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Spelling performance of 6- and 8-year-old Irish children; Is it <*analice*> or <*analyze*>?

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Keywords: **Spelling, phonological ability, rapid automatized naming, Irish school-age children**

Running Head: **SPELLING PERFORMANCE OF 6- AND 8-YEAR-OLD IRISH CHILDREN**

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Abstract

The association of phonological and lexical-semantic processes with spelling ability in children has received scant research interest even though uncovering such associations can increase our understanding of literacy development. A cross-sectional study was carried out with 42 six- and eight-year-old children in the southeast of Ireland. The children took part in tasks assessing reading, letter-sound knowledge, phonological ability, phonological short-term memory, and rapid automatized naming. They also completed an assessment of spelling ability involving regular words, irregular words, and pseudowords. Analyses revealed that, for both age groups, and for all three word types, spelling accuracy was strongly associated with phonological ability scores. In contrast, phonological short-term memory was found to be significantly associated with regular word and total word spelling for the younger group. For the older group, rapid automatized naming was associated with all word categories. Qualitative analysis of the spelling errors revealed that an increase in spelling ability was accompanied by greater prevalence of phonologically appropriate errors. Our findings have important implications for teaching and assessment practices for spelling.

Keywords: Spelling, phonological ability, rapid automatized naming, school-age children

Spelling, just like reading and writing, is a key aspect of functional literacy (Norton et al., 2007). It is also considered to have a significant effect on writing performance and other literacy-related skills (see Graham & Santangelo, 2014). Limpo et al. (2017) describe spelling as the "externalization of language in the form of written text, which involves the retrieval, assembling, and selection of orthographic symbols" (p. 26). Berninger et al. (2009) define spelling as the ability to use letter sequences to signify precise words with an attached pronunciation and meaning. In order to support the development of spelling skill educators need to know the factors that affect spelling accuracy. The Report of The National Early Literacy Panel (Lonigan & Shanahan, 2009) identified the following main skills that have a medium to large effect on later literacy development: alphabet knowledge, phonological awareness (PA), rapid automatized naming (RAN) and phonological short-term memory (PSTM). There is far less research regarding spelling accuracy, in general, in comparison to reading (Keilty & Harrison, 2015). This study aimed to identify significant predictors (such as reading, letter-knowledge, PA, RAN and PSTM) of single word spelling accuracy in young Irish children aged 6 and 8 years old. The group was divided into advanced spellers (age 8 students who have more years of experience and practice), and beginning spellers (aged 6 who are just gaining experience with spelling). The study also explored, apart from spelling accuracy, the type of spelling errors made, as these can provide a window into the strategies the children use when spelling words. Awareness of the factors that predict spelling accuracy should lead to increased understanding of effective means for teaching spelling and mitigating spelling difficulties. By looking at beginning and advanced spellers, one could also examine fine developmental differences.

Relationship between spelling with literacy and cognitive-related variables

Reading and spelling are closely related, and correlations between the two are reported to be high, typically above *r* =.70 (Ehri, 2000). This close association is reported in young and older children (e.g., Bruck & Waters, 1988; Ehri, 1997) and adults (Shankweiler & Lundquist, 1992). In a longitudinal study with 970 children, Treiman et al. (2019a) reported a strong influence of kindergarten (6 years old) spelling ability on later reading skill (in Grades 1 to 9). Similar results were found by Conrad et al. (2019) in a training study with 48 Grade 2 children. Given the asymmetry in transparency between reading and spelling (spelling having more inconsistent phoneme-grapheme correspondences than reading, Spencer (2009), one would expect negligible effects of reading on spelling. Conversely, Georgiou et al. (2020), in a longitudinal and cross-linguistic study with children from Grade 1 to 2, found unidirectional effects from reading to spelling, but not the other way around. This discrepancy could be because Georgiou et al. (2020) tested older children than those in the study of Treiman et al. (2019b).

Another factor that has been found to affect spelling skill is letter knowledge (e.g., (Caravolas et al., 2001; Georgiou et al., 2020; Lervåg & Hulme, 2010; Ritchey et al., 2010; Schaars et al., 2017; Yeong & Rickard Liow, 2011). Children are exposed to letters from an early age (Treiman, 2017). Letter knowledge requires one to be aware of letter names and letter sounds. In Ireland, letter-sounds are taught from the time students start primary school. Al Otaiba et al. (2010), in a study with 288 English-speaking kindergarten children, found that the single strongest predictor of spelling scores was letter-sound knowledge. Apart from literacy-related reading and letter-sound knowledge, other variables have been found to be strongly correlated with spelling, as noted above, such as PA, PSTM and RAN (Niolaki et al.,

2020; Caravolas, 2004; Caravolas et al., 2001; Jong & Leij, 1999; Nielsen & Juul, 2016; Savage et al., 2008; Savage & Frederickson, 2006; Pritchard et al., 2020).

Extensive evidence has highlighted the role of PA in early literacy skill (Diamanti et al., 2017). Phonological skills - the ability to discriminate speech sounds and manipulate them - has been found to be a robust predictor of spelling (Caravolas, 2004; Caravolas et al., 2001). Nation and Hulme (1997) carried out a study with children in the UK aged five to nine years looking at the relationship between phonological skills and spelling. They reported that phonemic segmentation (breaking the word into its smallest sound units, phonemes) was an excellent predictor of spelling ability. Also, in a 3-year longitudinal study, with 153 British children looking at the development of spelling skill, it was found that measures of phonologically appropriate errors (PAE) in spelling, and reading accuracy predicted conventional spelling (Caravolas et al., 2001). The researchers suggested that children's spelling improves as their phonological skills develop, and they become more aware of the writing system. The association between PA and spelling was further studied by Paige et al. (2018) with 2,100 kindergarten students in the Midwestern United States. It was found that letter naming and PA were significant predictors of spelling knowledge by the end of kindergarten.

Phonological awareness has been reported to be a unique predictor of spelling among young children (Caravolas et al., 2005). This is also found with older children in Year 3 and 4 in English schools (age 7 to 9 years) while Stainthorp et al. (2013) found that PA contributed significantly to the spelling of both regular and irregular words. However, Georgiou et al. (2012) followed 68 English-speaking children from preschool (5.5 years) to Grade 2 (7.5 years) and found that letter-knowledge and RAN were strongly related to spelling over and above the contribution of PA. Similar results were reported by Pritchard et

al. (2020), who surprisingly could not find a longitudinal association between PA and letter knowledge in English-speaking 5-6 year old children. The only significant associations were found between RAN and spelling accuracy. In a cross-sectional study with beginning and advanced spellers, Niolaki et al. (2020) found a significant association between PA and spelling for beginning spellers but not more advanced ones. Findings concerning PA do not seem to be consistent, and this could be due to the different tasks used to assess the constructs.

In addition to PA, PSTM has also been linked to spelling development (Caravolas et al., 2001; Jong & Leij, 1999; Nielsen & Juul, 2016), although little investigation has been dedicated to this association (Binamé & Poncelet, 2016). PSTM is considered to be the ability to keep phonological (speech-related) information in memory for a short period of time (Fiez, 2016, p. 855). Deficits in PSTM have been identified as one factor underlying spelling difficulties (Steinbrink & Klatte, 2008). Plaza and Cohen (2007) reported that PSTM did not remain an independent predictor of spelling development when PA and RAN were included in the analyses, and similar results were reported by Landerl and Wimmer (2008) and Caravolas et al. (2001). Findings in relation to the role of PSTM seem to be inconsistent; one would expect that as children learn to spell, they rely strongly on phonological memory to retrieve the correct letter sequence. Caravolas et al. (2001) did not find an association between PSTM and spelling in children, perhaps due to the type of items used to test spelling (monosyllabic words).

Regarding RAN, the association with children's spelling ability is not clear. RAN is a measure of how quickly one can name out loud a small set of symbols, pictures, colors or objects (Niolaki et al., 2020). Several studies have found that RAN predicts spelling ability in primary school-aged children (Nielsen & Juul, 2016; Savage et al., 2008; Savage &

Frederickson, 2006; Pritchard et al., 2020). Stainthorp et al. (2013) found that RAN significantly contributed to spelling performance for irregular words, suggesting RAN was specifically related to lexical-semantic processes. Donker et al. (2016) found poor RAN was a risk factor for spelling difficulties in Dutch primary school children. However, other studies have found contradictory findings. Vaessen and Blomert (2013), with primary school Dutch children, reported that RAN (letters and digits) did not contribute to spelling performance in any primary school grades. Similarly, Georgiou et al. (2016) found that RAN (digits and colors) did not predict spelling in 304 grade 4 children (age range 9.5 years to 10.9 years) who were speakers of English, Chinese and Finnish. However, if, as Stainthorp et al. (2013) suggest, RAN is involved in establishing fully specified representations, the contribution of RAN may indeed differ depending on the age or experience of the child and the type of word being spelled.

Theoretical Framework

The Dual Route theory of spelling (Barry, 1994) was used to interpret our findings. According to this model, the mental processes involved in spelling involve a lexical/semantic route and a sublexical route (Coltheart et al., 2001). The lexical route relies on whole word recognition and allows effective processing of words. The retrieval of familiar and irregularly spelled words (such as <cat > or <yacht>) occurs in the lexical route. The sublexical route, on the other hand, involves the use of the phoneme-grapheme rule system (Treiman, 2017). This route allows for the effective spelling of regularly spelled words (such as <cat>) and unfamiliar words or pseudowords (such as <ig>). However, it will fail with irregular words, leading to phonologically plausible misspellings (<yacht> -> <yhot>) (see Niolaki et al., 2014). Spelling demands the development of precision in the use of phoneme-

grapheme correspondences in accordance with the self-teaching hypothesis (Share, 1999), and as children get older, the use of the lexical route increases.

Spelling can also provide a diagnostic window into a student's knowledge of the sound system not only through tracking spelling ability but also through inspection of their errors. Moats (1996) carried out a study on spelling errors using 19 adolescents with reading and spelling difficulties. Findings revealed that the poorer spellers in this group made more errors than the better spellers on specific phonological and morphophonological constructions. For example, a disproportionately large number of errors was found in the representation of liquid and nasal consonants, especially after vowels and spellings of inflections -ed and -s.

Misspellings can also be classed into phonologically appropriate and phonologically inappropriate errors concerning the target word (Niolaki et al., 2014). Phonologically appropriate errors (for example, <night> -> <nite>) can potentially indicate a difficulty with lexical processes, whereas phonologically inappropriate errors (such as <shelf> -> <sleve>) indicate a deficit in sublexical spelling processes. As children get older, the performance of the lexical route improves and higher precision is expected and less phonologically inappropriate errors are anticipated (i.e., Bourassa & Treiman, 2001; Sénéchal, 2016; Treiman, 2017; Treiman et al., 2019; Treiman et al., 2016).

The newly developed Interpretive Spelling Test (IST) (Niolaki et al., 2019) was used to assess the children's spelling in the present study. This test comprises separate lists of regular words, irregular words, and pseudowords and allows for identifying strengths or difficulties with phonological and/or lexical-semantic processes. Since the IST comprises regular words, irregular words, and pseudowords, it allows for testing of the association of variables such as PA, PSTM, and RAN, with sublexical spelling processes (using scores for

regular word and pseudoword spelling) and lexical-semantic spelling processes (using scores for regular and irregular word spelling).

Extant research has primarily focused on predictors of spelling without distinguishing between different types of words and has mainly involved spelling of short, monosyllabic words. In the current research, specifically, it was decided to explore whether sound-letter spelling production (a child hears a dictated sound and has to write the letter(s) that make the sound), a task more closely aligned to spelling skill, is more associated with spelling than letter-sound production (a child sees a letter/s and has to say orally what sound it makes), a task more related to reading skill. Although the association between letter-sound knowledge has been researched in the past, what needs to be further explored is whether this reported strong association holds for different word types (regular words, irregular words, and pseudowords). This study also aimed to see whether the influence of PA on spelling is held even after controlling for reading skill and whether its contribution would differ for different word string types (irregular words, regular words, and pseudowords). The study also considered it informative to see whether it would obtain similar findings to Caravolas et al. (2001) in relation to PSTM or, due to the use in the current investigation of mono- and multi-syllabic words, there would be evidence that the children would rely on PSTM to retrieve spellings. The study also looked at the contribution of RAN to spelling ability across different word types as results so far seem to be inconsistent, and like PA might differ depending on word string type. Finally, spelling errors were classified as phonologically appropriate (sounds like the target word) and phonologically inappropriate (omissions, additions, substitutions, transpositions of letters and letter groups, and unclassified) to gain insight into the spelling processes being used by the children.

Purpose of the Present Study

Findings of previous research seem to be inconsistent regarding spelling skill. As a child's phonological skills improve, so does their spelling ability (Caravolas et al., 2001). Thus, one should expect less phonologically inappropriate responses and higher accuracy as the children gain a better grasp of the sound-letter associations, and their orthographic knowledge and morphological awareness becomes robust (Bourassa & Treiman, 2001; Sénéchal, 2016; Treiman, 2017; Treiman, Hulslander, et al., 2019; Treiman et al., 2016). PA, RAN, and PSTM all appear to have some effect on spelling ability. Concerning PA and spelling, research has highlighted their association, especially for beginning spellers (Niolaki et al., 2020; Caravolas et al., 2001; Paige et al., 2018); however, there is also evidence against this association (see Niolaki et al., 2020; Georgiou et al., 2012; Pritchard et al., 2020). Findings with respect to RAN have also been varied concerning its contribution to spelling (Georgiou et al., 2016; Savage & Frederickson, 2006; Stainthorp et al., 2013; Vaessen & Blomert, 2013). Findings for an association of spelling with PSTM have also been varied (Lervåg & Hulme, 2010; Plaza & Cohen, 2007; Steinbrink & Klatte, 2008).

It was expected in this study that advanced spellers (8-year-old children in their fourth year of formal education in Ireland) would do significantly better in all literacy, spelling and cognitive tests in comparison to beginning spellers (6-year-old children in their second year of formal education in Ireland). Concerning the cognitive correlates, it was expected that PA and PSTM should influence the spelling of all word types according to past research evidence. However, the association with irregular word spelling might be less in comparison to regular words or pseudowords (Niolaki et al., 2020; Jongejan et al., 2007; Nielsen & Juul, 2016). For RAN, as its association to phonological or orthographic processing is not yet clear-cut, it was expected that if RAN is tapping phonological processing, it should be

associated with pseudoword spelling. If it is tapping orthographic processing, it should be associated with irregular spelling.

To address these hypotheses, the study posed the following research questions:

RQ1. Are more advanced spellers better in all literacy, spelling and cognitive tests in comparison to beginning spellers aged 6-years-old?

RQ2. Are children producing more phonologically appropriate errors and having a better grasp of letter knowledge as they gain more experience with spelling accuracy?

RQ3. Are reading accuracy and letter knowledge strong correlates of spelling accuracy of all word types?

RQ4. Is letter-sound knowledge (an oral production task) or sound-letter knowledge (a written production task) a better correlate of spelling of all word types?

RQ5. Are PA and PSTM associated with spelling of all word types?

RQ6. Is RAN associated with pseudoword spelling or irregular word spelling?

Method

Participants

This cross-sectional study consists of two cohorts of students, beginning (Year 1 in the UK; mean age: 6.8 years, *SD*= .35), and advanced spellers (Year 3 in the UK; mean age 8.9 years, *SD*= .29). A co-educational DEIS (Delivering Equality of Opportunity in School) rural primary school in the southeast of Ireland was approached to participate in the study. DEIS is an action plan for educational inclusion in Ireland. The scheme helps to address the educational needs of children and teens from disadvantaged communities. Twenty-four

beginning (17 girls) and 18 advanced spellers (12 girls) participated. Of the forty-two children who participated in the study, 99% were Irish born. The Irish and UK education system relies on the teaching of synthetic phonics. Much research has been carried out in the area of literacy, and the Rose report (2006, p. 5) outlined that "synthetic" phonics offers young children the "best and most direct route to becoming skilled readers and writers". Children in Ireland begin formal literacy instruction when they start primary school at age four to five.

Materials

Literacy assessments

Interpretive Spelling Test: IST (Niolaki et al., 2019). The test consists of 106 words (36 irregular words (e.g., <nature>), 36 regular ones (e.g., <ground>) and 34 pseudowords (e.g., <scade>). The words in the IST are matched on psycholinguistic variables (e.g., zipfrequency[1] Kruskal-Wallis $\chi^2(1) = .66$, $p>.05$), number of letters ($\chi^2(2) = 1.78$, $p>.05$), phonemes ($\chi^2(2) = .28$, $p>.05$) and syllables ($\chi^2(2) = 5.85$, $p>.05$), and zipf contextual diversity[1] ($\chi^2(1) = 1.37$, $p>.05$)). The pseudowords were created from the regular words in the test. The words were administered in the context of a sentence to avoid homophonic errors, but the child had to spell the single target word. There was no discontinuation rule with this test. Raw scores were used in the analysis. A Cronbach alpha of .82 was achieved with beginning 'spellers' scores, and a Cronbach alpha of .87 was achieved with advanced 'spellers' scores.

Error analyses. All errors were scored by the first and second author aiming for 100% agreement on the type of errors the children made. Following extant literature (Bourassa & Treiman, 2001; Treiman, 2017; Treiman et al., 2019b; Treiman et al., 2016) errors were

classified into two categories of phonologically appropriate (e.g., <night> -> <nite>) and inappropriate responses (e.g., <shelf> -> <sleve>). The latter category was divided further in omissions (e.g., errors of the diagraph (<sh>-> <s>) or the magic <e>), additions (including more letters than necessary in the response (e.g., <without> -> < whithout>)), substitutions and letter rotations (e.g., <ch>-><j> and <b> -> <d>), transpositions (swapping the position of letters or letter groups (e.g., <probably> -> <prolbee >)), and unclassified (errors that do not fall into any of the above categories (e.g., <sandwich> -> <samiwj>)).

WIAT II: Wechsler Individual Achievement Test II (2005). An additional single word spelling test, the WIAT II spelling subtask, was used to assess the child's spelling ability (written spelling of dictated letters, sounds and words that are pronounced in sentences). This test was used to provide an index of construct validity for the IST. A discontinuation rule was applied, and the test stopped once six consecutive errors were made. The WIAT II is standardized on the UK population. It has reliability of .93 for 5-year-olds, .94 for 6-year-olds, .95 for 7-year-olds and .93 for 8-year-old.

Diagnostic Test of Word Reading Processes (DTWRP). This is a test of single-word reading aloud for children aged 6 to 12. The test comprises 90 items: 30 irregular or exception words which provide a measure of lexical-semantic reading processes; 30 pseudowords which provide a measure of phonological recoding processes; and 30 regular words which can be read by either process (Forum for Research in Literacy and Language (FRiLL), 2012). The DTWRP word and pseudowords lists do not differ in number of phonemes, letters and syllables (Niolaki & Masterson, 2015). A discontinuation rule was applied to each section of the test after five consecutive errors. The DTWRP has a complete reliability score of .99, and for pseudowords a value of .96, exception words .97 and regular words .97.

Diagnostic Spelling Test – Spelling sounds to dictation (DiST). This test consists of 32 sounds. The sounds of the letters were spoken, and the students wrote the letter(s) that made the sound (Kohnen et al., 2009). There was no discontinuation rule for this test.

Letter-Sound Recognition Test (LeST). Students were asked to view the grapheme(s) and sound them out (51 items in total). This test was untimed, and there was no discontinuation rule. The letter-sound recognition test is a standardized test that assesses grapheme-phoneme correspondence knowledge (Larsen et al., 2015). The test-retest reliability of the test is .88.

Cognitive assessments

Spoonerisms subtest from the Phonological Assessment Battery (PhAB, Frederickson et al., 1997). The child listened to two words and was asked to swap over the first sound in each, e.g., */King John/* became */Jing Kohn/*. This test helps to examine whether a child can divide up single-syllable words and then combine the segments to provide new words or word combinations (Gallagher & Frederickson, 1995). The task has in total twenty word pairs.

Comprehensive Test of Phonological Processing (CTOPP, Rashotte et al., 1999). This test was used to assess PSTM and rapid naming. The *pseudoword repetition test,* for assessing PSTM, consisted of 30 pseudowords increasing in difficulty and length. Students listened to the pseudowords on a computer and were asked to repeat each pseudoword after hearing it. This test was discontinued after three consecutive errors. The task has high reliability: α=.85. The *rapid digit naming test,* for assessing RAN, consisted of 36 digits which were displayed on a sheet, and students were asked to name them aloud as quickly as possible. There was no discontinuation rule. The RAN digits test has a high level of reliability, α=.87.

Procedure

The sound-letter spelling test (DiST) and the single-word spelling tests (WIAT II and IST) were carried out in a small class group setting (maximum of 10 children per group) and with portions of the test to avoid fatigue (each test administered on separate days) while the single word reading, letter-sound recognition, spoonerisms, PSTM and RAN tasks were carried out individually (in the school office). British Psychological Society ethical guidelines were considered, and approval was obtained from the University's Psychology Ethics Committee. Irish Garda vetting was in place before test administration in the school. Permission to test in the school was sought from the principal, and information sheets and consent forms were distributed to the assigned classes. Forty-eight consent forms were sent home with students, and only students who returned the consent forms participated in the study (N=42). Testing was carried out for two months in Spring 2018 by the first author. Raw scores were used in the analyses, which are presented next.

Results

Tests of normality were carried out on scores from all the assessments. Shapiro-Wilk's (SW) test and visual inspection of histograms showed that most variables were approximately normally distributed with Z scores between 3.33 and -3.33. The only variables that deviated from normality were, for the beginning spellers, single word spelling, IST irregular words and PSTM; and for the advanced spellers, IST irregular words and letter-sound knowledge. However, on visual inspection, they appeared approximately normally distributed. A summary of the scores in the assessments for both beginning and advanced spellers is given in Table 1. It is evident that as children progressed in grade groups, they also improved in their literacy and cognitive task performance (please see *t-tests* reported in Table 1). This is consistent with past research findings (e.g., de Bree & van den Boer, 2019).

Correlations

Pearson correlation was used to examine the relationship between all the variables in beginning and advanced spellers. The results are presented in Table 2. The lower orthogonal represents the results for the advanced spellers, and the upper orthogonal for the beginning spellers.

For beginning spellers, a significant relationship was found between single word spelling test scores (WIAT II) and IST regular and irregular word, and pseudoword scores. A strong significant association was found between the IST and DTWRP reading scores for all three types of words. The sound-letter spelling scores (DiST) were significantly associated with IST regular word and pseudoword spelling scores. The letter-sound knowledge scores (LeST) were significantly associated with IST regular and irregular word spelling scores and marginally significantly with pseudoword spelling scores (p=.06). PA was strongly associated with all IST spelling sub-categories. PSTM was significantly associated with DTWRP total scores and DTWRP regular word scores. PSTM was also significantly associated with IST total scores and IST regular word scores.

For the advanced spellers, a significant relationship was found between IST regular and irregular word and pseudoword scores with single word spelling scores (WIAT II). The IST was also associated with DTWRP regular and irregular word and pseudoword reading scores. Finally, strong associations were found between the IST and letter-sound knowledge (LeST), PA and RAN. Sound-letter spelling (DiST) and PSTM scores were not associated with any spelling and reading scores.

Error analyses

An analysis of the errors made by both beginning and advanced spellers was carried out. The errors were calculated based on phonologically appropriate or phonologically inappropriate errors. The latter category was divided into smaller clusters (omissions, additions, substitutions, transpositions, and unclassified errors). Table 3 outlines the results. Overall, beginning spellers made fewer phonologically appropriate errors (PAE) in comparison to advanced spellers ($p<.001$). Also, beginning spellers made more errors (79%) than the advanced spellers (53%). In beginning spellers, it can be seen across regular, irregular and pseudowords that children primarily made omission, substitution and unclassified errors (average scores 28.7% (*SD*=1.8), 24.8% (*SD*=5.1) and 24.7% (*SD*=1.6), respectively). The pattern was not dissimilar in the advanced spellers, where a higher percentage of errors occurred across all word types concerning omission and substitution errors (average scores 34.86% (*SD*=4.6) and 34.36% (*SD*=4.1), respectively). However, unclassified errors across all word types were below 1% (average scores .58% (*SD*=.56)). There is an increase in omission, addition and substitution errors and a substantial drop in transposition and unclassified errors as the children progress in school and practice more with spellings. It was found that advanced spellers used *-ed* for the end *-t* (the pseudoword <*impabit*> was written as <*impabed*>), which was not the case for beginning spellers. This indicates a tendency to overgeneralize the grammatical past test rule in items that do not require it (Deacon & Bryant, 2006).

Discussion

In the present study, spelling, literacy and cognitive tests were carried out with beginning and advanced spellers in an Irish primary school. The study aimed to identify factors that determine the spelling of different words and how the children's spelling

performance alters as they become more experienced with letter-sound associations. The study also aimed to provide fine-grained qualitative information about the children's spelling. The IST (Niolaki et al., 2019) was used as it distinguishes between regular and irregular words, and pseudowords and, as such allows for the identification of associations between the variables tested and phonological and/or lexical-semantic processes following models that predict the use of the sublexical and lexical route when spelling (Barry, 1994; Coltheart et al., 2001). Firstly, comparisons were carried out in relation to the scores achieved by students in beginning and advanced spellers to see if developmental trends were evident. Children's spelling performance improved as expected (de Bree & van den Boer, 2019; Plaza & Cohen, 2007). Spelling improves as children learn more about the writing system and their phonological skills improve – this could also be due to more prolonged exposure to synthetic phonics teaching (Caravolas et al., 2001). This was corroborated by the qualitative analysis of spelling errors, as the rate of PAEs increased with grade, and the opposite trend was observed for unrelated spelling errors.

Reading aids children's ability in part to spell words, and strong associations were reported in the past (de Bree & van den Boer, 2019; Georgiou et al., 2020; Treiman, 2017). In this study, reading was found to be a significant correlate of spelling across all word types (R^2 ranging from 80-58), and this is in keeping with past research. Shankweiler and Lundquist (1992) showed that performance in both reading and spelling tests are highly correlated in older children and adults. However, it is notable in the current findings that the lowest association was observed between irregular word spelling and pseudoword reading. This is expected, as irregular word spelling and pseudoword reading rely on different processes (lexical and sublexical, respectively).

Letter knowledge aids a child in grasping the alphabetic principle for reading and spelling (Caravolas et al., 2001; Lonigan & Shanahan, 2009; Yeong & Rickard Liow, 2011). The findings revealed that for beginning spellers, sound-letter spelling was associated with total spelling score, regular words and pseudowords, but not irregular words. On the other hand, letter-sound knowledge was associated with regular and irregular word spelling but not pseudoword spelling. For advanced spellers, sound-letter spelling was not statistically associated with spelling (for any of the letter string types). However, letter-sound knowledge was significantly associated with spelling for all letter string types. Letter-sound knowledge appears, therefore to play a fairly robust role in spelling for both age groups. More exposure to the reading of made-up words in advanced spellers may explain how pseudoword spelling also correlated with letter-sound knowledge, which was not found for beginning spellers. Letter-sound knowledge has previously been reported to have a significant impact on the development of reading and spelling skills (e.g., O'Carroll, 2011).

This study did not find that sound-letter spelling was associated with spelling scores for advanced spellers. This may have been due to a lack of variance in scores, although one might have expected stronger associations with spelling than those found for letter-sound knowledge due to the similarity between the tasks (writing component). Thus, it seems that letter-sound knowledge exerts a stronger influence on spelling rather than sound-letter spelling, maybe due to the strong emphasis on phonics teaching in the initial years of primary education or because as children progress in school and as a result practice more with spelling and learn more about the spelling rules, they do not rely on sublexical processes so much.

Phonological awareness plays an essential role in early literacy experiences (Diamanti et al., 2017). Segmenting and blending were tested in this study using the spoonerisms test.

The analysis identified PA as the strongest correlate (after reading) of spelling for all word types and both grade groups. The data complement findings showing that PA is a stable and robust predictor of spelling (Caravolas et al., 2001; Vaessen & Blomert, 2013). Our results are not aligned with de Bree and van den Boer (2019), who could not find a significant contribution to spelling after controlling for reading. Georgiou et al. (2012) also reported no association for young Greek spellers. However, in the latter study, they did not control for reading. The difference in results across studies might be due to participant age and task differences. In the current study, a spoonerisms task was used, whereas in the previous studies blending and phoneme deletion tasks were used, which may impose less cognitive demands than spoonerisms.

PSTM was associated with IST total spelling scores and regular word spelling for beginning spellers. A significant relationship between PSTM and IST scores was not found for the advanced spellers. Landerl and Wimmer (2008) reported that PSTM was not an independent predictor of spelling in their study, with 115 children followed from Garde 1 to 8. However, Lervåg and Hulme (2010) found that PSTM was a longitudinal predictor of both word and pseudoword spelling (Lervåg & Hulme, 2010). Verbal STM assessed in preschool was also found to be related to spelling at the age of eight by Bradley and Bryant (1985). This study did not find strong associations apart from the correlation between regular word spelling and PSTM for the beginning spellers. This is perhaps as one would expect since verbal memory should be an essential component for remembering the sequence of letters and phonemes in spelling words before they are committed to the orthographic lexicon. This also supports the idea that beginning spellers rely more on sublexical processes rather than lexical ones.

In this study, RAN was not associated with beginning spellers' spelling, but it was strongly associated with the spelling of the advanced spellers and all word types. This strong association for older children could potentially suggest that fast and accurate retrieval of the correct sequence of letters from memory is important for spelling. This finding supports previous results reported by Savage and Frederickson (2006) and Stainthorp et al. (2013) for older British children. This change in reliance could potentially support a move to lexical processing or in establishing more fully-specified representations (as suggested by Stainthorp et al., 2013)

The IST test used in this study provides a rich niche in comparison to other spelling assessments as it allows us to see the results students achieved in regular word, irregular word, and pseudoword spelling and to test models suggesting that there are distinct processes in spelling as well as reading (Barry, 1994). Indeed, our findings indicate that different processes are associated with different types of words and that even for the more challenging to remember irregular words, PA is seminal. PA's strong association with all word types might indicate that reading is not enough to master spelling. These results also support the notion that spelling might not be acquired in an incidental way, but explicit and direct instruction is also an essential factor (Cornman, 1902; Peters, 1985). However, one must treat these results with caution due to the sample size.

This study also examined spelling errors, as these can provide a better picture of the children's spellings, especially if accuracy is not very high. The errors were categorized as phonologically appropriate or phonologically inappropriate. Both groups (beginning and advanced) made more phonologically appropriate errors for irregular words rather than regular words. So, a strong regularity effect and influence of phonics training which is not an optimal strategy for irregular words was observed. In addition, as children gain more

experience with spelling, they make more phonologically appropriate errors as advanced spellers made more phonologically appropriate errors for both word types than beginning spellers. This suggests more effective use of the phonological system in comparison to the beginning spellers' performance.

Phonologically inappropriate errors were then divided into smaller clusters (omissions, additions, substitutions, transpositions, and unclassified errors). Beginning spellers had a higher proportion of these errors in comparison to advanced spellers. This was expected, with advanced spellers having two full years of education behind them. Beginning spellers' errors were mainly omission, substitution and unclassified in comparison to advanced spellers where most of the mistakes were omission and substitution. Unclassified errors played a much lesser role in advanced spellers' responses in comparison to beginning spellers. It is also interesting that the children presented a similar profile in the type of errors they made across the three word types tested. However, one should note that for irregular words, the beginning spellers made more unclassified errors than omission and substitution; the latter two categories, by contrast, were the primary type of errors made for regular words and pseudowords. This finding supports the idea that for irregularly spelled items, exposure to the words is not enough to master these; explicit teaching and direct instruction are important (Graham & Santangelo, 2014). In this study, only typically developing spellers were included; for children with literacy difficulties, the importance of practice, direct and explicit instruction for all word types is essential (Niolaki et al., 2020).

A small sample of children (N=42) participated in the study, and it was based on one school in the southeast of Ireland. A larger random sample of the general population of beginning and advanced spellers in Ireland would be beneficial in confirming the results. Also, with a larger number of participants, this study could have conducted regression

analyses to test further the associations between the variables. Advanced spellers did significantly better on most tests (literacy, spelling, cognitive tests) compared to beginning spellers, which was expected due to increased exposure to reading and practicing spelling. It was found that reading and PA were important spelling correlates for both grades. PSTM was also important for regular words and all words for the beginning spellers. For the advanced spellers, RAN was also a strong associate of conventional spelling. These findings suggest that age and experience are critical factors when looking at spelling associates and processes.

Educational Implications

The testing of different word types (regular words, irregular words, and pseudowords) provides information on a child's profile in relation to their strengths and areas of need in spelling. This provides information on challenges that students are having and allows for focused, tailored and appropriate intervention to be applied. Looking at phonologically appropriate and inappropriate errors using the different word types will further aid in identifying areas where instruction needs to be given to enhance spelling ability for the child. Phonics is important as it allows children to 'sound out' words which helps spelling and also reading. The systematic and explicit teaching of reading and phonics are important for the spelling process and being aware of letter-sound knowledge is important for this purpose. This was also proven to be the case by our research. What is interesting is the association (of course only correlational) with rapid naming, so games that involve oral and fast retrieval of letters that constitute words could be an addition for the daily teaching of spelling.

Being aware of phonology and orthography are all significant concepts in learning to spell. Taking a developmental approach will ensure all children are being taught at their appropriate level and not the 'one size fits all approach'. Spelling is as important in today's society as it was in previous decades, and accurate and appropriate spelling is important for

all ages and intellectual abilities. Looking at the different word types will provide further information to teachers and educators on how best to aid students' spelling.

Note: [1]Values were derived from Subtlex-UK (van Heuven et al., 2014)

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Table 1

Mean literacy and cognitive -related scores for beginning and advanced spellers (standard deviations are in parentheses).

Literacy measures	Beginning spellers (N=25)	Advanced spellers (N=18):	*ttest*
Single word spelling[1] (max.cor. 53)	13.84 (5.78)	24.17 (5.1)	$t(41)=6.05$, $p<.01$
IST total[2] (max.cor.106)	22.32 (13.5)	49.67 (24)	$t(41)=4.75$, $p<.01$
IST irregular[2] (max.cor. 36)	2.6 (4.38)	12.44 (8.3)	$t(41)=5.02$, $p<.01$
IST regular[2] (max.cor. 36)	11.28 (6.07)	20.22 (8.4)	$t(41)=4.04$, $p<.01$
IST pseudowords[2] (max.cor. 34)	8.44 (4.95)	17 (8.2)	$t(41)=4.24$, 8$p<.01$
DTWRP total[3] (max.cor. 90)	30.04 (16.65)	57.22(17.8)	$t(41)=5.13$, $p<.05$
DTWRP irregular[3] (max.cor. 30)	8.2 (5.98)	20.5 (4.6)	$t(41)=7.30$, $p<.05$
DTWRP regular[3] (max.cor. 30)	12.8 (7.14)	21.89 (5.5)	$t(41)=4.52$, $p<.05$
DTWRP pseudowords[3] (max.cor. 30)	9.04(4.54)	14.83 (8.5)	$t(41)=2.88$, $p<.05$
Sound-letter spelling[4] (max.cor. 32)	27.32 (2.36)	27.83 (2.5)	$t(41)=.68$, $p=.49$

Letter-sound recognition[5] (max.cor. 51)	39.56 (4.59)	42.17 (6.6)	$t(41)=1.53$, $p=.13$.
Cognitive measures			
PA[6] (max.cor. 20)	5.12 (4.1)	11.89 (5.2)	$t(41) = 4.79$, $p<.05$
PSTM[7] (max.cor. 30)	12.52 (4.14)	16.17 (2.5)	$t(41)=3.30$, $p<.05$
RAN[7] (secs)	28.48 (8)	22.89 (7.3)	$t(41)= 2.35$, $p<.05$

Note: [1]WIAT II (2005); [2]IST (Niolaki et al., 2019); [3]DTWRP (FRiLL, 2012); [4]DiST (Kohnen et al., 2009); [5]LeST(Larsen et al., 2015); [6]PhAB (Gallagher & Frederickson, 1995); [7]CTOPP (Rashotte et al., 1999)

Table 2

Correlation of literacy and cognitive assessments in beginning and advanced spellers; the upper orthogonal for the beginning spellers and lower orthogonal for the advanced spellers

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. IST total	-	.83**	.94**	.83**	.76**	.84**	.77**	.77**	. 83**	.46*	.54*	. 71**	.43*	-.11
2. IST irregular	.96**	-	.75**	.48*	.62**	.76**	.74**	.64**	.81**	.20	.47*	.73**	.34	-.22
3. IST regular	.98**	.93**	-	.68**	.72**	.83**	.77**	.80**	.75**	.50**	.55**	.64**	.51**	-.12
4. IST pseudowords	.94**	.82**	.89**	-	.63**	.85*	.49*	.56**	.62**	.47*	.37†	.52**	.25	.04
5. Single word spelling	.86**	.86**	.86**	.74**		.82**	.79**	.75**	.78**	.57**	.52**	.78**	.29	-.36
6. DTWRP total	.89**	.89**	.85**	.82**	.81**	-	.94**	.97**	.91**	.42*	.75**	.81**	.42*	-.20
7. DTWRP irregular	.79**	.77**	.73**	.79**	.72**	.95**		.86**	.77**	.35	.68**	.74**	.36	-.22
8. DTWRP regular	.87**	.85**	.85**	.81**	.75**	.95**	.90**	-	.84**	.46*	.81**	.74**	.46*	-.14
9. DTWRP pseudowords	.87**	.89**	.85**	.78**	.83**	.97**	.87**	.87**		.36	.57**	.81**	33	-.22
10. Sound-letter spelling	.32	.19	.3	.43	.3	.34	.25	.26	.4	-	.47*	.328	.02	-.28
11.Letter-sound recognition	.79**	.75**	.74**	.77**	.65**	.81**	.77**	.82**	.75**	.27	-	.66**	.07	.09
12. PA	.81**	.83**	.74**	.76**	.76**	.87**	.83**	.79**	.87**	.43	.83**	-	.31	-.20

13. PSTM	-.19	-.26	-.11	-.18	-.27	-.05	-.06	.05	-.1	.1	-.34	-.3	-	-.29
14. RAN	-.56*	-.55*	-.52*	-.53*	-.63**	.61**	-.61**	-.62**	-.56*	-.36	-.35	-.47*	-.01	-

Note: *p<.05, **p<.01, ***p<.001

Table 3

Beginning and advanced 'spellers' spelling error analysis (standard deviations are in parentheses)

	Beginning spellers (79% errors)				**Advanced spellers (53% errors)**				
Errors (%)	Irregular	Regular	Pseudowords	**Mean**	Irregular	Regular	Pseudowords	**Mean**	***Ttest*** [1]
PAE	19.46 (12)	10.84 (7.8)	-	**11.22 (.2)**	26.72 (18)	14.49 (14)	-	**17.63 (8.6)**	***t(42)=3.8, p<.001***
Omission	21.62 (12)	31.59 (12)	27.13 (13)	**28.7 (1.8)**	28.10 (20)	30.03 (18)	39.80 (22)	**34.86 (4.6)**	***t(42)=6.2, p<.001***
Addition	6.37 (5.6)	5.89 (7.6)	9.90 (7.9)	**6.80 (1.5)**	6.13 (5.8)	7.70 (9.5)	13.29 (12)	**9.98 (4.01)**	***t(42)=3.7, p<.001***
Substitution	20.19 (7.2)	22.93 (8.1)	30.17 (16)	**24.85 (5.1)**	33.60 (12)	36.51 (13)	44.38 (17)	**34.36 (4.1)**	***t(42)=6.5, p<.001***

Transposition	2.09	5.28	1.98	**4.33**	2.62	1.21	.60	**1.65**	***t(42)=5.1***
	(3.1)	(5.1)	(3.7)	**(2.2)**	(4.1)	(3.7)	(2.5)	**(.52)**	***p<.001***
Unclassified	30.15	23.63	27.10	**24.70**	2.78	1.11	.00	**.58**	***t(42)=61.2,***
	(23)	(17)	(24)	**(1.6)**	(4.4)	(4.7)	(0)	**(.56)**	***p<.001***

Note: PAE= Phonological appropriate errors, [1]t-test calculated based on the group-means