal partial knowledge of the target words. We posed three main research questions:

RQ1: Do children with DS differ from TD children in terms of spelling accuracy and their related cognitive and linguistic abilities?
RQ2: What is the relative contribution of predictors for spelling accuracy in children with DS compared with TD children?
RQ3: How can an examination of spelling errors contribute to our understanding of the spelling processes in children with DS?

METHOD

Participants

Approval for the study was obtained from the University of Sydney Human Research Ethics Committee. All participants were residents of Singapore. The children with DS were recruited through the Down Syndrome Association (Singapore) and a school for children with special needs in Singapore. Inclusion criteria were a diagnosis of DS, intelligible speech, and an absence of serious visual impairment and/or severe sensorineural hearing loss. Only two individuals who expressed an interest in participating in the study were excluded: One of these children was diagnosed with Noonan syndrome, and the other was diagnosed with intellectual disability but did not have Down syndrome. TD children were recruited from a Singapore government after-school-care service.

Rather than selecting two groups of participants based on chronological age, children with DS and TD children with similar receptive vocabulary skills were selected from the larger pool of participants who elected to take part in the study. This ensured comparison of spelling acquisition processes for children with similar levels of single-word comprehension. The participants reported in the current study include a group of children with DS (n = 22, 11 males and 11 females, 7 years 8 months to 13 years 10 months) and a TD group (n = 22, 16 males and 6 females, 6 years 6 months to 10 years 10 months).

English is the official language of business and education in Singapore and was the dominant language for all participants. English was spoken at school 100% of the time. Parents of all 44 participants confirmed that English was spoken at home at least 70% of the time (when a child was exposed to another language in the home, this was Mandarin, except in a single case where a child was exposed to Malay in the home). Participants who were exposed to another language did not use their second language to an extent where they would be considered bilingual or fluent in two languages. All 44 children passed a hearing screener that was carried out prior to formal testing, where frequencies of 500, 1000, 2000, 4000 KHz at 25dB HL (Doyle, 1998) were presented to the left and right ear.

Measures for Predictors of Spelling Ability

A battery of tests was used to assess the children's linguistic and cognitive abilities.

Phonological awareness. The Sound Deletion subtest from the York Assessment of Reading for Comprehension (YARC; Snowling et al., 2009) was used to assess phonological awareness. Participants were shown pictures from the YARC Sound Deletion Picture Book. To familiarize the participant with phoneme deletion, the concept was first taught using toy cars to symbolize individual phonemes (e.g., three cars were displayed to symbolize the phonemes /b/, /i/, /k/). In response to the question, "What do you get when you take the sound /b/ away," the tester removed the toy car corresponding to the deleted phoneme. In all, three demonstration items were presented before the start of the test. All 12 items were administered to each participant, and a score of 1 was awarded for each correct response. If a participant kept quiet or gave the wrong answer, the response was marked as zero. A time frame of 10 s was applied for each item, before a nonresponse (zero) was marked. For children ranging in age from 4 to 7 years, the Cronbach test of item reliability has an alpha of .93 (Snowling et al., 2009). Articulation errors were relatively minor for the group with DS and no genuine difficulties were encountered.

Phonological short-term memory. The Digit Span subtest of the Clinical Evaluation of Language Fundamentals–Fourth Edition (CELF–4; Semel, Wiig, & Secord, 2003) was administered. The tester read out a series of digits arranged in increasing length, and two trials were given for each span length. Participants were asked to repeat the digits in the same order (i.e., forward digit span). A zero was recorded if a digit repeated on a task was incorrect. One demonstration item was presented before the start of the test. A total of 16 items were administered and testing stopped if two consecutive errors were obtained. If a participant kept quiet or gave the wrong answer, the response was marked as zero. A time frame of 10 s was applied for each item, before a nonresponse (zero) was marked. According to Semel et al. (2003), the test–retest reliability is .80 for individuals 5 to 21 years of age.

Measures for Control Variables

Receptive vocabulary. The Singapore Bilingual Vocabulary Test (SBVT; Rickard Liow & Tng, 2003; see also Young et al., 2012) was administered in English. Participants sat in front of a computer screen and listened to a target word read aloud by the tester. Participants were then asked to indicate their answer by pointing to the correct image (out of four choices) on the screen, or to say the number corresponding to the correct image. A total of 70 items were administered, and a score of 1 or zero was given for a correct or incorrect response, respectively. If a participant kept quiet or gave the wrong answer, the response was marked as zero. A time frame of 10 s was applied for each item before a nonresponse (zero) was marked. The SBVT was chosen to ensure that test items were culturally appropriate. There is no specific psychometric data regarding validity but the SBVT was designed after the British Picture Vocabulary Scale (Dunn & Dunn, 1982) which is a widely used vocabulary test. Based on the data we collected in the current study, we calculated that Cronbach item reliability has an alpha of .81.

Nonverbal intelligence. Thirty-six items in the Raven's Coloured Progressive Matrices (Raven's CPM; Raven, Court, & Raven, 1995) were administered. Participants were asked to select the correct piece from a choice of six to form a matching picture. Prior to testing, participants were given three demonstration trials to familiarize themselves with the test procedure. In each demonstration trial, participants were given a picture puzzle made out of paper shapes. Each picture puzzle had a missing piece, and participants were asked to choose the correct piece to complete the picture. Demonstration trials were similar to those used by previous authors (Cologon, Cupples, & Wymer, 2011). A score of 1 was awarded for each correct response from Item 1 to Item 36. If a participant did not indicate a response or gave the wrong answer, the response was marked as zero. A time frame of 10 s was applied for each item before a nonresponse (zero) was marked. No score was given for demonstration items. The Cronbach test of item reliability has an alpha of .94 (Raven et al., 1995). This psychometric information was obtained from the testing of children 4 to 11 years of age.

Outcome Measure

Spelling test. A spelling test comprising 30 words of varying syllable structures (CVC, CVCC, CCVC, CVCVC, and CVCCVC) from the Word Spelling Test (see Yeong & Rickard Liow, 2011; see the appendix) was administered individually. The tester read each word aloud, accompanied by a sentence containing the target word. Children wrote their answers down on a piece of paper and were instructed to try their best to spell all the target words. Spelling accuracy was defined as the number of whole words spelled correctly. If a participant did not write anything down on paper, the response was marked as zero. A time frame of 15 s to commence the spelling was applied for each item before a nonresponse (zero) was marked. Cronbach's test of item reliability has an alpha of .98 and accuracy scores on this test correlate with scores on the Wide Range Assessment Test–Fourth Edition (Wilkinson & Robertson, 2006) at $r = .80$. These psychometric measures were obtained from the testing of children 5 to 7 years of age.

Procedure

The assessment session lasted up to two hours, with short breaks included. Assessments were carried out at a convenient location for the child (such as the school premises, in a room at the child's home, or at the Down Syndrome Association). The tasks were presented in a variable order. To maintain engagement, a picture timetable was provided and participants were allowed to choose the order of the tasks to be completed.

RESULTS

Analyses addressing each of our three research questions are outlined next. All assumptions for all analyses were met.

RQ1: Do Children With DS Differ From TD Children in Terms of Spelling Accuracy and Their Related Cognitive and Linguistic Abilities?

To answer this question, independent *t* tests were computed to examine group differences on each variable (see Table 1). Note that the TD group and the group with DS did not differ significantly

TABLE 1
Descriptive Statistics for Typically Developing Children and Children With Down Syndrome, and *t*-Test Results

	Typically Developing[a]		*Down Syndrome*[b]		
Variable (Max Score)	M	SD	M	SD	t*(42)*
Age in months	102.91	16.78	130.86	19.21	5.14***
SBVT vocabulary (70)	48.78	7.86	45.18	7.21	1.58
Raven's matrices (36)	31.18	3.63	14.18	5.19	12.57***
YARC sound deletion (12)	9.59	2.61	3.41	1.76	9.20***
CELF–4 digit span (16)	11.59	2.61	5.14	1.64	9.81***
Spelling accuracy (30)	21.95	9.75	4.41	5.81	7.25***

Note. Even if a highly conservative Bonferroni adjustment of .05/6 (.008) is used, the *t*-test results remain unchanged in terms of which variables are significantly different for the two groups. SBVT = Singapore Bilingual Vocabulary Test; YARC = York Assessment of Reading for Comprehension; CELF–4 = Clinical Evaluation of Language Fundamentals–Fourth Edition.

[a]$n = 22$.

[b]$n = 22$.

***$p \leq .001$ (two-tailed probabilities corrected for unequal variances).

in terms of receptive vocabulary, $t(42) = 1.58$, $p > .05$. Despite a significant difference in age (almost 28 months on average), the performance of TD children was still significantly better than that of children with DS for the three main predictor variables (phoneme deletion, phonological short-term memory, and nonverbal intelligence), as well as the outcome variable of spelling accuracy. The relatively large standard deviation in the Raven's matrices task in the group with DS is consistent with known variation in nonverbal intelligence.

RQ2: What Is the Relative Contribution of Predictors for Spelling Accuracy in Children With DS Compared With TD Children?

To answer this question, separate correlation and regression analyses were carried out for each group.[1] Table 2 shows the correlation matrices for TD children (below diagonal) and children with DS (above diagonal). The pattern of relationships was different for the two groups: Receptive vocabulary was strongly associated with spelling accuracy for the group with DS but not for the TD children, whereas spelling accuracy scores were more strongly correlated with sound deletion for the TD children than for the children with DS.

These patterns of correlations across the groups suggest that the relative contributions of processes underlying spelling acquisition are different for children with DS compared to those of

[1]Our sample size is comparable with studies that have used regression analysis to examine literacy in children with DS. In their study of reading ability, Cupples and Iacono (2000) conducted a multiple regression analysis using five predictors with 19 children with DS. More generally, our sample size compares favorably with recent studies of literacy in DS reported in the disability literature (e.g., Cologan et al., 2011, conducted a reading intervention study with seven children with DS; Tsao, Fartoukh & Barbier, 2011, investigated handwriting in 11 adults with DS).

TABLE 2
Pearson's Correlations Showing Relationships Among Variables for Typically Developing Children (Below Diagonal) and Children With Down Syndrome (Above Diagonal)

Variable	*1*	*2*	*3*	*4*	*5*
1. SBVT vocabulary	—	.39	.31	.22	.62**
2. Raven's matrices	−.05	—	.50*	.38	.27
3. YARC sound deletion	−.13	.62**	—	.41	.25
4. CELF–4 digit span	.34	.59**	.27	—	.50*
5. Spelling accuracy	−.13	.72**	.77**	.41	—

Note. The results were derived using raw scores. Partial correlations controlling for age revealed some changes in the significance level for the typically developing group but no changes in significance for the children with Down syndrome. SBVT = Singapore Bilingual Vocabulary Test; YARC = York Assessment of Reading for Comprehension; CELF–4 = Clinical Evaluation of Language Fundamentals–Fourth Edition

*$p \leq .05$. **$p < .01$ (two-tailed probabilities).

TD children. To determine more precisely which cognitive and linguistic variables were the most important in predicting spelling accuracy, separate hierarchical regression analyses were conducted. For each group, receptive vocabulary (SBVT scores) and nonverbal intelligence (Raven's CPM scores) were entered in Block 1, with phoneme deletion and phonological short-term memory scores, the main variables of interest, in Block 2. Regression diagnostics confirmed no problems with outliers (Cook's distances all < 1; TD $M = .07$ and DS $M = .07$) or autocorrelation (Durbin Watson for TD = 1.51; DS = 2.30), and standardized residuals were within limits. Table 3 shows the regression results. Unique variance for each of the significant predictors (sr^2) is not included in Table 3 but is reported in the following text.

For TD children, Models 1 and 2 were both significant: $F(2, 19) = 10.40$, $p < .001$, and $F(4, 17) = 9.57$, $p = .001$, respectively. Moreover, two of the predictors, nonverbal intelligence (Raven's CPM) and phoneme awareness (YARC sound deletion), accounted for a significant proportion of the unique variance in predicting spelling accuracy (51% and 17%, respectively).

For the children with DS, Model 1 was significant, $F(2, 19) = 5.80$, $p = .011$, and Model 2 approached significance, $F(4, 17) = 2.81$, $p = .09$. Again, two of the predictors accounted for a significant proportion of the unique variance in predicting spelling accuracy, but for the children with DS these were not nonverbal intelligence or phoneme awareness. Instead, receptive vocabulary (SBVT) and phonological short-term memory (Clinical Evaluation of Language Fundamentals–Fourth Edition [CELF–4] digit span) accounted for a significant proportion of the unique variance in predicting spelling accuracy (32% and 15%, respectively). Although the two groups were matched on their SBVT receptive vocabulary scores (rather than age), there was variability in receptive vocabulary *within* each group; thus, this control variable still accounted for a substantial proportion of the unique variance in predicting spelling achievement for children with DS.

RQ3: How Can an Examination of Spelling Errors Contribute to Our Understanding of the Spelling Processes in Children With DS?

We undertook an item analysis by looking at the 30 words in the spelling test and comparing errors across our two groups. For every word in the spelling test, there were more errors by children with

TABLE 3
Regression Results for Predictors of Spelling Accuracy for Typically Developing Children and Children With Down Syndrome

Step	*Variable*	*Std. β*	t	*Adj.* R^2	ΔR^2
Typically developing children					
1.	SBVT vocabulary	−.09	−.59	.47	.52***
	Raven's matrices	.71	4.49***		
2.	YARC sound deletion	.53	3.05**	.62	.17**
	CELF–4 digit span	.11	.61		
Children with Down syndrome					
1.	SBVT vocabulary	.60	3.15**	.31	.38**
	Raven's matrices	.04	.42		
2.	YARC sound deletion	−.06	−.31	.42	.15†
	CELF–4 digit span	.44	2.35*		

Note. The results reported here were derived using raw scores. When age is added as a separate Step 1, it is a significant predictor for both groups (borderline for children with Down syndrome); it is important to note that results at the final step remained similar for both models even after age had been taken into consideration. SBVT = Singapore Bilingual Vocabulary Test; YARC = York Assessment of Reading for Comprehension; CELF–4 = Clinical Evaluation of Language Fundamentals–Fourth Edition.
†$p \leq .10$. *$p \leq .05$. **$p \leq .01$. ***$p \leq .001$.

DS compared to TD peers matched for receptive vocabulary. The word *stop* elicited the fewest number of errors in each group. No word elicited 100% errors in the TD group; however, there were three words that elicited 100% errors in the group with DS (*disturb, beef*, and *direct*).

For the words that elicited 100% errors for the children with DS, we noted that 17 of 22 children produced a spelling for the target word *disturb* that contained the letter *d* ("d," "disble," "diuntb," "dirstp," "dim," "dielg," "distirab," "distrud," "dunan," "d," "distub," "dinead," "d," "d," "d," "d," "d"). For the target word *beef*, 16 of 22 children with DS produced a spelling that contained the letter *b* ("bove," "breemp," "bff," "beaff," "bianen," "b," "bralling," "beaf," "beaf," "breef," "b," "b," "bf," "BP," "bif," "b"). Of the remaining responses from six children with DS, four contained the letter *f* ("deaff," dfirs," "f," "fven"). For the target *direct*, 15 of 22 children with DS produced a spelling that contained the letter *d* ("die," "dare," "d," "dien," "direted," "drirect," "dietrt," "dide," "done," "d," "did," "d," "d," "d," "d"). These responses indicate some letter or letter-sound knowledge.

Often, spelling errors consisted of a single letter (accounting for 32.76% of the errors for TD children and 47.16% of the errors for children with DS). We examined whether these single letter attempts provided further evidence of letter or letter-sound knowledge of the target words.

On average, 32.27% of the single letter errors made by children with DS included the correct first letter of the intended target word (e.g., "g" for *grab*), compared with 35.45% of errors made by the TD group. When we looked at spelling errors that were longer than a single letter, on average, 42.08% of errors made by children with DS included the correct first letter of the intended target (e.g., "gab" for *grab*), compared with 58.55% of errors made by TD peers.

In terms of adhering to the CV structure of the target word (indicative of some phonological awareness), on average, 14.66% of incorrect responses from the group of children with DS adhered to the CV structure of the target. For the TD group, on average, 32.05% of incorrect responses adhered to the CV structure of the target. To illustrate what we mean by adherence to CV structure, the group of children with DS generated 20 incorrect responses for the target word *club*; of these, 35% adhered to the CV structure of the target ("clum," "clam," "clam," "clam," "clud," "clep," "clap"). The TD group generated seven incorrect responses for the target word 'club' and 42.86% of these adhered to the CV structure of the target ("clud," "clab," "clud").

Last, we undertook broad categorisation of spelling errors that *were longer than a single letter*. The percentage of spelling errors that were longer than a single letter for children with DS and TD children were 41.84% and 38.41%, respectively. Although we did not attempt to place every type of spelling error that was longer than a single letter into a particular category (e.g., we did not attempt to categorize errors such as "rilive" for the target *tube*, "libtrs" for the target *limit*, or "eolelm" for the target *marble*) we were able to distinguish eight categories where spelling errors approximated the target in a straightforward way: phonologically plausible errors, homophones, morphological errors, double-letter errors, reversal of adjacent letters, omission of a single letter, additional letters, and voicing errors. For each of our two groups, the percentage of errors in each category was calculated by counting the number of errors in that category and dividing that number by the total number of spelling errors for the group. Table 4 provides a breakdown of the errors for the children with DS and the TD group, along with examples of errors.

It is possible to view some of these eight categories as being related to phonological awareness (e.g., phonologically plausible errors and homophones). The group of children with DS

TABLE 4
Spelling Errors in Each of Eight Categories for TD Children and Children With DS

Spelling Error Type	*Examples*	*TD*	*DS*
Phonologically plausible	"beaff" for beef	6.21	1.07
Homophones	"made" for maid	1.70	0.18
Voicing errors	"lab" for lap	5.08	0.70
Double-letter errors	"pretee" for pretty	2.26	0.53
Reversal of letters	"brith" for birth	1.70	1.59
Omission of letters	"distub" for disturb	10.17	5.15
Additional letters	"finlish" for finish	1.70	0.70
Morphological errors	"feel" for feeling	0.00	1.07
Uncategorized errors (longer than a single letter)	"libtrs" for limit	38.41	41.84
Single-letter responses	"d" for date	32.76	47.16

Note. Values are expressed as a percentage of total number of spelling errors. TD = typically developing; DS = Down syndrome.

made fewer phonologically plausible errors compared with the TD group. It is also possible to conceptualize some of these errors as being related to phonological short-term memory issues (double-letter errors, reversal of letters, omission of letters, additional letters, single-letter responses). The group of children with DS made more of these kinds of errors than the TD group.

DISCUSSION

Children with DS are known to have difficulties with literacy skills. Compared with studies of reading, much less is known about spelling development in this population. The main aim of the current study was to compare spelling performance in children with DS and their TD peers and determine whether the relative contribution of cognitive and linguistic processes underpinning spelling are similar across children with DS and TD peers when the two groups are matched for receptive vocabulary. An additional aim was to explore the types of spelling errors that children made in order to enrich our understanding of spelling processes in children with DS.

Our results using an experimental spelling task (Yeong & Rickard Liow, 2011) confirmed that children with DS do not perform as well as TD children even when they are matched with younger peers for receptive vocabulary. The regression analyses examining the predictors of the number of correct spelling responses, after taking into account nonverbal intelligence as well as receptive vocabulary, revealed that nonverbal intelligence and phonological awareness were significant predictors of spelling accuracy for TD children. Sound isolation and segmentation skills are crucial for spelling development (Caravolas et al., 2001). Such phonological awareness skills form a strong foundation for spelling in TD children, allowing them to correctly spell words that are new or unfamiliar (Stuart & Masterson, 1992).

In contrast, phonological short-term memory and receptive vocabulary were the best predictors of spelling accuracy for children with DS. Poor phonological short-term memory abilities may affect the ability to successfully hold all letters and their corresponding sounds in memory (Broadley & MacDonald, 1993). In addition, a reduced receptive vocabulary could result in potential spelling errors, particularly when choosing the right spelling, such as “made” versus “maid” in a given context: “My *maid* cooks for us” (Burt & Fury, 2000). Previous research has indicated a link between receptive vocabulary and spelling in individuals with DS (Cardoso-Martins et al., 2009). In summary, the relative influence of predictors was different for our two groups.

It is worth pointing out that although the two groups were matched on vocabulary there was variation within the groups in terms of vocabulary. Our findings suggest that this variation is linked with variability in spelling for the group of children with DS but not the TD group.

Following this quantitative analysis of spelling accuracy, we examined the types of spelling errors made by the two groups of children. In view of the fact that our regression analyses had indicated that phonological awareness was not a significant predictor of correct spellings in children with DS, we were interested to know whether an analysis of spelling errors might reveal the use of phonological awareness in this group. In short, our analyses of spelling errors revealed that children with DS do seem to make use of some phonological awareness ability; however, their weak phonological short-term memory appears to limit their success. Some children with DS were able to produce the first letter of the target correctly. There was also evidence that some spelling errors of children with DS adhered to the CV structure of the target. Last, a small number of spelling errors made by children with DS were phonologically plausible or homophones. As confirmed by our regression analysis, the contribution of phonological awareness to spelling is limited in children with DS when compared with TD children; however, there is evidence in the spelling errors of children with DS that some of them are trying to apply their knowledge of phonology.

Our findings that TD children's spelling may benefit more from their phonological awareness than children with DS mirrors research that has examined reading ability. Lemons and Fuchs (2010) drew a similar conclusion from their review of 20 studies that had investigated the relationship between phonological awareness and reading ability. Still, Lemons and Fuchs were quite explicit in emphasising that children with DS are likely to benefit from interventions regarding phonological awareness. Such instruction would probably also aid spelling development in these children. Indeed, Fletcher and Buckley (2002) found a positive correlation between reading, spelling, and phonological awareness in children with DS who received early instruction and support. Certainly, our examination of the types of spelling errors made by children with DS suggests that some of these children are trying to recruit their phonological awareness skills in their spelling attempts. Further refining the regularity of the target words in the spelling tests used in this kind of research may help to provide deeper insight. In addition, it might be useful to include a nonword repetition task in future investigations of predictors of spelling. This might determine whether children with DS have established the same quality of phonological representations seen in TD children (as per Burt & Shrubsole's, 2000, study of spelling in healthy adults).

The finding that nonverbal intelligence has an impact on spelling in TD children may be explained in terms of the executive functions required to support phoneme deletion skills and could be worthy of further research. In children with DS, however, nonverbal intelligence did not predict spelling. This mirrors research examining reading ability where children with DS achieved lower IQ scores but demonstrated reading abilities above what was predicted for IQ (Byrne, MacDonald, & Buckley, 1995). By contrast, other research has found that the average reading ability in children with DS was low relative to their higher IQ scores on cognitive measures (Cardoso-Martins et al., 2009). For children with DS, phonological short-term memory, and possibly receptive vocabulary, played a role in spelling acquisition skills, which may support phonological awareness in a different way.

Some reasons for low spelling *accuracy* in children with DS may be found in the predictive power of the digit span measure of phonological short-term memory, together with receptive vocabulary for spelling accuracy in children with DS. This suggests that these children may be spelling by recalling letters serially. This could be based on the sight vocabulary they have developed from reading, perhaps supported by receptive vocabulary. Our analyses of spelling *errors* revealed that children with DS make a number of spelling errors that appear to reflect problems with phonological short-term memory. Children with DS appear to make more of these kinds of errors relative to phonologically plausible errors. We cannot be absolutely certain that single letter responses and errors where letters have been reversed, omitted, or added are due to impaired phonological short-term memory but it seems reasonable to hypothesize that these types of errors might be linked to the function of phonological short-term memory. Most of the spelling errors that were uncategorized showed that children with DS were able to produce the first letter of the target word correctly. This may reflect phonological knowledge such as letter-sound knowledge that is being limited by phonological short-term memory.

Implications for Intervention

The finding that receptive vocabulary significantly predicted spelling accuracy in children with DS could be important for intervention. As vocabulary grows, children become acquainted with more words (Ouellette, 2006) and develop more secure long-term phonological representations (Baddeley, Gathercole, & Papagno, 1998; Yeong & Rickard Liow, 2011). As they develop a larger vocabulary, more semantic connections are formed between various printed words (Muter, Hulme, Snowling, & Stevenson, 2004). Building these semantic links may serve to reinforce phonological and visual representations of printed words, which may in turn foster spelling development.

The results of this study suggest that phonological short-term memory plays an important role in spelling outcomes for children with DS. Therefore, interventions, including those targeting phonological awareness, could be designed to accommodate the phonological short-term memory limitations of this population. For example, children with DS may benefit from spelling strategies that emphasize chunking in order to reduce memory load (Treiman & Cassar, 1996). Chunking techniques involve breaking up a word into component parts (Treiman & Cassar, 1996). For example, a child could be taught to spell *teacher* by chunking the word into "tea" and "cher" at the syllable level. Alternatively, words can also be divided according to prefixes and/or suffixes, (Nation, 1997). For instance, a list of common word endings involving one syllable chunked spelling patterns (e.g., "tion," "ed," "ing") could possibly be memorized by sight (Ehri, 2000). Further research is necessary to determine if chunking strategies are beneficial for spelling acquisition in children with DS.

An intervention study of first-grade TD children carried out by Roberts and Meiring (2006) investigated two different instructional contexts for teaching phonics in order to improve literacy outcomes: spelling generation versus phonics embedded in literature. Postintervention analyses of reading and spelling ability showed that teaching phonics in the context of spelling generation was the most effective instructional technique. See also Weiser and Mathes (2011) for research on the role of encoding (spelling) for literacy instruction. It would be interesting to examine whether children with DS might benefit from instructional techniques that utilize spelling activities in order to improve literacy outcomes.

Limitations

There are some limitations of the current study. Primarily, we did not include assessment of our participants in relation to variables such as oral language (other than receptive vocabulary), letter-sound knowledge, and visual word recognition in our analyses. With regard to word recognition, we did attempt to measure this; however, most children achieved at or close to ceiling on the Early Word Recognition subtest of the YARC so we were unable to include this variable in our regression analyses. Further research employing additional measures of phonological awareness such as sound blending would also be valuable.

The sample sizes were relatively small for regression analyses. Moreover, the group of children with DS had a relatively low accuracy rate. Although we provided Cook's distances to show there were no outliers, the statistical significance and implications of our regression results should be interpreted with caution (although see Footnote 1 for reference to studies with similar sample sizes). Nevertheless, our results concerning differences between the spelling ability of children with DS and their TD peers is consistent with previous research in areas related to spelling ability, that is, reading ability (e.g., Lemons & Fuchs, 2010).

Some other issues were raised by reviewers. The first relates to the matching of our two groups in terms of receptive vocabulary. Although our analyses revealed no statistically significant difference in vocabulary across our two groups using a conventional alpha level of .05, it was suggested that it would have been ideal if the two groups could have been more closely matched. Second, it was pointed out that our analyses do not incorporate possible effects of age. We used raw scores for our correlational and regression analyses because some of our measures did not produce standardized scores. Although we did not have enough participants in each age bracket to conduct a thorough analysis of the impact of age, we reran our correlational and regression analyses taking age into consideration. The results were similar, especially with regard to the group of children with DS. It is important to note that results at Step 2 in the regression analysis for each group remained unchanged once age had been taken into account. As might be expected, we posit that there is more potential for age to influence spelling ability in TD children compared to children with DS. It is necessary to conduct additional research with a much larger sample size (i.e., a larger number of children of each age across a broader range of ages) in both a TD group and a group of children with DS in order to explore this further.

Conclusion

The results of this study indicate that children with DS exhibit difficulties with spelling accuracy when compared with TD children matched for receptive vocabulary. This difference in spelling accuracy appears to be related to the relative contribution of processes underpinning spelling. Phonological awareness was a significant predictor of correct spellings in our TD group but not our group of children with DS; however, the group with DS exhibited some phonological awareness in the types of spelling errors that they made. Judging from our examination of spelling errors, children with DS do share some similar skills in their spelling attempts as TD children (i.e., use of phonological awareness); however, this is likely to be limited by phonological short-term memory deficits. Phonological short-term memory was found to be a significant predictor of correct spellings in children with DS, and the limitations of phonological short-term memory could also be seen in the types of spelling errors that these children made. Thus, it would appear that children with DS develop spelling skills along a different trajectory compared to TD children. One of the broader theoretical implications of this finding concerns models of spelling and whether a single framework can accommodate TD children and those children with specific developmental disabilities.

Further research using longitudinal and intervention methodologies are needed to determine causality, in particular the extent to which phonological awareness and phonological short-term memory affect longer term spelling outcomes in children with DS. Such research should include assessment of a broader range of underlying cognitive and linguistic processes known to influence spelling in order to provide further insight toward enhancing the spelling skills of children with DS.

REFERENCES

The American Academy of Pediatrics Committee on Genetics. (2001). Health supervision for children with Down syndrome. *American Academy of Pediatrics*, *107*, 442–449.

Baddeley, A. D., Gathercole, S. E., & Papagno, C. (1998). The phonological loop as a language learning device. *Psychological Review*, *105*, 158–173.

Bochner, S., Outhred, L., & Pieterse, M. (2001). A study of functional literacy skills in young adults with Down syndrome. *International Journal of Disability, Development and Education*, *48*, 67–90.

Bosman, A. M. T., & Van Orden, G. C. (1997). Why spelling is more difficult than reading. In C. A. Perfetti, L. Rieben, & M. Fayol (Eds.), *Learning to spell: Research, theory, and practice across languages* (pp. 173–194). Hillsdale, NJ: Erlbaum.

Bourassa, D. C., & Treiman, R. (2001). Spelling development and disability: The importance of linguistic factors. *Language, Speech and Hearing Services in Schools*, *32*, 172–181.

Broadley, I., & MacDonald, J. (1993). Teaching short term memory skills to children with Down syndrome. *Down Syndrome Research and Practice*, *1*, 56–62.

Buckley, S. J. (2001). *Reading and writing for individuals with Down syndrome—An overview*. Cumbria, UK: Down Syndrome Education International.

Burt, J., & Fury, M. (2000). Spelling in adults: The role of reading skills and experience. *Reading and Writing: An Interdisciplinary Journal*, *13*, 1–30.

Burt, J., & Shrubsole, C. (2000). Processing of phonological representations and adult spelling proficiency. *Australian Journal of Psychology*, *52*, 100–109.

Byrne, A., MacDonald, J., & Buckley, S. (1995). Investigating the literacy, language and memory skills of children with Down syndrome. *Down Syndrome Research and Practice*, *3*, 53–58.

Byrne, A., MacDonald, J., & Buckley, S. (2002). Reading, language and memory skills: A comparatively longitudinal study of children with Down syndrome and their mainstream peers. *British Journal of Educational Psychology*, *72*, 513–529.

Caravolas, M., Hulme, C., & Snowling, M. J. (2001). The foundations of spelling ability: Evidence from a three-year longitudinal study. *Journal of Memory and Language*, *45*, 751–774.

Cardoso-Martins, C., Peterson, R. L., Olson, R. K., & Pennington, B. F. (2009). Component reading skills in Down syndrome. *Reading and Writing: An Interdisciplinary Journal*, *22*, 277–292.

Caselli, M., Monaco, L., Trasciani, M., & Vicari, S. (2008). Language in Italian children with Down syndrome and with specific language impairment. *Neuropsychology*, *22*, 27–35.

Cologon, K., Cupples, L., & Wymer, S. (2011). Effects of targeted reading instruction on phonological awareness and phonic decoding in children with Down syndrome. *American Journal on Intellectual and Developmental Disabilities*, *116*, 111–129.

Conners, F. A., Rosenquist, C. J., Arnett, L., Moore, M. S., & Hume, L. E. (2008). Improving memory span in children with Down syndrome. *Journal of Intellectual Disability Research*, *52*, 292–299.

Cupples, L., & Iacono, T. (2000). Phonological awareness and oral reading skill in children with Down syndrome. *Journal of Speech, Language, and Hearing Research*, *43*, 595–608.

Doyle, J. (1998). *Practical audiology for speech language therapists*. London, UK: Whurr.

Dunn, L. M., & Dunn, L. M. (1981). *Peabody Picture Vocabulary Test*. Wilmington, DE: Guidance Associates.

Dunn, L. M., & Dunn, L. M. (1982). *British Picture Vocabulary Scale*. Windsor, UK: NFER-Nelson.

Dunn, L. M., & Dunn, L. M. (1997). *Peabody Picture Vocabulary Test* (3rd ed.). Circle Pines, MN: American Guidance Service.

Ehri, L. C. (2000). Learning to read and learning to spell: Two sides of a coin. *Topics in Language Disorders*, *20*(3), 19–36.

Fletcher, H., & Buckley, S. J. (2002). Phonological awareness in children with Down syndrome. *Down Syndrome Research and Practice*, *8*, 11–18.

Gathercole, S. E. (1999). Cognitive approaches to the development of short-term memory. *Trends in Cognitive Sciences*, *3*, 410–419.

Gillon, G. (2004). *Phonological awareness: From research to practice*. London, UK: Guilford.

Jarrold, C., & Baddeley, A. D. (2001). Short-term memory in Down syndrome: Applying the working memory model. *Down Syndrome Research and Practice*, *7*, 17–23.

Kennedy, E. J., & Flynn, M. C. (2003). Training phonological awareness skills in children with Down syndrome. *Research in Developmental Disabilities*, *24*, 44–57.

Kessler, B., & Treiman, R. (2003). Is English spelling chaotic? Misconceptions concerning its irregularity. *Reading Psychology*, *24*, 267–289.

Laws, G. (1998). The use of non-word repetition as a test of phonological memory in children with Down syndrome. *Journal of Child Psychology and Psychiatry*, *39*, 1119–1130.

Laws, G., & Gunn, D. (2002). Relationships between reading, phonological skills and language development in individuals with Down syndrome: A five year follow-up study. *Reading and Writing: An Interdisciplinary Journal*, *15*, 527–548.

Lemons, C., & Fuchs, D. (2010). Phonological awareness of children with Down syndrome: Its role in learning to read and the effectiveness of related interventions. *Research in Developmental Disabilities*, *31*, 316–330.

MacDonald, G. W., & Cornwall, A. (1995). The relationship between phonological awareness and reading and spelling achievement eleven years later. *Journal of Learning Disabilities*, *28*, 523–527.

Muter, V., Hulme, C., Snowling, M. J., & Stevenson, J. (2004). Phonemes, rimes, vocabulary, and grammatical skills as foundations of early reading development: Evidence from a longitudinal study. *Developmental Psychology*, *40*, 665–681.

Muter, V., Hulme, C., Snowling, M., & Taylor, S. (1998). Segmentation, not rhyming predicts early progress in learning to read. *Journal of Experimental Child Psychology*, *71*, 3–27.

Muter, V., & Snowling, M. (1998). Concurrent and longitudinal predictors of reading: The role of metalinguistic and short-term memory skills. *Reading Research Quarterly*, *33*, 320–337.

Naess, K., Halaas Lyster, S., Hulme, C., & Melby-Lervag, M. (2011). Language and verbal short-term memory skills in children with Down syndrome: A meta-analytic review. *Research in Developmental Disabilities*, *32*, 2225–2234.

Nation, K. (1997). Children's sensitivity to rime units when spelling words and nonwords. *Reading and Writing: An Interdisciplinary Journal*, *9*, 321–338.

Nation, K., & Hulme, C. (1997). Phonemic segmentation, not onset-rime segmentation, predicts early reading and spelling skills. *Reading Research Quarterly*, *32*, 154–167.

Otaiba, S. A., Puranik, C. S., Rouby, A., Greulich, L., Sidler, J. F., & Lee, J. (2010). Predicting kindergarteners' end-of-year spelling ability based on their reading, alphabetic, vocabulary and phonological awareness skills, as well as prior literacy experiences. *Learning Disability Quarterly*, *33*, 171–183.

Ouellette, G. P. (2006). What's meaning got to do with it: The role of vocabulary in word reading and reading comprehension. *Journal of Educational Psychology*, *98*, 554–556.

Raven, J. C., Court, J. H., & Raven, J. (1995). *Coloured Progressive Matrices*. Oxford, UK: Oxford Psychologists Press.

Rickard Liow, S. J., & Tng, S. K. (2003). Biscriptal literacy development of Chinese children in Singapore. In C. McBrideChang & H. C. Chen (Eds.), *Reading development in Chinese children* (pp. 215–228). Westport, CT: Praeger.

Roberts, T. A., & Meiring, A. (2006). Teaching phonics in the context of children's literature or spelling: Influences on first-grade reading, spelling and writing and fifth-grade comprehension. *Journal of Educational Psychology*, *98*, 690–713.

Semel, E., Wiig, E. H., & Secord, W. A. (2003). *Clinical Evaluation of Language Fundamentals*, *Fourth edition (CELF–4*). Toronto, Canada: The Psychological Corporation.

Seung, H. K., & Chapman, R. (2000). Digit span in individuals with Down syndrome and in typically developing children: Temporal aspects. *Journal of Speech, Language, and Hearing Research*, *43*, 609–620.

Snowling, M. J., Stothard, S. E., Clarke, P., Bowyer-Crane, C., Harrington, A., Truelove, E., . . . Hulme, C. (2009). *York Assessment of Reading for Comprehension*. London, UK: GL Publishers.

Strattman, K., & Hodson, W. B. (2005). Variables that influence decoding and spelling in beginning readers. *Child Language Teaching and Therapy*, *21*, 165–190.

Stuart, M., & Masterson, J. (1992). Patterns of reading and spelling in 10 year old children related to prereading phonological abilities. *Journal of Experimental Child Psychology*, *54*, 168–187.

Terman, L. M., & Merrill, M. A. (1964). *Stanford-Binet Intelligence Scale*. New York, NY: Houghton.

Treiman, R. (1993). *Beginning to spell: A study of first-grade children*. New York, NY: Oxford University Press.

Treiman, R., & Cassar, M. (1996). Effects of morphology on children's spelling of final consonant clusters. *Journal of Experimental Child Psychology*, *63*, 141–170.

Treiman, R., Zukowski, A., & Richmond-Welty, E. D. (1995). What happened to the "n" of sink? Children's spellings of final consonant clusters. *Cognition*, *55*, 1–38.

Tsao, R., Fartoukh, M., & Barbier, M. L. (2011). Handwriting in adults with Down syndrome. *Journal of Intellectual and Developmental Disability*, *36*, 20–36.

Tunmer, W. E., Herriman, M. L., & Nesdale, A. R. (1988). Metalinguistic abilities and beginning reading. *Reading Research Quarterly*, *23*, 134–158.

Vaessen, A., & Blomert, L. (2013). The cognitive linkage and divergence of spelling and reading development. *Scientific Studies of Reading*, *17*, 89–107.

van Bysterveldt, A. K. (2009). *Speech, phonological awareness and literacy in New Zealand children with Down syndrome* (Unpublished doctoral dissertation). University of Canterbury, New Zealand.

Weiser, B., & Mathes, P. (2011). Using encoding instruction to improve the reading and spelling performances of elementary students at risk for literacy difficulties: A best-evidence synthesis. *Review of Educational Research*, *81*, 170–200.

Wilkinson, G. S., & Robertson, G. J. (2006). *Wide Range Achievement Test*, Fourth Edition *(WRAT–4)*. Lutz, FL: Psychological Assessment Resources.

Yeong, H. M. S., & Rickard Liow, S. J. (2011). Predictors of early spelling development in English: Comparison of English–L1 and Mandarin–L1 bilingual children. *Journal of Educational Psychology*, *103*, 470–488.

Young, S. E., Purcell, A. A., Ballard, K. J., Rickard Liow, S. J., Da Silva Ramos, S., & Heard, R. (2012). Bilingual children with nonsyndromic cleft lip and/or palate. *Journal of Speech, Language, and Hearing Research*, *55*, 1314–1328.

APPENDIX

TABLE A1
Word Spelling Test Word

Target	*Letters*	*Phonemes*	*Syllable Structure*	*Sentence*
grab	4	4	CCVC	They tried to grab the boy.
police	6	5	CV/CVC	My father works in the police force.
date	4	3	CVC	This letter has today's date.
dive	4	3	CVC	They dive into the water.
birth	5	3	CVC	She gave birth to a baby girl.
safe	4	3	CVC	It is not safe to jaywalk.
feeling	7	5	CV/CVC	Tom is feeling sad.
maid	4	3	CVC	My maid cooks for us.
pointed	7	6	CVC/CVC	The boy pointed to the dog.
pipe	4	3	CVC	The water pipe had burst.
fall	4	3	CVC	Peter hurt his arm in a fall.
dream	5	4	CCVC	She had a bad dream.
past	4	4	CVCC	They walked past the library.
finish	6	5	CV/CVC	He could not finish his food.
lap	3	3	CVC	One more lap of the swimming pool.
film	4	4	CVCC	They went to watch a film.
club	4	4	CCVC	Which club do you belong to?
tube	4	4	CVC	They put a tube into the tank.
disturb	7	6	CVC/CVC	Do not disturb him at work.
stop	4	4	CCVC	Stop at the junction.
telling	7	5	CV/CVC	John was telling us a story.
village	7	5	CV/CVC	Mary lives in a fishing village.
seem	4	3	CVC	These problems seem difficult.
beef	4	3	CVC	I do not eat beef.
type	4	3	CVC	This is a type of vegetable.

(*Continued*)

TABLE A1
(Continued)

Target	*Letters*	*Phonemes*	*Syllable Structure*	*Sentence*
train	5	4	CCVC	The train has left the station.
believe	7	5	CV/CVC	They do not believe in Santa Claus.
limit	5	5	CV/CVC	The speed limit on this road is 60 km per hour.
marble	6	4	CV/CC	There were cracks in the marble tiles.
pretty	6	5	CCV/CV	She looks pretty today.

Note. Adapted from Yeong and Rickard Liow (2011). © American Psychological Association. Adapted by permission of the American Psychological Association.