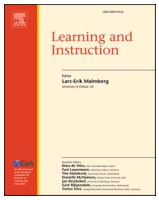
Learning and Instruction 80 (2022) 101635

Contents lists available at ScienceDirect

Learning and Instruction

journal homepage: www.elsevier.com/locate/learninstruc



Spelling predictors; investigating the role of phonological ability and rapid naming in a large cross-sectional British study

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ARTICLE INFO

Keywords:
Literacy
Spelling
Phonological ability
Rapid automatised naming
School-age children

ABSTRACT

This study aimed to identify predictors of single word spelling performance in children using a novel test containing regular words, irregular words and pseudowords. We assessed reading ability, letter-sound knowledge, phonological awareness (PA) and rapid automatised naming (RAN) in children aged 4–12 years (N = 641). Mixed model analyses with hierarchical nested data were conducted with Year_group (Yr R to Yr 6) included as a factor, PA and RAN as predictors, and reading and letter-sound knowledge as covariates. For irregular word spelling, PA and RAN were significant predictors, but the associations were dependent upon the year the children attended. Interestingly, for regular words and pseudowords PA was not significantly related. For pseudowords, only RAN was a significant predictor and only in Yr 2. We argue that a better understanding of spelling development can be achieved using tools that distinguish between regular and irregular words and pseudowords, as different processes seem to be associated with the different types of letter string across the variable levels of spelling experience.

Despite changes in the curriculum, only 75.5% of pupils in the UK currently reach the expected standard in reading and writing (Department for Education (DfE), 2019). Similar findings have been reported for US as only 86% and 79% (Grade 4 and 12, respectively) achieve at or above the basic writing levels in the National Assessment of Educational Progress (The Nation's Report Card, 2020). Being a competent writer and reader is also dependent on being a good speller (Graham & Santangelo, 2014; Niolaki et al., 2021). Children who experience difficulties during the process of learning to spell can be at heightened risk of written expression difficulties (Graham et al., 2002), may experience low academic self-esteem and expectations (see for both aspects, Niolaki et al., 2021; Terras et al., 2009), and may be prone to educational dropout and consecutively higher risk of unemployment (Barwick & Siegel, 1996; Korhonen et al., 2014). Therefore, it is important to be able to have a better understanding of how spelling should be taught and/or assessed and what predicts spelling achievement.

Until the pioneering work conducted by Read (1975), spelling was considered to be a rote learning activity where spelling learning was believed to be primarily a 'caught' incidental learning process rather than an explicitly 'taught' systematic learning task (Peters, 1967). However, the research of Read (1975), Frith (1985), Ehri (2014), Treiman, 2017 and others has demonstrated that spelling acquisition involves the application of phonological and orthographic processes in a systematic way. Perhaps surprisingly, the majority of schools in the UK

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https://doi.org/10.1016/j.learninstruc.2022.101635
Received 3 May 2021; Received in revised form 23 May 2022; Accepted 25 May 2022
Available online 3 June 2022

still teach spelling using rote learning techniques even though many teachers are concerned that learning to spell isolated words in spelling lists does not generalise to children's writing (Wray, 2014). Treiman, 2017 highlighted that spelling research is sparse in comparison with the research carried out on reading. Conscious attention to lower-level skills such as spelling can affect processing capacity and, as a result, interfere with other writing components such as text production and planning (Berninger, 1999). It is important to understand the factors that affect spelling, especially the language and cognitive predictors (such as reading ability, letter-knowledge, phonological ability and rapid automatised naming), as this can inform school practices and increase the number of children who become good spellers and, consequently, good writers.

English spelling, in comparison to other orthographies, is less transparent (Seymour et al., 2003), and for children, it takes far longer to master this multilayered linguistic skill in comparison to reading (Kroese et al., 2000). Currently, we are not aware of when children become more confident with spelling or master spelling skill, and we are also not aware if this competence differs according to different word types. Thus, in the present study we focused on spelling in children in the year groups spanning primary school, and using a tool that distinguishes between different types of printed letter string. The assessment comprises irregular words (e.g., *yacht*) that cannot be spelled accurately if someone uses sublexical processes, regular words (e.g., *impact*) that can be spelled accurately using lexical and sublexical processes, and pseudowords (e.g., *imbit*) which need to be spelled by sublexical processes. Essential to spelling is the ability to map sounds to letters; as soon as this is mastered, the production of familiar words becomes automatic, and children gradually build a lexicon of correctly spelled words (orthographic representations) (Stainthorp, 2019).

The theoretical framework adopted for the present research was the dual-route (DR) model of spelling (Barry, 1994), which proposes that children use both lexical-semantic and sublexical processes to spell. Research in support of the model comes from dissociations noted among surface and phonological developmental and acquired dysgraphia (Brunsdon et al., 2005; Rowse & Wilshire, 2007; Shallice, 1981). Surface dysgraphia involves selective difficulty with lexical-semantic processes, and phonological dysgraphia involves selective difficulty with subexical processes. The inclusion in the present study of an assessment that comprises regular and irregular words and pseudowords is a strength because analysing performance with these letter string types separately, and the association with literacy-related variables, can provide information about underlying processes involved in sublexical and lexical-semantic spelling. We can also investigate how the associations might change with age and school year group.

In the current study, we have defined spelling regularity in the same way as for reading, as such, regular items follow English phoneme-graphene correspondence rules (Rastle & Coltheart, 1999). Irregular words, such as *yacht*, will be misspelled if the child uses the most common letter(s) associated with each phoneme– i.e., <yacht> –> <yot> (see simplicity principle, Vousden et al., 2010; and Spencer, 2009); however, regular words such as <impact> would be correct. In categorising words as regular or irregular, we considered that the mappings for spelling are not always the same for reading. The phoneme-graphene correspondence system generates a number of possible spelling patterns ordered by the most common and phonologically plausible spellings (e.g., the vowel/i:/will generate in order: *ea, ee, ie* and *e-e*). This is also consistent with the phonics approach taught in UK schools; teachers emphasise phoneme-graphene correspondences and combine these with sight word recognition, morphology and etymology, the latter two mainly as children get older (Department for Education, 2013). A similar approach was followed in the development of the spelling tool, which is also based on how probable it is for a letter or letter combination to appear in the child's written language. For example, the word <habit> was classed as regular based on Spencer's (2009) spelling count for children because/b/is much more likely to be spelled with a single (probability 0.96) than a double <bb> (probability 0.0374).[1]

The use of different letter string items (irregular words, regular words and pseudowords) also provides an opportunity to test whether there are associations and dissociations between the different processes for spelling according to the DR model (Barry, 1994). For example, one would expect that if irregular words and pseudowords tap different processes (lexical/semantic and sublexical, respectively) that they will be less strongly related after controlling for the influence of year group. But as regular words tap both processes they might be strongly associated with both irregular words and pseudowords.

To gain a deeper understanding of children's spelling processes, we assessed children in the first years of formal education through to the last years of primary school. We assessed phonological awareness and rapid automatised naming (RAN) as the association of these skills with spelling ability for different letter string types can illuminate the processes children use for spelling.

The concurrent and longitudinal association of phonological awareness (the ability to recognise and manipulate speech sounds) with spelling has been well investigated and established in the past (Al-Otaiba et al., 2010; Caravolas et al., 2001; Moll et al., 2014; Niolaki et al., 2020). For English, spelling instruction has been found to lead to improvement in phonological awareness, the effect size of this association had been reported to be medium ($d = 0.51$) (Graham & Santangelo, 2014). However, the majority of studies focused on the early school years (age 4 to 7), fewer studies have focused on the upper grades of primary school (i.e., fourth and fifth grade) when spelling ability and sublexical and orthographic processes should be well established (e.g., van den Boer et al., 2015, for Dutch, and Nielsen & Juul, 2016; for opaque Danish). Nielsen and Juul (2016) found that phonological awareness (PA) was a powerful predictor of early spelling ability in Grade 2 but not in Grade 5. This might be interpreted as increased reliance on lexical-semantic processes rather than phonological spelling processes with age and literacy experience. In contrast, however, Caravolas et al. (2005) reported that in a cross-sectional study with Czech and English children (in Grades 2 to 5 and 2 to 7, respectively), PA was a strong predictor of performance for older as well as younger spellers.

There is also some evidence indicating that PA does not relate to spelling in early years (up to Grade 2), as reported by Georgiou et al. (2012). These researchers attributed the lack of longitudinal association observed in their study to their use of a blending task to assess PA. In this task, the children found it difficult to blend phonemes but not syllables. One would expect, according to the DR model, that PA should be important for spelling regular words and pseudowords and be less critical for irregular words, as the latter type of letter string is less predictable from sound-letter correspondences. We aimed to determine whether PA was associated with spelling ability in children aged four to 12. This age range covers UK Foundation/Key Stage 1 (Yr R up to Yr 2) and Key Stage 2 (Yr 3 up to Yr 6). The main difference between Foundation/Key Stage 1 (FKS1) and Key Stage 2 (KS2) regarding spelling pedagogy is that for the younger group, literacy instruction focuses on systematic synthetic phonics for reading; however, in KS2 teaching of

[1] Regularity and its definition can be considered somewhat subjective – regularity could be defined by the most frequent PGC, context-sensitive PGCs (e.g., soft 'c', long 'e' in the final position of monosyllabic words such as me, we etc., morphology such as prefixes and suffixes, and so the list goes on). What gets included is somewhat subjective. We have chosen what we consider a parsimonious definition (that also aligns to a reasonable extent with the phonics instruction children receive early in their literacy education), where we look at the most frequent PGC only (in a context insensitive way). Under this definition, words like 'try' would be irregular because the final long vowel sound is not usually spelled with a 'y'. Words like 'me', 'we', etc., would similarly be classified as irregular. 'Deadly' is irregular because the short vowel is usually spelled 'e' rather than 'ea'.

Table 1
Processes involved in English spelling (lexical/semantic and sublexical) and hypotheses.

	Lexical processes	Sublexical processes
Regular words	X	X
Irregular words	X	X to a lesser extent
Pseudowords		X
Reading all items (regular words, irregular words and pseudowords)	X	X
Letter_sound knowledge (sounds and graphemes)		X
PA	X	X
RAN	x (if tapping lexical processes)	X (if tapping sublexical processes)
Specific hypotheses	• We expected that spelling for all word types will improve as children progress in Year_groups (spelling experience and practice) and regular word spelling with be better than irregular and pseudoword spelling. • We also expected that as children progress in year groups real word (regular and irregular) spelling will eventually become better than pseudoword spelling (we do not have a prediction for a specific year group that this change will happen as this has not been explored in the past). • Reading should be strongly associated with spelling of all word types and for all year_groups. We expect that many processes involved in spelling will overlap with reading so that better readers will be better spellers. By covarying reading we can concentrate more clearly on the specific predictors of interest to this paper (PA and RAN) • Letter knowledge (sounds and graphemes) is expected to be strongly associated with pseudoword and regular word spelling for all year_groups as this variable is tapping sublexical processes. Therefore, it should be expected to be less strongly associated with irregular word spelling. • PA is expected to be associated with all word types as this variable is found to be strongly associated with spelling. This association should be stronger for regular and pseudowords rather than irregular words as children use systematic synthetic phonics as the main teaching medium (especially in the early years). • If RAN taps sublexical processes it should be associated with pseudoword spelling. • If RAN taps lexical processes it should be associated with irregular word spelling.	

spelling is more systematic, focusing on given lists of words that the children practice weekly. The words can be grouped based on a specific spelling pattern (e.g., <cian>) or just be tricky words that need to be taught following the look, copy, cover, spell technique.

RAN, the speed of naming familiar pictures, digits and letters, has been mainly assessed in relation to reading, and especially reading fluency, with strong associations reported between these constructs (Georgiou & Parrila, 2020). This can potentially be understood, as both RAN and reading (accuracy and speed) are associated with the automatic retrieval of visual-verbal information. The association of RAN and spelling ability has also been reported in several studies (Niolaki et al., 2020; Caravolas et al., 2012; van den Boer et al., 2015; Georgiou et al., 2012; Stainthorp et al., 2013). In a recent metanalysis using only studies with alphabetic orthographies, a moderate association was found between RAN and spelling ($r = 0.35$) (Chen et al., 2021). Caravolas et al. (2012) found that scores in RAN and PA at the onset of literacy instruction (mean age 5 years) predicted English spelling performance in participants 10 months later. Similar findings were reported by Georgiou et al. (2012), but only for RAN and spelling for Grade 2 children. Niolaki et al. (2020) also reported strong associations between RAN and spelling for young spellers (7 years old) but not for more advanced spellers (9 years old). Similar findings were reported for young spellers (Grade 1 and 2) of Dutch for real words and pseudowords with alphanumeric RAN (de Bree & van den Boer, 2019). Some studies have reported findings indicating that RAN may be associated with lexical-semantic, rather than phonological processes in spelling. Stainthorp et al. (2013), with a group of Year 3 and 4 poor spellers, found an association between RAN scores and irregular word spelling. The association between RAN and lexical-semantic processing was also supported by Bar-Kochva and Nevo (2019), who found that RAN (in kindergarten and Grade 1) longitudinally predicted Hebrew spelling in Grade 2. Hebrew is an opaque orthography, so sublexical processes cannot be relied upon to produce correct spellings (p. 116).

In summary, although past research in English has demonstrated an association between spelling skill and RAN, it is still not entirely clear whether RAN predicts both irregular word and pseudoword spelling, and which are the cognitive processes that underpin the RAN-spelling association. If RAN is primarily associated with spelling at the letter and letter cluster level and involves fast retrieval of information from orthography to inform phonology, one would expect that RAN will be more strongly associated with pseudoword rather than irregular word spelling (Niolaki et al., 2020; Caravolas et al., 2012; Georgiou et al., 2012; van den Boer et al., 2015). Conversely, if RAN taps orthographic knowledge primarily, it should be associated primarily with irregular word spelling (Bar-Kochva & Nevo, 2019Bar-Kochva & Nevo, 2019; Stainthorp et al., 2013), and should be more strongly associated with spelling ability.

In the current study, we also assessed the children on reading (de Bree & van den Boer, 2019; Georgiou et al., 2019) and letter-sound knowledge (Caravolas et al., 2001; Lervåg & Hulme, 2010) since these have been found to be strongly associated with spelling. In a metanalysis looking at the effect on reading of spelling instruction, Graham and Hebert (2011) reported an average effect size of 0.62 for the influence of spelling instruction on reading. Reading is considered to be a covariate that we aimed to control for, as many processes involved in spelling will overlap with reading so that better readers will be better spellers. By covarying reading we can concentrate more clearly on the specific predictors of interest to this paper (PA and RAN).

A large effect size was also reported for the influence of phonics teaching (which involves letter-sound knowledge) on spelling for kindergarten children (d=0.67) and first graders (d=0.32), but not for second through sixth graders by Hammill and Swanson (2006). Finally, in the current study we also tested children in sound-letter knowledge (Kohnen et al., 2009); this skill, although closely linked to spelling as it involves written rather than oral production, has not been tested in relation to spelling until now. Also letter knowledge (sounds and letter (s)) is an additional control variable tapping sublexical knowledge and an essential process for spelling. Therefore, it is important to explore whether after controlling for year_group, reading and letter knowledge the association between spelling of the different types of letter string still holds for PA and RAN or maybe the power is lost due to the influence of the control variables (de Bree & van den Boer, 2019).

1. The present study

In summary, little is known about predictors of spelling beyond the early years (about age 7). Current standardised spelling tests do not distinguish between different types of letter string. We assessed the contribution of reading and letter-sound knowledge and cognitive variables PA and RAN, to the spelling of regular and irregular words and pseudowords across different levels of spelling experience. In our study, the children were four to 12 years old. We aimed to see if the strong associations reported in the past between spelling and PA and spelling

Table 2
Number and age of participants per year-group (standard deviations are in parentheses).

	Yr R	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Foundation/Key Stage 1	Key Stage 2
Number of Participants	62	104	143	76	89	64	103	309	332
Age_years	4.9 (.32)	6.1 (.36)	7.1 (.67)	8.2 (.44)	9.1 (1.02)	10.1 (.33)	11.1 (.33)	6.34 (.95)	9.75 (1.29)

Note. Yr = Year.

and RAN will hold after controlling for year group, reading and letter knowledge (sublexical correspondences) and whether the strengths of the associations between the cognitive predictors and spelling will vary depending on the different letter string type. Finally, we aimed to assess whether the strong associations reported in the past for reading ability and letter-sound knowledge would hold for sound-letter knowledge and spelling ability. Based on the DR model (Barry, 1994) irregular word spelling should tap predominantly lexical/semantic processes, while pseudoword spelling should tap mainly phonological processes.

We expected, following past research, that children would spell regular words more accurately than irregular ones due to irregular word spelling drawing primarily only on lexical-semantic processes while regular word spelling draws on both lexical-semantic and sublexical processes. We also expected that the children would spell real words more accurately than pseudowords due to real-word spelling involving both lexical-semantic and sublexical processes, while pseudoword spelling draws on sublexical processes only. Table 1 provides a summary of the expected findings and hypotheses.

In addition, we anticipated that PA would be a strong predictor of irregular word, regular word and pseudoword spelling due to spelling being primarily a phonological encoding task. Previous findings on spelling predictors mainly concentrated on children aged 4 to 7, thus we could not be sure if the associations would hold for older children with more advanced spelling skill after controlling for year group. To the extent that RAN taps sublexical processes, it should be a significant predictor of spelling of regular words and pseudowords. If it is related to orthographic processes, it should be associated with irregular word spelling but not pseudoword spelling. Year groups were also expected to moderate the relationship between spelling and the literacy and cognitive predictors as Key Stage 1 children rely more on phonics due to teaching, whereas Key Stage 2 children have more experience with spelling the words which are now more automatically processed, and phonological processes have less prominence.

2. Methods

2.1. Participants

A total of 641 children (310 boys) participated in the current study. All children attended primary schools in England from Reception Year (Yr R) (age 4–5) to Year 6 (Yr 6) (age 10–12). We advertised our project through university workshops focusing on literacy and interested schools in learning more about spellings agreed to participate. Children came from seven different state primary schools (a combination of rural and urban settings) and from 25 different classrooms; data were collected in 2017 and 2018. Table 2 gives a breakdown of the year-groups and the participants' age per year and per group (Foundation/Key Stage 1 & Key Stage 2).

As part of their usual school practice, children were taught spelling and reading via phonics and letter-sound instruction initially (this formally starts in Yr R). As they progressed in the year-groups weekly spelling tests occurred where children had to learn approximately ten words for spelling using the *look-say-copy-cover-spell* technique. All parents/carers of the students who took part returned consent forms before testing took place, and children assented to participate in the study, according to the University's ethical requirements. There were no exclusionary criteria such as having English as an Additional Language or a special needs plan. So, the sample can be considered representative of the usual classroom population.

2.2. Materials

We investigated children's spelling using the Interpretive Spelling Test, which comprises subtests for regular words, irregular words and pseudowords. We examined associations with reading ability, letter-sound and sound-letter knowledge, and PA and RAN. The assessments we used are outlined next.

2.2.1. Interpretive Spelling Test (IST)

The IST comprises three sections: 36 irregular words, 36 regular words and 34 pseudowords. A list of the items is provided in Appendix A. Items were matched across the three sections on several psycholinguistic variables (e.g., zipfrequency[2] Kruskal-Wallis $\chi^2(1) = 0.66$, $p > .05$), number of letters ($\chi^2(2) = 1.78$, $p > .05$), phonemes ($\chi^2(2) = 0.28$, $p > .05$) and syllables ($\chi^2(2) = 5.85$, $p > .05$), Nsize ($\chi^2(2) = 0.46$, $p > .05$) and zipf contextual diversity[1] ($\chi^2(1) = 1.37$, $p > .05$)). We made sure that the items varied in frequency to be appropriate for beginning and more advanced spellers (mean zipfrequency: 4.42 *SD*: 1.05 range 1.17–6.35). The pseudowords were created by combining syllables from the regular word test items (e.g., <yesterday> <property> – <yesperty>).

The test re-test reliability of the IST is high (irregular words $\alpha = 0.97$, regular words $\alpha = 0.96$ and pseudowords $\alpha = .94$). Children in all the year groups spelled all 106 IST items (firstly the irregular words, followed by the regular words and finally the pseudowords). The test was administered as a spelling to dictation task. Individual target words were presented first, followed by a short sentence with the target item embedded, then the word was again repeated. For pseudowords, the items were repeated clearly three times. The first and second author scored all item responses for accuracy. Once scores were agreed between the two authors, a total score for each word type was awarded for each child. Spellings were scored one point for correct and zero if they were incorrect for regular and irregular words. For pseudowords, we created a bank of phonologically acceptable responses, which were used consistently in the scoring.

2.2.2. Sound-letter(s) spelling test

The Diagnostic Spelling Test (Department for Education, 2019) was used to test children's ability to spell sounds to dictation. The children had to spell in total 32 letters and letter combinations. The alphas calculated based on our sample were: Foundation/KS1 $\alpha = 0.99$ and KS2 $\alpha = 0.99$.

2.2.3. Reading accuracy

The Diagnostic Test of Word Reading Processes ((DTWRP) Forum for Research into Language and Literacy (FRiLL), 2012) was employed. The test has three sections: 30 irregular words, 30 regular words and 30 pseudowords. The children were presented with a card for each section and were asked to read the items aloud. The test incorporates a stopping rule of five consecutive errors. The alphas for our samples were high: Foundation/KS1 total items $\alpha = 0.99$, irregular words $\alpha = 0.99$, regular words $\alpha = 0.99$ and pseudowords $\alpha = .99$ and KS2 $\alpha = 0.98$; KS2: total items $\alpha = 0.98$, irregular words $\alpha = 0.99$, regular words $\alpha = 0.98$ and

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

Table 3
Mean scores, standard deviations and *N* per variable and grade separately (standardised deviations are in parentheses).

	Yr R[a]		Yr 1		Yr 2		Yr 3		Yr 4		Yr 5		Yr 6	
	N	*M*	*N*	*M*	*N*	*M*	*N*	*M*	*N*	*M*	*N*	*M*	*N*	*M*
IST[b]														
Irregular (%correct)	61	0.9 (2.7)	104	13.6 (15.5)	134	26.9 (21.5)	75	48.9 (22.3)	87	59.4 (22.9)	64	73.4 (21)	103	78.9 (14.2)
Regular (%correct)	61	9.2 (10.5)	103	36.2 (18.4)	142	53 (22.8)	75	70.4 (19.7)	87	77.2 (18.2)	64	83.9 (13.7)	103	87.7 (10.3)
Pseudowords (% correct)	61	7.8 (9.3)	103	41.2 (20.6)	138	46.4 (19.6)	75	57.1 (21.4)	87	70.6 (15.1)	64	68.1 (13.7)	103	77.7 (12.8)
Literacy correlates														
DiST[c] (%correct)	60	70.4 (19.1)	104	91.1 (7.7)	139	86.5 (11.1)	74	83.6 (11.6)	89	88.3 (8.6)	64	87.4 (11.2)	101	84.6 (15.9)
Reading (SS)[d]	60	108 (13.9)	104	112.1 (15.3)	139	107.6 (14.6)	76	110.9 (13)	88	109.8 (13.6)	61	115.1 (12.7)	100	111.8 (12.8)
LeST[e] (%correct)	61	61 (16)	104	86 (13)	142	89 (8.5)	76	86 (13)	89	86 (132)	64	85 (10)	101	87 (7.1)
Cognitive correlates														
PA (%correct)	60	9.1 (13.6)	104	26.9 (31.1)	137	36.3 (31.2)	76	55.1 (35.6)	88	74.2 (29.8)	64	82.7 (22.1)	100	85 (20.7)
RAN digits (SS)	60	10.5 (4.1)	104	12.1 (3.3)	139	12.5 (2.5)	76	11.95 (2.5)	89	10 (3.3)	64	9.8 (3.2)	102	11.4 (2.2)

Note.
[a] Yr R = Reception Year.
[b] IST Interpretive spelling test.
[c] Sound-Letter Spelling Test.
[d] Diagnostic Test of Word Reading Processes (Forum for Research into Language and Literacy (FRiLL), 2012).
[e] Letter-Sound Knowledge Test, Percentage correct are provided for IST, DiST and PA as Standard Scores are not available. For all other children, Standard Scores (SS) (based on published data) are provided with mean either 100, 10 or 0.

pseudowords α = .98.

2.2.4. Letter(s)-Sound Knowledge Test

The Letter-Sound Test (LeST, Larsen et al., 2015) is a 51-item test of grapheme (letter or letter combination) to phoneme knowledge. The child is presented with a card that contains the graphemes, and they are asked to provide the sounds they make. There is no stopping rule. The alphas for our samples were: Foundation/KS1 α = 0.99 and KS2 α = 0.99.

2.2.5. Phonological awareness (PA)

We adopted the Spoonerisms test created by Frederickson et al. (1997). The child listens to two words and has to swap the first sound of each word (e.g., "King-John" ->/jing/-/kon/). There are three pairs of practice items and ten word-pairs in total. Two discontinue criteria were applied: either three consecutive errors or else the testing time exceeded 3 min from commencement. The alphas for our samples were: Foundation/KS1 α = 0.98 and KS2 α = 0.98.

2.2.6. Rapid automatised naming (RAN)

The RAN digits sub-task from the CTOPP2 (Wagner, Torgesen, & Rashotte, 1999) was employed. The children had to name 36 digits as quickly and accurately as possible. The time taken was recorded in seconds. We did not test letter names as the younger children tend to mix them with letter sounds, and we aimed to use a measure suitable for all children. Also, we avoided RAN colors due to color blindness and also RAN digits has demonstrated stronger association with spelling rather than non-alphanumeric RAN (Donker et al., 2016). The RAN digits' alphas for our samples were: Foundation/KS1 α = 0.99 and KS2 α = 0.99.

2.3. Procedure

Children were tested in their schools in small groups for the spelling assessments and individually for all other assessments during the second term (of three) of the year. The youngest children were tested in small groups of no more than three children (1–3) per research assistant, and the activities took place over several sessions. For the IST, children were encouraged to spell any sounds they could recognise in a word, and no more than 10 to 15 words were spelled at a time. Data were collected and scored by trained Research Assistants who were supervised by the first author. In the case of multiple responses, the most accurate response was accepted. The percentage of missing data due to non-responses was 2.8% out of total data collected.

3. Analyses

As we had nested data mixed model analyses were used to examine predictors of spelling separately for each type of word (first irregular words, second regular words and third pseudoword scores as the dependent variables). For each, we compared two different models: one with nested data (classroom and school) and one without nested data, aiming to find which model provides a better fit. The predictors apart from PA and RAN were reading and the combined variable letter-sound knowledge. The latter two variables were included as control variables.

4. Results

We initially focused on predicting spelling accuracy from year group (with seven levels - Yr R, Yr 1 to Yr 6). For each word type, we ran two separate models – a mixed effects model with nested data (school and class) and one without, to assess whether the fit of the model could be improved. For irregular, regular words, and pseudowords the χ^2 differences between the mixed effects and non-hierarchical models were 8.08 ($p < .05$, $df = 1$), 57.11 ($p < .05$, df = 1) and 81.96 ($p < .05$, $df = 1$), respectively, indicating that accounting for the nested structure of the data, (school and classroom), improved the fit of the models significantly. All subsequent analyses, therefore, used mixed effects models to model the nested structure of the data (school and classroom).

4.1. Spelling accuracy and experience

Looking specifically at the effect of year group as a factor, three models were built for the three different word-types. Experience with spelling significantly predicted irregular, regular and pseudoword spelling scores, (F (1, 23.54) = 592.27, F (1, 21.77) = 260.65 and F (1, 21.01) = 123.42, respectively), such that irregular, regular word and

Table 4
Partial correlations controlling for year group between regular word, irregular word and pseudoword spelling accuracy and literacy and cognitive correlates.

	1	2	3	4	5	6	7
1. Reading[a]	–						
2. LeST_DiST[b]	.554***	-					
3. PA[c]	.543***	.287***	-				
4. RAN Digits[d]	-.422***	-.300**	-.168*	-			
5. Irregular spelling	.648***	.238**	.563***	-.219***	-		
6. Regular spelling	.771***	.437***	.535***	-.332***	.760***	-	
7. Pseudoword spelling	.638***	.464***	.480***	-.327***	.541***	.733***	-

Note. *$p < .05$, **$p < .01$, ***$p < .001$.
[a] Diagnostic Test of Word Reading Processes (Forum for Research into Language and Literacy (FRiLL), 2012).
[b] Letter-Sound Knowledge Test_Sound-Letter knowledge combined.
[c] PA=Spoonerisms (Frederickson et al., 1997) and.
[d] RAN digits (CTOPP-2).

Table 5
Mixed model analyses with irregular, regular and pseudoword spelling scores as the criterion variable.

	Predictors for Irregular words			Predictors for regular words			Predictors for pseudowords		
	b	*t*	r^2	*b*	*t*	r^2	*b*	*t*	r^2
(Intercept)	−1.2	-.65	*.02*	**−4.5**	**−2.6**	***.10***	**−4.3**	**−2.2**	***.08***
Year 1	**−5.02**	**−2.3**	***.09***	**5.09**	**2.7**	***.11***	**7.3**	**3.4**	***.14***
Year 2	−3.08	−1.1	*.04*	**9.7**	**4.2**	***.17***	**7.2**	**2.8**	***.11***
Year 3	-.04	-.01	*.0004*	**8.52**	**3.3**	***.13***	2.8	.93	*.04*
Year 4	−1.85	-.62	*.03*	4.28	1.6	*.06*	**7.8**	**2.6**	***.10***
Year 5	6.88	1.84	*.07*	**11.54**	**3.5**	***.14***	1.9	.51	*.02*
Year 6	**10.4**	**2.94**	***.11***	**15.14**	**4.8**	***.19***	**12.6**	**3.5**	***.14***
Reading[a]	**.26**	**15.2**	***.52***	**.24**	**16.1**	***.54***	**.15**	**9**	***.34***
LeST_DiST[b]	-.05	−1.08	*.04*	.06	1.4	*.06*	**.14**	**2.8**	***.11***
PA[c]	-.39	−1.78	*.06*	.06	.31	*.01*	.16	.74	*.03*
RAN Digits[d]	-.007	-.2	*.008*	.05	1.8	*.07*	.01	.41	*.02*
Year 1 * PA	.38	1.69	*.06*	-.17	-.86	*.03*	-.04	-.21	*.01*
Year 2* PA	**.71**	**3.09**	***.12***	.25	1.2	*.04*	.16	.73	*.03*
Year 3* PA	**.72**	**3.13**	***.13***	.24	1.1	*.04*	.15	.65	*.03*
Year 4* PA	**.81**	**3.48**	***.14***	.23	1.1	*.04*	-.02	-.11	*.004*
Year 5* PA	**.89**	**3.56**	***.14***	.11	.5	*.02*	.06	.27	*.01*
Year 6* PA	**.69**	**2.81**	***.11***	.02	.09	*.003*	.01	.04	*.002*
Year 1 * RAN	.07	1.34	*.05*	-.06	−1.2	*.05*	-.08	−1.58	*.06*
Year 2 * RAN	-.06	-.81	*.03*	**-.29**	**−4.1**	***.16***	**-.20**	**−2.51**	***.10***
Year 3 * RAN	-.05	-.54	*.02*	-.13	−1.4	*.06*	.08	.85	*.03*
Year 4 * RAN	.06	.47	*.02*	.11	1.1	*.04*	.09	.71	*.03*
Year 5 * RAN	**-.43**	**−3.01**	***.12***	-.17	−1.3	*.05*	.24	1.6	*.06*
Year 6 * RAN	**-.42**	**−2.7**	***.11***	**-.28**	**−2.1**	***.08***	-.22	−1.4	*.06*

Note.
[a] Diagnostic Test of Word Reading Processes (Forum for Research into Language and Literacy (FRiLL), 2012).
[b] Letter-Sound Knowledge Test_Sound-Letter knowledge combined.
[c] PA=Spoonerisms (Frederickson et al., 1997) and.
[d] RAN digits (CTOPP-2). All significant associations are in bold.

pseudoword spelling improved significantly with experience, $b = 5.14$, t (23.54) = 24.34, $p < .001$, [3,4] $r^2 = 0.98$, $b = 5.96$, t (21.77) = 16.14, $p < .001$, $r^2 = 96$ and $b = 5.48$, t (21.01) = 11.11, $p < .001$, $r^2 = 0.92$, respectively.

Pairwise comparisons with Bonferroni corrections were conducted for word type. These revealed that accuracy for regular words was significantly (*ps* < .001) higher (M = 21.6, SD = 10.8) than for pseudowords (M = 18.2, SD = 8.9) or irregular words (M = 15.4, SD = 11.7). Accuracy for pseudowords was significantly ($p < .001$) higher than for irregular words. Children were more accurate with regular words than irregular words in every year group ($p < .001$). Regular word and pseudoword accuracy were not significantly different for Yr R and Yr 1 groups. However, this difference was significant in each of the other year groups, with regular word accuracy higher than pseudoword accuracy (see Table 3). Irregular word accuracy was significantly lower than pseudoword accuracy up to Yr 4 (apart from Yr 3), but for Yr 5 and Yr 6, irregular word accuracy was significantly higher than pseudoword accuracy.

4.2. The relationships between word types

In order to understand how different word types might tap distinct processes, the next analysis focused on the relationships between the different word types controlling for year group (Table 4). It is noteworthy that irregular word spelling had stronger associations with regular word spelling ($r = .76$) than pseudoword spelling ($r = 0.54$) and this difference was significant ($z = 6.79$ $p = .001$). However, the association between regular word spelling and pseudoword spelling was stronger ($r = 0.73$) than the one between irregular word spelling and pseudoword spelling, and this difference was statistically significant ($z = 5.62$, $p = .001$) (Eid, Gollwitzer & Schmidt, 2011, p. 547). This indicates that irregular words are tapping different and distinct processes from pseudowords, and our findings based on these associations are consistent with models that propose the existence of different process – lexical/semantic for irregular words and sublexical for pseudowords. This is consistent with models that suggest distinct lexical and sublexical

[3] Effect size calculator Becker (1999) at https://lbecker.uccs.edu/.
[4] The formula used to calculate effect sizes for t was $\sqrt{\frac{t^2}{t^2+df}}$ (Field, 2018).

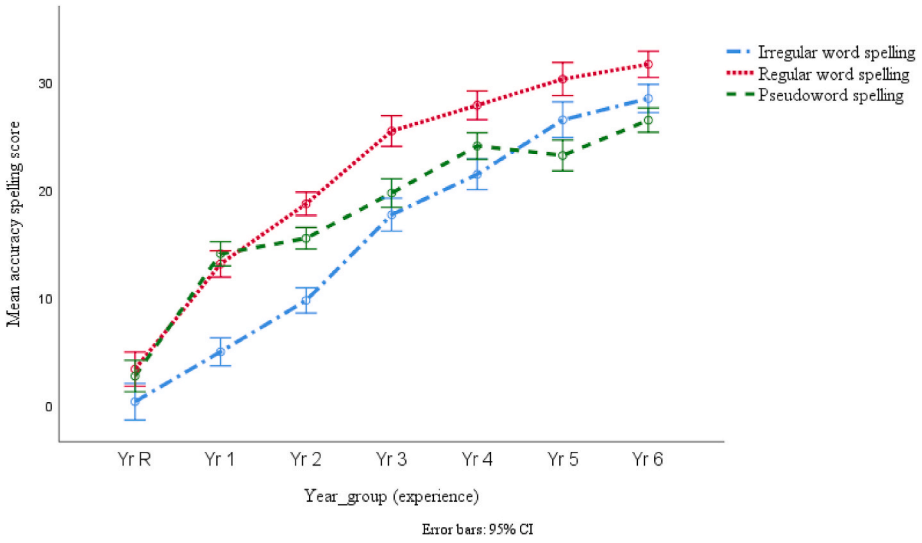

Fig. 1. *Mean accuracy spelling for regular, irregular and pseudowords and interaction with Year_group (experience).*

processes.

4.3. The changing effect of PA and RAN with experience

Our final analysis focused on the extent to which the cognitive variables (PA and RAN digits[5]), controlling for literacy-based predictors (DTWRP reading score and sublexical knowledge), predicted spelling accuracy for each word type, as a function of year group (experience). Sublexical knowledge was comprised of scores for letter(s)-sound knowledge and sound-letter(s) knowledge, as the two variables seemed to be tapping similar constructs ($r = .44$). Table 5 presents the results of the model analyses for each word type.

4.4. Irregular words

In terms of spelling progression across the year groups, the results indicate that there is an initial small decrease in performance from Yr R to Yr 1, but this trend is reversed such that by Yr 6 children's spelling has significantly improved relative to Yr R.

There is no effect of PA in Yr R; however, by Yr 2 and through to Yr 6, there is a significant change, such that the effect of PA is stronger than in Yr R. This can be seen visually in Fig. 2 with a visible increase in PA slopes as the year groups increase. Similarly for RAN, there is no effect of RAN in Yr R, but by Yr 5 and Yr 6 there is a significant change, such that the effect of RAN is stronger than in Yr R. This can be seen visually in Fig. 2, with a visible steepening in the RAN slopes as the year groups increase (with the exception of Yr 4).

In summary, children's irregular word spelling improves by the end of primary school, and there is evidence for effects of PA and RAN for more experienced children.

4.5. Regular words

In terms of spelling progression across the year groups, the results indicate that with the exception of Yr 4 children, spelling significantly improved relative to Yr R.

There is no effect of PA in Yr R, and the insignificant interaction terms indicate that this does not change with experience. Similarly, there is no effect of RAN in Yr R; however the effect of RAN is significantly stronger in Yr 2 and Yr 6 compared to the Yr R children. These effects are illustrated visually in Fig. 2. With the exception of Yr 4, the RAN slopes first change direction and then increase to Yr 6, relative to Yr R.

In summary, children's regular word spelling improves after Yr R, there is no evidence for effects of PA on regular word spelling after controlling for reading and sublexical knowledge, and there is evidence that for some children (Yr 2 and Yr 6), there is an effect of RAN on regular word spelling.

4.6. Pseudoword spelling

In terms of spelling progression across the year groups, the results indicate that with the exception of Yr 3 and Yr 5 children, pseudoword spelling significantly improved relative to Yr R.

There is no effect of PA in Yr R, and the insignificant interaction terms indicate that this does not change with experience. Similarly, there is no effect of RAN in Yr R; however the effect of RAN is significantly stronger in Yr 2 compared to the Yr R children. These effects are illustrated visually in Fig. 2, with Yr 2 showing the steepest RAN slope relative to Yr R.

In summary, children's pseudoword word spelling improves after Yr R, there is no evidence for effects of PA on pseudoword spelling after controlling for reading and sublexical knowledge, and there is evidence that for some children (Yr 2), there is an effect of RAN on pseudoword word spelling.

5. Discussion

The present study differs from previous research studies investigating single-word spelling performance in children (Al-Otaiba et al., 2010; Caravolas et al., 2001; Caravolas et al., 2005; de Bree & van den Boer, 2019; Georgiou et al., 2012; Lervåg & Hulme, 2010; Moll et al., 2014) in three main respects. Previous research primarily involved children in the early years of literacy acquisition and employed monosyllabic or short words that can affect the ecological validity of the results. We utilised a spelling test that has a balanced number of pseudowords, regular and irregular words, which vary in word length and where the words differ in frequency, and we collected data from a large sample of participants from seven school year groups.

Examining the children's spelling performance firstly for the three types of letter string, consistent with past research (de Bree & van den Boer, 2019), and with our hypothesis, we found that across year groups, children spelled regular words better than irregular words and

[5] Analyses with a transformation on RAN yield the same result (only untransformed data are reported).

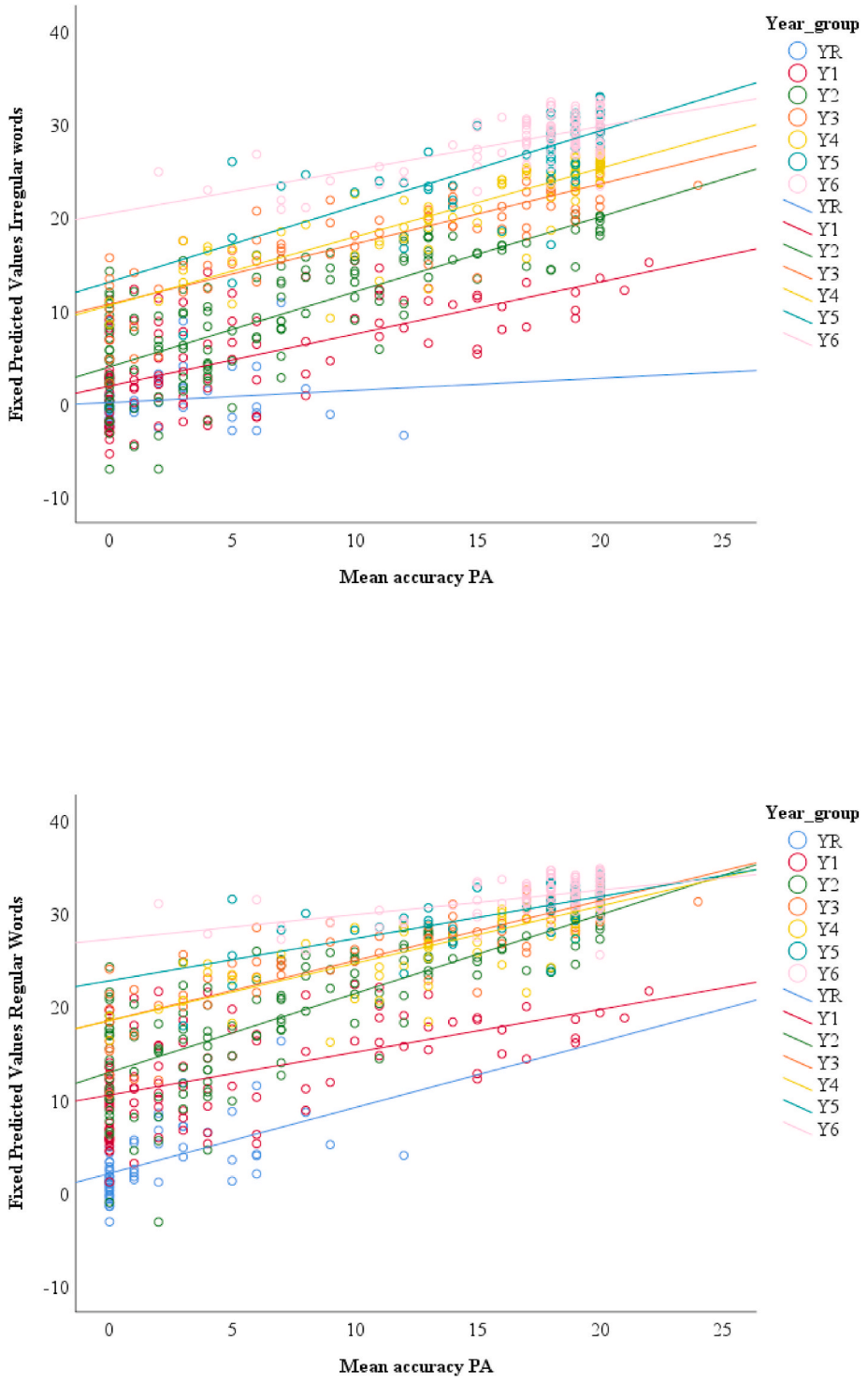

Fig. 2. Depiction of slope differences across the year groups for each predictor (PA and RAN digits).

pseudowords. Also, irregular word spelling demonstrated a stronger association with regular word than pseudoword spelling. Regular word spelling, which taps both lexical-semantic and sublexical processes, has a similar association to irregular word and pseudoword spelling (*p=ns)*. These findings are consistent with previous research (de Bree & van den Boer, 2019) and expectations from the DR model (Barry, 1994) - the dissociation observed between irregular words and pseudowords indicates reliance on different processes. By this, we do not suggest, there are clearly distinct processes for each of the three word-types; however, there is strong evidence that reliance differs, and children will use them to a greater or lesser extent depending on age and word type. This, of course, does not entail that these processes will necessarily be used exclusively. Looking at the results from the partial correlational analyses, reading was a consistently strong predictor of spelling and with large effect sizes, consistent with developmental models that propose a strong association between these two abilities (Ehri, 1997). Our results agree with de Bree and van den Boer (2019) as the influence of reading on spelling is more pronounced than the impact that cognitive and other

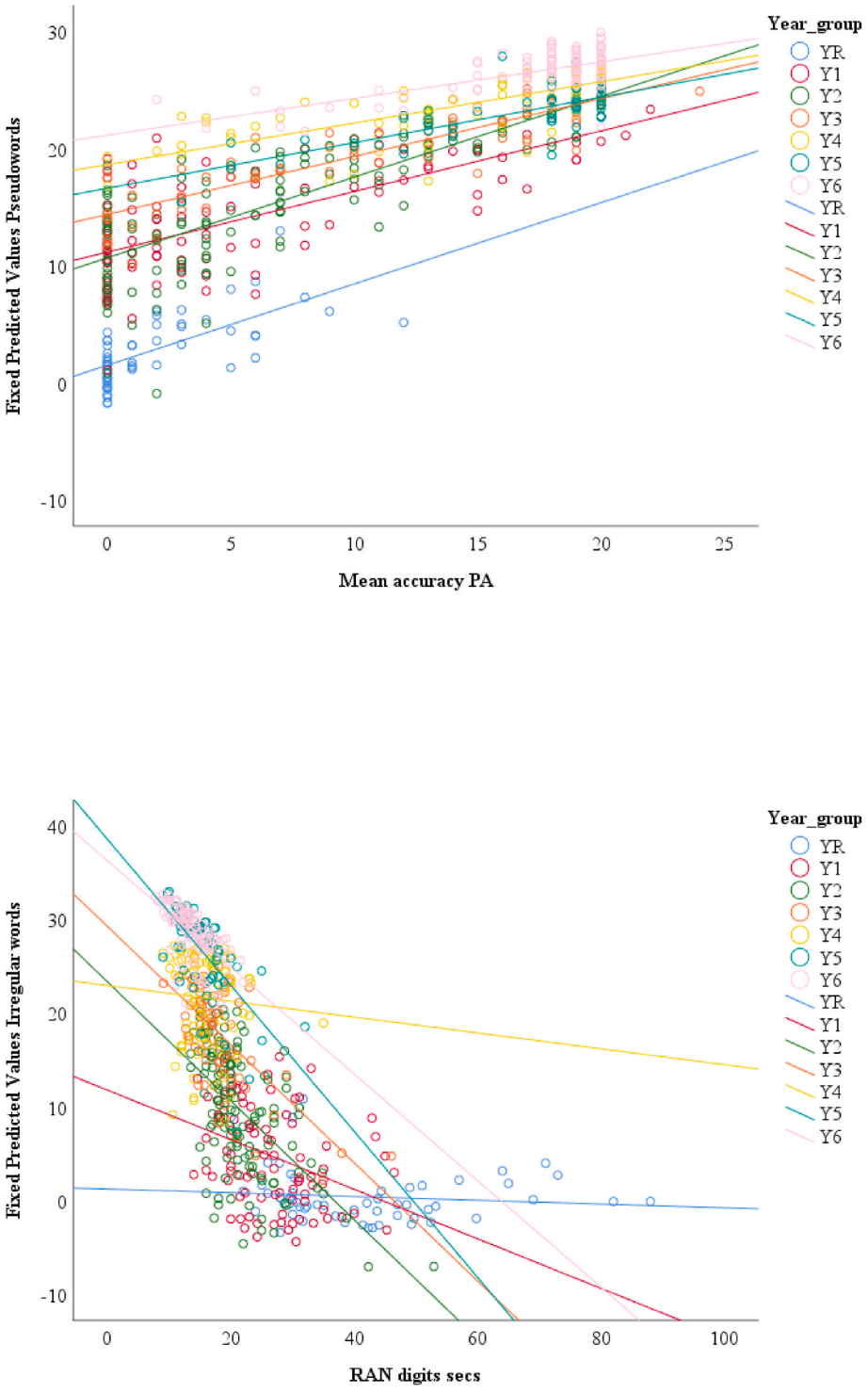

Fig. 2. (*continued*).

literacy variables (i.e., sublexical knowledge) have.

The division between different word types (irregular words, regular words and pseudowords) in the assessment of spelling in the current study further strengthens models that propose the distinction between different processes (lexical/semantic and sublexical ones, i.e., the DR model for spelling (Barry, 1994)). Even models, such as the IMP model that supports statistical learning (which is considered a powerful strategy in generalising learning in untaught items) agree that both sublexical and lexical/semantic processes exist. The IMP model, similar to the DR model, suggests that words can be divided into distinct regular and irregular (exception) categories (Treiman, 2018, p. 648). Our data speak in favour of these distinct processes as we can see a clear dissociation between irregular words (words that cannot be spelled via the sublexical route) and pseudowords (which can be spelled by the sublexical route but the lexical route will fail). The correlational results clearly show a low association between these two letter string categories.

Sublexical knowledge was a strong predictor of pseudoword spelling only. For irregular and regular words there was no association and for irregular word spelling specifically the sublexical knowledge coefficient

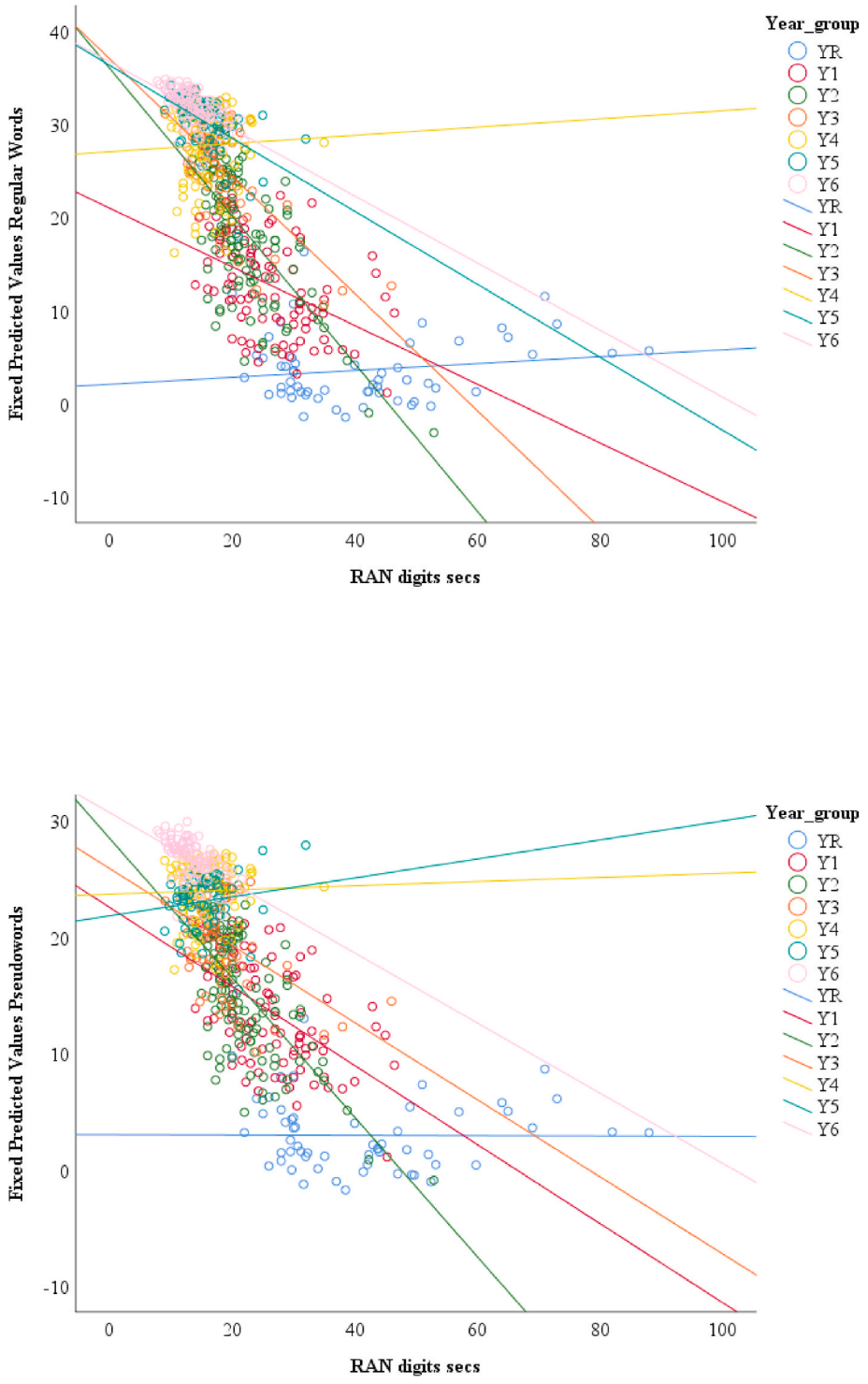

Fig. 2. (*continued*).

was negative, indicating that better knowledge was associated with worse performance in spelling irregular words. This ties in nicely with the DR framework (Barry, 1994), as words that do not reliably follow sound-letter correspondences, cannot solely rely on phonological processes. One can tentatively suggest that the strong and positive association with pseudoword spelling in our study could potentially indicate that letter and sound knowledge is a sublexically-related variable, but further evidence is needed. For irregular words, use of a sublexical strategy will not be appropriate as these words are not predictable from phonology; proficient spelling requires the mastery and integration of different skills, and phonology is not enough on its own to support accuracy. Arguably our finding of the significant contribution of sublexical knowledge to pseudoword spelling supports extant literature (Al-Otaiba et al., 2010; Caravolas et al., 2001, 2012; Georgiou et al., 2012) by highlighting the importance of sublexical knowledge for not only reading but also spelling performance (especially for pseudowords). However, we should note that for irregularly spelled items, as noted above, the association was negative, which indicates that overreliance on phonic skills for this year group is not an optimal strategy for irregular word spelling.

Consistent with this pattern of results, a recent simulation of the DR model indicated that regular words were self-taught via sublexical processes, whereas for irregular words, the need for additional contextual information was apparent (Pritchard et al., 2018). This could indicate that regular words initially rely more on the sublexical route, and as their retrieval becomes more automatic there is less reliance on phonological skills (sublexical knowledge). For regular words classroom experience across year groups (apart from Yr 4) was a significant predictor. This is reinforced by the fact that regular word spelling was consistently more accurate than irregular and pseudoword spelling. It also supports findings reported in several studies with older children (Niolaki et al., 2020; Nielsen & Juul, 2016). However, these studies did not include examination of different letter string types, and it appears important to do so as these relate differently to literacy-related processes.

The literature reviewed presents some conflicting findings regarding the association of PA with spelling. As the children become older there are indications that the strength of the association decreases with age (Nielsen & Juul, 2016). In the current study, we found a robust change in the association between PA and irregular word spelling with experience, as indexed by Year group, such that the effect of PA on spelling increased relative to Yr R. What is interesting is that PA did not significantly predict regular words or pseudowords in Yr R and this did not change with experience, which supports our previous argument that as retrieval becomes automatic there is less reliance on phonological processes for regular words. Only irregular words that require precise knowledge of the item to be spelled require reliance on memory and spoonerism as a task relies strongly not only on phonology but also memory, thus the strong association observed. The strong effects of PA on irregular word spelling is in accordance with most past research, which primarily focused on younger participants. This was evident even after controlling for reading and sublecxical knowledge (Al-Otaiba et al., 2010; Caravolas et al., 2001; Caravolas et al., 2005; de Bree & van den Boer, 2019; Lervåg & Hulme, 2010; Moll et al., 2014). However, our findings strongly suggest that there is need to control for the type of words included in the spelling assessments.

Our findings in relation to RAN are also very interesting. Relative to no effect of RAN on spelling in Yr R for all word types, RAN was a significant predictor of irregular word spelling only in Yrs 5 and 6. RAN was also predicting regular word spelling in Yr 2 and 6 and pseudoword spelling in Yr 2. Our results, therefore, agree with Lervåg and Hulme (2010), who found that RAN was associated with both real word and pseudoword spelling. However, this result, as we found, is affected by experience. Lervag and Hulme used objects and colors, and we used digits. This difference could have caused the stronger associations that Lervag and Hulme found with both words and pseudowords. That we found a strong predictive relation between irregular word spelling and RAN in the experienced spellers could suggest that it is associated with lexical-semantic processes (Bar-Kochva & Nevo, 2019Bar-Kochva & Nevo, 2019; Stainthorp et al., 2013) rather than sublexical ones. This is also strengthened by the association between regular word spelling and RAN in Yrs 2 and 6. However given there was an effect of RAN on pseudoword and regular word spelling in Yr 2 could suggest that there is also an association with sublexical processes (de Bree & van den Boer, 2019; Mehlhase et al., 2019; Moll et al., 2014; Nielsen & Juul, 2016; van den Boer et al., 2015). This means that RAN is important as the children advance in school to unitise at a fast pace the spelling patterns identified in irregular words. A speculation is that irregular words due to their phoneme-graphene inconsistences require well specified orthographic representation.

Our findings indicate that RAN and PA tap distinct constructs, which independently contribute to spelling skill. PA seems to be associated with lexical-semantic spelling processes, maybe due to the strong memory component included in the spoonerisms task. The finding that RAN was a significant predictor of regular and pseudoword spelling in younger children suggests that the measure of RAN we used taps sublexical processes, perhaps reflecting the ability to convert phonology to orthography speedily during spelling. The fact that RAN also predicted irregular and regular word spelling of advanced spellers indicates that RAN is independent from the strong effect of phonology due to instruction and an underdeveloped orthographic lexicon which characterise the young learners. Another potential explanation of the difference between PA and RAN is that PA does not require the same depth of knowledge about phonology to orthography correspondences as perhaps RAN does.

Interestingly our findings both support and contradict a recent metanalysis that explored the role of RAN and spelling, where the researchers found a strong effect of RAN with real word spelling rather than pseudoword spelling and stronger associations between opaque orthographies than transparent ones (Chen et al., 2021). In our study, the effect of RAN on irregular and regular word spelling was evident for more advanced spellers. However, there weas also an effect of RAN on pseudoword spelling for beginning spellers (Year 2), suggesting that it also taps sublexical processes. Therefore, this highlights the need to use more fine-tuned spelling tools.

The results for PA and RAN hold after we have controlled for Reading and sublexical knowledge. Reading in particular is likely to explain much of the variance in spelling – this can be seen from the size of the effect of reading on spelling for all three word types in Table 5. The fact that there are observable effects of RAN and PA after controlling for such a robust predictor further strengthens the claim that PA and RAN tap distinct processes involved in spelling. Also, it is worth noting that the effects of PA on spelling and the effects of RAN on spelling are very similar for regular and pseudowords, but qualitatively different for irregular words. This further supports a theoretical framework for distinct processes (lexical/sublexical), tapped by RAN and PA.

Our findings, although compelling, are not without limitations. Firstly, one should acknowledge that other important processes, such as morphological awareness and orthographic knowledge, were not assessed, and this is something that future research needs to pursue (McCutchen et al., 2014). Also, the pseudoword task was created by combining syllables from real words, which means that the stimuli were very word-like, which could have affected the results. However, creating the pseudowords in this way (following the construction procedure described in the DTWRP reading assessment) does have the advantage that they are more directly comparable to the regular words, as they are matched on length and contain the same phonological and orthographic information but without the semantic association. Another advantage of adopting this procedure is that the spelling and reading ability (using DTWRP) of children across the different letter string types is more comparable.

A further limitation might be the fact that we included only one measure each for PA and RAN in the present study, but the assessments we used have shown good reliability and strong associations with spelling in the past. The measure of PA that we adopted was spoonerisms, and it has been argued that this taps phonological memory as well as PA, but it is an appropriate measure to use to avoid ceiling effects, especially with older spellers (Landerl et al., 1997), which helped us make robust comparisons. Even for younger spellers (i.e., Foundation/Key Stage 1), for whom one might expect the task to be difficult to master; the reliability of the spoonerisms task was exceptionally high .98. An additional limitation is linked to the fact that we only calculated the total time taken to name all the items in the RAN task. In future studies, the time taken to name each item could be considered.

In the current study we chose to investigate the changing effect of PA and RAN as a function of school year group, rather than aligned with changes in the school curriculum. However, in the UK, the primary curriculum changes in Yr 3, essentially splitting the primary years into two stages: Key Stage 1 (Yr R - 2) and Key Stage 2 (Yr 3–6). Children in Key Stage 1 receive a strong phonics-based instruction programme, and in Key Stage 2 children typically develop effective knowledge of spelling rules (Venezky & Massaro, 1976). As stated in the National Curriculum,

encoding skills should be secure by Key Stage 2, and more emphasis is placed on morphology, etymology and whole-word acquisition of irregular or exception words (Department for Education, 2013). Thus, one might expect to see change as a function of Key Stage membership, rather than Year group. However, Fig. 1 shows quite regular (curvy) linear trend for all three word-string categories, following, at first sight, a somewhat different path (linear and second order component). If Key stage should matter, one would expect a disruption at Y3 which was not the case. The sharp difference occurs between Yr 4 and 5 where children become better in irregular word than pseudoword spelling. Maybe at this Year group onwards the lexical semantic system becomes more efficient and independent from the strong influence of phonology. As we saw earlier PA for regular word spelling is no longer seminal.

A final limitation that should be acknowledged is the fact that we did not use a speeded measure to assess reading, especially as RAN requires a timed response. It might have been the case that inclusion of reading fluency rather than accuracy could have subsumed the effect of RAN. This is something that could be considered for future research, although, due to the characteristics of English orthography, untimed reading can be considered relatively difficult, even for competent readers (Seymour et al., 2003).

6. Conclusion

Overall, our study demonstrates the importance of using a spelling tool that can reliably capture distinct spelling processes. For educators, it is important to know that spelling of irregular words takes more time to improve than regular word spelling, and PA seems to be a strong predictor of spelling skill for irregular words primarily. For remedial purposes, an assessment that differentiates among processes can help the educator identify the locus of a child's spelling difficulty and guide appropriate remediation. Specifically, teaching skills identified by the mixed model analyses such as PA, but also activities targeted at the different letter string types should be part of an intervention focusing on spelling. For RAN currently, there is not an intervention tailored to school practices, but as the ability to match orthography to phonology and the opposite seems to have a seminal contribution for the children it might be that training children to spell words not only in writing but also orally can be a way to consolidate the spelling of the word. It seems that RAN taps this ability to consolidate an automatic, accurate and high in quality orthographic representations (Bowers & Wolf, 1993; Stainthorp et al., 2013). Perception and production of the word through different sensory modes and via different playful practices can enhance the knowledge of the correct sequence of letters in a word (Niolaki et al., 2021). This study aimed to increase the understanding of the factors that affect spelling and, as a result, school spelling practices. We hope that increasing this knowledge will ultimately lead to more children who become good spellers and, consequently, good writers. In that way, we will help every child "*read like a butterfly and write like a bee*" (Pullman, 2002, p. 2).

Author statement

Georgia Niolaki: Supervision, Conceptualization, Formal Analysis, Methodology, Data curation, Visualization, Investigation, Writing, Original Draft & Reviewing and Editing.

Janet Vousden: Supervision, Conceptualization, Methodology, Data curation, Visualization, Writing, Original Draft & Reviewing and Editing.

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Jackie Masterson: Conceptualization, Methodology, Visualization, Investigation, Writing, Original Draft & Reviewing and Editing.

Acknowledgements

This work was supported by the [BA/Leverhulme Small Research Grant (2017–2019)] under Grant [number SG170586]. The authors are grateful to Coventry University undergraduate and postgraduate students for their help in stimuli selection and data collection, and the teachers, parents and children of the participating schools.

Appendix

Appendix A. List of irregular and regular words and pseudowords used in the IST

Irregular items	Regular items	Pseudowords
today	life	(practice item I) tep
other	best	(practice item II) ig
try	cup	shilf
young	check	fize
nature	tend	swem
search	list	prond
prove	shelf	chust
flavour	clip	tind
buckle	prize	lirst
dairy	fond	clep
coast	swept	lep
wheat	stem	ceck
moment	ground	bife
please	strong	lorty
country	perfect	impabit
people	without	withound
shoulder	scram	scade
deadly	grand	perout
fortune	habit	scrand
science	impact	greem
blazer	blade	spantern
autism	sporty	blarper
aspire	scarper	grong
addict	lantern	strofect
absolutely	probably	artivity

(*continued on next page*)

(*continued*)

Irregular items	Regular items	Pseudowords
together	understand	underbably
remember	yesterday	grastic
important	property	proterday
language	artistic	sudgement
station	gravity	jubside
neighbour	demonstrate	sombone
marvellous	sandwich	demowich
societies	subside	sandstrate
defence	judgement	yesperty
analyse	selfishly	trelfishly
councillor	trombone	prostand

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