Young Children's Spelling Representations and Spelling Strategies

Keywords: Spelling; Implicit; Explicit; Representations; Recognition; Production

Abstract

While traditional models of spelling describe the skills and knowledge required for development, the underlying cognitive processes that drive spelling success are often overlooked. Ninety-six English-speaking children, aged 5-to-7 years, completed two tasks which provided a direct measure of their spelling recognition and spelling production, respectively. Using a combination of performance measures and self-explanations, we assessed the relationship between children's performance on both the recognition and procedural tasks. Two separate hierarchical cluster analyses identified distinct profiles based on children's spelling recognition and spelling production, respectively. While these different profiles appeared related, log-linear analysis confirmed that the relations between recognition and production profiles were strongly moderated by children's spelling experience. Overall, the findings provide further support for application of the Representational Redescription (RR) and Overlapping Waves (OW) models in relation to young children's spelling acquisition within an English orthography.

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1. Introduction.

Spelling is a complex process that requires children to understand and apply rules of phonology and morphology (while recognising their exceptions) to build up orthographic representations of words. A number of theories have sought to provide domain specific explanations of spelling. Early theories of spelling development traditionally comprise stage-like formulations focussing on either the co-occurrence with reading (Frith, 1980) or spelling skill alone (Bear, Invernizzi, Templeton, & Johnston, 2000; Nunes, Bindman, & Bryant, 1997). Alternative approaches propose greater flexibility in how children acquire spelling knowledge, such as phase theory (Ehri, 1999, 2000) or item-based formulations (Share, 1995; 1999) which state that children can simultaneously coordinate phonological, orthographic, and morphological skills from quite early in their spelling development (Daffern, Mackenzie & Hemmings, 2015).

While previous theories have provided some understanding about the knowledge involved in successful spelling and the approximate order in which knowledge is acquired (Critten & Pine, 2009), less is known about the underlying cognitive processes that actually drive spelling development. The cognitive mechanisms underlying the development of spelling knowledge, or the nature of spelling representations, are often overlooked and the extent to which implicit/explicit representations drive spelling production requires further consideration (Critten & Pine, 2009; Steffler, 2001). One solution is to consider the application of more general cognitive models of development, including the Representational-Redescription model (Karmiloff-Smith, 1992) and the Overlapping Waves model (Siegler, 1996), to define the cognitive basis of spelling development. The present study sought to bring together both cognitive models for the first time to help explore the relationship between the representations and mechanisms required for early spelling acquisition.

1.1 The Representational Redescription Model

Despite suggestions around the implicit and explicit features of spelling knowledge (Gombert, 1992; Steffler, 2001), the nature of children's explanations and spelling performance at the implicit and explicit level remains underspecified. The Representational Redescription (RR) model of cognitive development (Karmiloff-Smith, 1992) describes learning as a process through a multi-representational system whereby implicit level representations of knowledge are redescribed into a series of more explicit representations (Levels E1, E2, E3). In the current study, we define the term 'representations' in relation to children's underlying knowledge and understanding of spelling units as indicated in their own verbal justifications and self-explanations. In line with the RR model, at the implicit level information is encoded in a procedural data-driven format and this knowledge cannot be *consciously* accessed or *verbalised* so procedural skills are devoid of conscious understanding. However, children may still achieve some degree of *behavioural mastery* or task success despite having no accessible or verbalisable knowledge of their successful procedures. Through sufficient practice, behavioural mastery of procedures occurs and knowledge is redescribed into more accessible explicit formats (E1). Explicit representations therefore signify later and more advanced development as knowledge can be consciously accessed, verbalised and generalised across situations. However, explicit level 1 (E1) procedures often produce a decrease in task success as contrary to evidence in the environment, abstracted theories may be over-applied leading to errors and causing to a U-shaped performance curve. Gradually at Explicit Level 2 (E2) these over-application errors start to decrease as greater acknowledgement of environmental information alongside the internalised theories enables a realisation that there are exceptions to the theories. Finally at Explicit Level 3 (E3) knowledge is now fully explicit not only leading to task success but the ability to apply this knowledge within and across domains in a flexible and creative way.

Very few studies have considered the application of the RR model in relation to spelling (Critten, Pine & Steffler, 2007; Critten, Pine & Messer, 2013; Lorandi & Karmiloff-Smith, 2012). In

one initial study, Critten et al. (2007) sought to understand how early representations underlie the phonological to morphological development of spelling. Using a spelling recognition task, five-to-seven year-olds were given 15 sets of three alternative spellings of a target word, (e.g., *lost, losed, losted*) and asked to identify which was the correct target word; to explain why their choice was correct, and why the other alternatives were spelled incorrectly. Children's knowledge and understanding was categorised as a predominant level of representation (RR levels: Implicit, E1A, E1B, E2, E3) based on their orthographic choices and their verbal explanations. Children's early explicit knowledge was denoted by theories that had been abstracted in relation to phonology (level E1A) and morphology (level E1B) and the over-application of these theories often resulting in phonological (e.g., choosing *kissd* instead of *kissed*) or morphological errors (e.g., choosing *losted* instead of *lost*). In contrast, children at Level E2 achieved higher recognition scores than those at level E1 and demonstrated both phonological and morphological knowledge for each explanation. Finally those few children categorised as Level E3, demonstrated excellent recognition skills and fully explicit verbal explanations for the choices made. While this study made a promising start in conceptualising early spelling representations using the framework of the RR model, no concrete evidence of implicit representations was found, and only knowledge of spelling recognition was explored.

In a subsequent study, and to address these earlier concerns, Critten and colleagues (2013) tested slightly younger children (5-to-6 year) compared to the previous study (6-to-7 years) and also incorporated an additional measure of explicit spelling production. Children's self-explanations on the recognition and production tasks were systematically compared. The first key finding was evidence of implicit representations where some children were able to achieve behavioural mastery, defined here as at least 70% accuracy in either the recognition or production of spelling items, despite being unable to explain the orthographic choices they made. On this basis, Critten et al. (2013) suggest that behavioural mastery in spelling is underpinned by the acquisition of implicit

representations reflective of early visual/logographic processes being present prior to the emergence of explicit representations that incorporate phonological information. The second key finding was that while the majority of children showed consistent performance across both the recognition and production spelling tasks, one group showed inconsistency by displaying more explicit knowledge in either the recognition or production task but not on both tasks together. While this finding offers an exciting glimpse into the possibility of identifying different groups of children based on their spelling knowledge and procedural skill, there is an important limitation. The production task prompted children to rely on just one particular spelling production strategy which was based on the correct or incorrect use of onset/rime (equivalent to analogy). The use of this specific and unconventional production task is an important limitation because it remains unclear whether these reported implicit and explicit levels of representations are in fact associated with other phonological or rule-based production strategies found in past studies (Farrington-Flint, 2015; Farrington-Flint, Stash & Stiller, 2008; Sheriston, Critten & Jones, 2016). Therefore, the relationship between spelling recognition and spelling production, in terms of the extent to which implicit/explicit representations might guide or constrain spelling production, requires further investigation in the present study.

There are two additional issues addressed in the current work that extends the findings of past studies. First, in both studies (Critten et al. 2007, 2013), analyses were conducted upon children's predominant type of representation (i.e. the level of understanding displayed most often) rather than considering intra-individual variation within each child's recognition scores across individual trials. Second, there was no real consideration of the role that age and prior spelling experience played in the level of explicit knowledge that children displayed. While Critten et al. (2013) suggest that implicit representations were associated with younger children neither studies actually explored year group effects on the early acquisition of spelling representations. These

limitations, alongside a closer examination of the connections between spelling recognition and spelling production abilities, are therefore addressed in the current work.

1.2 Overlapping Waves Model

The Overlapping Waves (OW) model of cognitive development (Siegler, 1996), rather than focussing on knowledge representations, describes how children apply new knowledge in relation to their explicit strategy choice. This model explores variation and adaptive change in children's domain-specific problem-solving strategies and proposes that children will use a variety of strategies to solve a problem, often choosing from a co-existing repertoire of procedures depending on the nature of the problem they are attempting to solve. Similar to the RR model of representation, some or all of these procedures and corresponding ways of thinking, may exist in parallel. The attributes of these strategies can occur, change and diminish at any time during development allowing children to shift from one strategy to another depending on which is deemed most appropriate at the time (Fazio & Siegler, 2013; Siegler, 1996). The frequency of strategies may also change, with children replacing simple strategies with those more advanced showing variability and adaptive choice.

A novel feature of this study is a direct test of the theoretical principles of both the RR model and OW model in relation to children's spelling development. While the RR model helps us to understand the state of spelling knowledge and how this changes, the OW model helps us to understand how knowledge can be applied in a variety of different ways to solve any given task. Therefore, an advantage of exploring spelling using both the RR and OW cognitive models is while the former concerns the acquisition and development of implicit/explicit knowledge, the latter considers how this knowledge is applied to solve problems and complete spelling tasks. This is not to say the two models are mutually exclusive as there is clearly an interplay between knowledge development and application in both contexts but there is a slightly different (if complementary) perspective of the learning process contained within each theoretical approach. In some ways, the

OW model will enable us to better understand how these different representational level(s) can be applied into different practical spelling strategies.

Unlike the RR model, however, there has been far greater emphasis on exploring the kinds of procedures involved in children's early spelling production (Farrington-Flint, 2015; Farrington-Flint et al., 2008; Kwong & Varnhagen, 2011; Sénéchal, Basque & Leclaire, 2006; Nunes et al., 1997). For example, Rittle-Johnson and Siegler (1999) provided the first attempt to apply the principles of the OW model to describe children's spelling strategies. A group of 5-to-7-year old's were asked to spell a set of 30 regular words and they also took account of children's self-reports to gain an insight into the spelling process. They found evidence of both an automatic retrieval of spellings from memory and a range of back-up strategies involving a more deliberate and considered process (e.g., use of small phonological units, analogy, morphology) which improved with age. The prominence of phonological and orthographic strategies appears to develop in line with children's spelling experience and instruction (Devonshire & Fluck, 2010). Kwong and Varnhagen (2005) explored children and adults' strategies in spelling nonwords using typing latencies and verbal self-reports in a longitudinal study which identified prominent shifts from back-up strategies to more direct retrieval methods. Finally, both McGeown, Medford and Moxon (2013) and Farrington-Flint et al. (2008), while demonstrating that young children chose from a range of coexisting strategies available, found developmental shifts in 6-to-8 year-old' spelling procedures with a move from phonological attempts to more consolidated orthographic strategies and retrieval from memory. The move towards more efficient consolidated spelling strategies is guided by children's acquisition of increasingly complex orthographic representations (Critten, Connelly, Dockrell & Walter, 2014).

There are key limitations in this area of research that are addressed in our current work. Despite providing a detailed understanding of the kinds of production strategies that children might employ during spelling, less is known about the underlying representations that might help to guide or constrain this spelling production. It is unknown, for example, whether those children with

implicit knowledge of spelling are constrained to less sophisticated procedural strategies or whether those with more advanced levels of knowledge can demonstrate the use of more sophisticated morphological rules to support their spelling production. It is argued that by comparing different-aged children's early spelling representations (as measured on a recognition task) against their explicit spelling production strategies (as measured on a production task) would provide a useful insight into concept-procedure interactions.

Furthermore, there is little by way of explanation for common characteristics of spelling, such as U-shaped development, or why children 'persist in using time-consuming back-up strategies that initially do little to improve performance' (Rittle-Johnson & Siegler, p.345). The perspective of the RR model would suggest it is likely that children's underlying implicit/explicit representations might account for U-shaped development in using spelling strategies, in as much as those children who persistently apply ineffective back-up strategies may hold level E1 rather than explicit E2 levels of spelling representation (Critten et al., 2013), although this interpretation requires investigation. Finally, there is scope for further examining the direct retrieval strategy in terms of whether it is always associated with production accuracy and whether it can be accompanied by explicit understanding of how/why a word is spelled as it is.

1.3 Present Study

This study will examine mechanisms of children's spelling in relation to both the RR and OW models of cognitive development for the first time as while there is growing evidence to support the application of both approaches in this domain, the relationship between children's spelling representations and production strategies remains unclear primarily because past studies have tended to consider spelling representations (Critten et al., 2007; 2013) and spelling procedures (Sheriston et al., 2016; Farrington-Flint, 2015; Farrington-Flint et al., 2008; Rittle-Johnson & Siegler, 1999) in isolation. Although Critten et al. (2013) did provide an attempt to explore possible relations between

spelling knowledge and procedures, they used an unconventional production task which failed to explore production strategies other than analogy. Therefore, the extent to which these different levels of spelling representations are related to a range of different procedural spelling procedures remains unclear. To address the limitations in past studies, we explored individual differences in young children's spelling representations (using a recognition task) against their spelling procedures (using a production task) across two different year groups to better understand the cognitive processes involved in the acquisition of spelling skills.

To assess the relations between spelling recognition and spelling production, four research questions were examined. First, to what extent do different-aged children show variation in their level of representations on a spelling recognition task? Second, to what extent to different-aged children show variation in their reliance on different procedural strategies in a conventional spelling production task? Third, in a comparison of the RR and OW models, what are the relations among children's spelling recognition and their spelling production strategies? Fourth, to what extent does year group moderate the relations between spelling recognition and spelling production?

2. Method

2.1 Participants

Ninety-six children from three different UK schools participated including 39 from Year 1 (*Mean* = 72.44 months, *SD* = 4.23) and 57 from Year 2 classrooms (*Mean* = 84.91 months, SD = 5.04). The schools were all mixed primary schools in the English Midlands, where families were predominantly white and from low/middle class backgrounds. Teachers confirmed that the children were being given spelling instruction in accordance with National Curriculum guidance specified by the UK Department for Education (2013) comprising systematic synthetic phonics work to build up knowledge of grapheme-phoneme correspondences. Children were also taught about frequent inflectional and derivational morphemes such as –ed and –er and orthographic units as part of the

literacy curriculum. The presence of typical spelling ability was confirmed using the single-word spelling subtest of the British Ability Scales III which showed that children in Years 1 and 2 were within normal range (Mean = 47.19, SD= 8.18 and Mean = 55.27, SD= 8.29, respectively). Typical oral language ability was assessed using the expressive vocabulary subtest of the Weschler Abbreviated Scale of Intelligence and showed that children in Years 1 and 2 were slightly higher than average (*Mean* = 112.67, *SD* = 7.53 and Mean= 109.94, SD= 14.46, respectively).

2.2 Measures & Procedure

All data was collected from each child individually in two forty-five-minute testing sessions. In session 1, children completed the BAS III spelling test, and the spelling recognition test. In session 2, the children completed the Wechsler Abbreviated Scale of Intelligence test before completing the spelling production test. However, to counterbalance the order of task presentation, half of the sample began with Session 1 and the remaining half began with Session 2. The time in between each testing session was no more than 14 days apart.

2.2.1. Expressive Vocabulary

A standardised measure of expressive vocabulary was included to ensure that the children had the appropriate oral skills to provide verbal explanations and justifications of the spelling items for the recognition and production tasks. Standardised vocabulary ability was measured using the expressive vocabulary subtest of the Wechsler Abbreviated Scale of Intelligence (WACI; Wechsler, 1999). Children were asked the meaning or definition for up to 30 single words that were orally presented by the experimenter. Children received 2 points for a complete answer or 1 point for a partially complete answer, e.g. for the word *shirt*, the response ‘you wear it’ would gain 2 points while the response ‘you put in on’ would gain 1 point. Wechsler reports internal reliability of .87 while the internal reliability score for our current sample was .85.

2.2.2. Spelling Ability

A standardised measure of single word spelling ability was included to ensure that the children had an appropriate level of spelling ability to participate in the study. Standardised single-word spelling ability was measured using the Spelling subtest of the British Ability Scales III (Elliott & Smith, 2011). Children were asked to write up to 75 single words that were orally presented by the experimenter. The task includes a variety of word types including nouns, adjectives, regular and irregular verbs and words including inflectional morphemes, e.g. *-ing*, *-ed* and derivational morphemes, e.g. *-ent*. Each word was presented three times: in isolation, in a sentence, then finally in isolation. Children received one point for each correct answer. Elliott and Smith report internal reliability of .96 while the internal reliability score for our current sample was .97.

2.2.3. Spelling Recognition Task

In line with past studies (Critten et al., 2007; 2013), an experimental spelling recognition task was used to elicit implicit and explicit knowledge of spelling units to identify the relevant levels of RR. Children were presented on a lap-top screen with 30 sets of words containing three alternative spellings, only one of which was correct (Appendix 1). Words and errors were originally derived from Nunes et al. (1997) and utilised by Critten et al. (2007, 2013) in the spelling recognition task replicated here. There were three word groups; regular past tense verbs, (e.g., *filled*,) irregular past tense verbs, (e.g., *sold)* and nonverbs, (e.g., *soft)*. Children were told the target word three times. They first heard the target word spoken by the experimenter in isolation before being presented in a contextually appropriate sentence and then finally presented for a third time again in isolation. Children were asked to identify the spelling that they thought was correct and provide a justification for their decision. Following each child's response, the experimenter pointed to the other two alternatives in turn and asked children to explain why they thought those spellings were incorrect. The order of presentation of each individual word was randomised across children to ensure the presentation of spelling items varied for each child. The session was audio-recorded to allow the authors to code each individual verbal explanation for later analysis.

Each child's spelling score and self-justification for the 30 sets of alternative spellings were individually transcribed for each child in relation to each target word (maximum score 30). Each was assigned to one of the representational levels (Implicit, E1A, E1B, E2, E3) as shown in Appendix 2 (Critten et al., 2007, 2013). The coding scheme carefully distinguishes between the implicit and explicit levels, where the former is characterised by no conscious awareness of phonological and morphological knowledge and the latter characterised by steadily increasing phonological and morphological knowledge that can be articulated.

The following example shows how the three verbal responses from the word set of *filled, filld, filed* was coded as one representational level (E1A) for a six year-old boy:

> Experimenter (pointing to screen): "Which of these is the correct spelling of filled?"
> Child: Points to the incorrect alternative 'filld'
> Experimenter (pointing to filld): "Why is this correct?"
> Child: "Because I sounded it out and it has two l's"
> Experimenter (pointing to filed): "Why isn't this spelled correctly?"
> Child: "Because it only has one l and an e"
> Experimenter (pointing to filled): "Why isn't this spelled correctly?"
> Child: "Because it has an e and it shouldn't"

For this word set it was decided that level E1A was the most appropriate level to code as the child had over-applied phonological knowledge to identify 'filld' as the correct alternative, had referred to some phonological knowledge in verbal justifications and showed an inability to understand the inflectional rule of -ed in either recognition or verbal justification.

In the present study the third author completed coding on a sample of 20% of participants, (carefully selected to cover examples from each of the six different representational levels across both year groups) and these scores were then rated by the first author. There was an overall

concordance rate of 90%, rising to 100%, following discussion and final agreement. Cronbach's alpha internal reliability confirmed a score of .82.

2.2.4. Spelling Production Task

A spelling production task was included to collect information about children's ability to spell the words they had been given in the spelling recognition task and about their ability to explain why they spelt the words in the way they did. Each child was orally presented with the same 30 target words that had been used in the recognition task (but presented in a different order) and were asked to spell each item without any visual prompts. Each child first heard the target word spoken by the experimenter, then presented in a contextually appropriate sentence, and lastly was presented for a third time in isolation. Children then wrote out each word on lined paper (numbered 1-30). After each attempt, children were asked to provide a self-report of the strategy they had chosen (see, Rittle-Johnson & Siegler, 1999). Each session was audio-recorded and later analysed to help categorise verbal self-reported strategies. The order of presentation of each individual word was randomised across children to ensure the presentation of spelling items varied for each child

The children's individual verbal explanations for each spelling item were transcribed and assigned to one of eight possible strategy types (see Appendix 3). The coding was based on both correct and incorrect responses. Unlike past studies which focus solely on retrieval and back-up strategies alone (Farrington-Flint et al., 2008; Rittle-Johnson & Siegler, 1999), we coded for three different kinds of retrieval-based strategies: (implicit correct, implicit incorrect and explicit retrieval). These different levels of retrieval were informed by whether children had accurately produced the spelling and could provide an explanation of how the word was structured in response to prompts. There were also five different procedural strategies: two comprising phonological information (either a small unit or large unit), morphology, analogy and other (no response, guessing). The third author coded a sample of 20% trials (carefully selected to include examples

from each of the eight strategy report types and across year groups) and these scores were then rated by the first author achieving a concordance rate of 100%. Cronbach's alpha confirmed an internal reliability score of .84.

3. Results

3.1. Children's Spelling Recognition

The children's spelling recognition accuracy, out of a maximum of 30 trials, ranged from 7 to 30 (out of a maximum score of 30) in Year 1 (*Mean* = 18.05, *SD*=6.48) and from 11 to 30 in Year 2 (*Mean* = 24.60, *SD* = 4.97). All children displayed at least one representational level relying on both implicit and explicit representations to aid spelling recognition and to justify their choices (see Table 1). In line with past studies (Critten et al., 2007; 2013; Nunes et al., 1997), very few children provided spelling justifications that were indicative of either the pre-implicit, implicit or E3 level but instead relied more on providing E1A or E1B level justifications. While children in Year 1 commonly indicated E1A level phonological knowledge (mean = 23.69), those in Year 2 demonstrated knowledge at both the E1A (*Mean* =13.38) and E1B levels (*Mean* = 13.98) with an occasional verbal explanations indicative of the E2 level (*Mean* = 2.05).

However, unlike past studies which identified predominant levels of representation and restricted children's performance solely to just one representational level (see, Critten et al., 2007; 2013), we explored individual differences in children's justifications across all thirty trials to help consider the coexistence of different levels of spelling representation. Hierarchical cluster analysis was used to identify distinct profiles based on children's spelling justifications on the spelling recognition task. Cluster analysis was chosen because this offers a valid statistical method of partitioning groups of scores based on the inter-relationships among a range of different variables and classifying them into meaningful groups (see, Farrington-Flint, 2015). Wards clustering algorithm was applied to the overall frequency scores for each of the six different representational

levels (e.g., pre-implicit, implicit, E1A, E1B, E2, E3). (Squared Euclidean Distance was used as the similarity measure rather than backward elimination because this provides a conservative measure of separating between scores). A three-cluster solution was selected accounting for 78% of the variance in all frequency scores (Table 2). (A four cluster solution was not chosen because of the formation of one small group comprising seven children). These three groups were partially ordered and distinct. (Labels are provided simply for ease of interpretation). The *E2 recognition* group (n=24) was the most sophisticated showing a variety of representational levels often providing explicit verbal explanations of phonological and morphological knowledge indicative of the E1B and E2 level. However, this group of children showed the most varied profile. Over thirty trials, they produced verbal explanations that corresponded to implicit and all explicit levels of representational knowledge. That is, on some occasions they produced explanations that were devoid of conscious insight or any explicit understanding of phonological theory (indicative of the implicit level) while on other occasions they showed a more advanced understanding providing clear explanations of morphological and phonological rules (indicative of E1B and E2 levels). This means that, in terms of orthography, both item-based and rule-based knowledge may be interlinked. The *E1B recognition* group (n = 33), in contrast, had a predominant E1B level of knowledge showing some understanding of both phonology and morphology, and morphological overgeneralisation errors by over-applying the -ed rule. Finally, the *E1A recognition* group (n = 39) provided explanations indicative of the E1A level and often made phonological overgeneralisation errors due to the predominance of phonological theory.

Insert Tables 1 and 2 about here

To further assess differences in spelling recognition accuracy among these three distinct profiles, a 3 x 2 ANOVA (recognition profiles x year group) was carried out (see Table 3). There was a significant main effect for year group ($F(1, 96) = 11.10$, $p < .01$) indicating that children in Year 2 were most accurate in identifying the correct written spelling of words. However, there was

no significant main effect for recognition profiles (F (1, 96) = 0.27, p =0.76) or any significant interaction between recognition profiles and year group (F (2, 96) = 1.03, p =0.37) indicating that children's spelling recognition accuracy was fairly similar across the three profiles.

Finally, to provide confirmation regarding the validity of these profiles, a direct discriminant function analysis was carried out. Discriminant function analysis is a powerful statistical tool which uses standardised coefficients to accurately estimate how well individuals are classified into three or more pre-determined groups (Tabachnick, Fidell, & Osterlind, 2001). We specifically used this technique because we needed to assess the relative accuracy of our classifications for each child within each of our recognition profiles. Wilk's Lambda revealed that there was a significant distinction among the three profiles (X^2 (12) = 233.57, p <.001) and correlation coefficients distinguished the *E2 recognition* group from the remaining two groups based on their E1A (r =-.73) and E1B spelling justifications (r = -.74). After removal of the first discriminant function, the model continued to discriminate between the remaining two groups (X^2 (5) = 15.55, p <.01) separating the *E1B recognition* group from the *E1A recognition* group on the basis of their pre-implicit knowledge (r =.31), implicit knowledge (r = .54) and E2 levels of spelling (r = .65). Overall, the model provided extremely accurate predictions for 87% for the *E2 recognition* group and 100% of the *E1B recognition* group and *E1A recognition* groups.

Insert Table 3 about here

3.2. Children's Spelling Production

Next we examined children's performance on the spelling production task (Table 4). Out of a maximum of 30 trials, children's spelling accuracy ranged from 0 to 25 in Year 1 (*Mean* =11.26,

SD = 6.19) and from 3 to 30 in Year 2 (*Mean* =18.88, *SD* = 6.70). No child relied on any one single strategy but instead reported using three or more different spelling production strategies across all trials. The most predominant strategy, across all thirty trials, for those children in Year 1 was their reliance on using small phonological units (*Mean* = 18.33) followed by either correct implicit retrieval (*Mean* = 4.10) or incorrect implicit retrieval (*Mean* = 3.44). Although small phonological units were most common within Year 2, those children also relied on their knowledge of analogy (*Mean* = 2.14) and morphological rules (*Mean* = 3.19). Explicit retrieval was rare, and was used on only four individual occasions by three children in Year 2.

The next step was to consider variation in children's spelling performance through the identification of different profiles based on their spelling production strategies. Similar to the recognition task, a hierarchical cluster analysis was used but this time to classify children's spelling strategy reports across all thirty trials on the production task. Wards clustering algorithm was applied to the overall production accuracy scores and the overall frequency for each individual strategy report across all trials (e.g., explicit retrieval, implicit retrieval correct, implicit retrieval incorrect, small unit phonology, large unit phonology, analogy, morphology). A three-cluster solution was selected accounting for 82% of the variance in scores (Table 5). (Labels are used for ease of interpretation). The *Rule-based spellers* (n = 41) had the highest production accuracy and relied on a range of approaches including small phonological units, analogy and morphological rules, indicative of using the phonological information of the displayed graphemes as well as attempting to retrieve larger word-subunits, such as analogies or morphological units, leading to accurate spelling production. The *Phonological spellers* (n = 35), were less accurate than the rule-based group and relied almost exclusively on applying small phonological units while the *Implicit spellers* (n = 20) relied on implicit retrieval processes and small phonological units with similarly low levels of accuracy.

Similar to before, we used a direct discriminant function analysis technique to assess the relative accuracy of the classification of children in each of these three production profiles. The analysis confirmed accurate classification of the three profiles with each of the original predictors (with the notable exception of large phonological units) differing significantly among the three profiles (X^2 (18) = 224.06, p <.001). The analysis discriminated the *Rule-based spellers* from the remaining two groups on the basis of their overall production accuracy (r = .64), their implicit incorrect retrieval (r = -.59), morphology (r = .36) and analogy procedures (r = .18). After removal of the first discriminant function, the model continued to discriminate between the *Phonological spellers* and the *Implicit spellers* (X^2 (8) = 96.75, p <.001) on the basis of small unit phonology (r =.81) and implicit correct scores (r = -.48). The model provided accurate predictions for 100% of the *Rule-based spellers*, 94% of the *Phonological spellers* and 95% of the *Implicit spellers*.

Insert Tables 4 & 5 about here

3.3. Relations among Recognition Profiles, Production Profiles & Year Group

Having identified individual differences in spelling ability, the final step was to consider relations among recognition profiles and production profiles within each year group using Bivariate Pearson correlations (see Table 6). First, based on children's performance on the spelling recognition task, there seems to be no significant correlations among children's overall spelling accuracy and any of the six representational levels within Year 1, but some association with pre-implicit level (r = -.41, p <.001), implicit level (r = -.37, p <.001) and E2 level (r = .29, p <.05) for those in Year 2.

Secondly, on the spelling production task, the children's overall production accuracy in Year 1 was moderately correlated to their self-reported use of explicit retrieval (r = .41, p <.001) implicit correct retrieval (r = .47, p <.001) analogy (r = .43, p <.001) and morphology (r = .53, p <.001). For those in Year 2, production accuracy was negatively correlated to a higher use of implicit incorrect

retrieval ($r = -.41$, $p < .001$), and small-unit phonology ($r = -.29$, $p < .05$) but positively correlated to a greater use of morphological strategies ($r = .51$, $p < .001$).

Finally, comparing children's performance across both spelling tasks, there is a moderate-to high significant relation between their overall spelling recognition accuracy and their overall spelling production accuracy in Years 1 and 2 ($r = .61$, $p < .001$ and $r = .83$, $p < .001$, respectively).

Insert Table 6 about here

To further assess these relations among recognition profiles, procedural spelling profiles and year group, we examined the percentage (and number) of children in spelling recognition profiles as a function of production profiles according to year group (see Table 7). There does seem to be an apparent relationship between the recognition and production profiles as children in the E2 recognition group also tend to show the most advanced strategies in production, and are classified as 'rule-based spellers' predominantly. Moreover, those children in the E1B recognition group tend to be slightly less sophisticated in production, and are classified as 'phonological spellers' predominantly. However there is a large variation in the breakdown of allocation across recognition and production profiles according to year group and this is particularly noticeable for children in the E1A recognition group. For those children in Year 1 the outcome is consistent with expectations as most children are classified as phonological spellers. However, for those children in Year 2 there is a surprising result as 68% (N=17) have been classified as 'rule-based spellers' and therefore their procedural skills are much more advanced than their representational levels.

To explore this effect of year group on the relationship between recognition and production profiles a hierarchical log-linear analysis was carried out using a three-way (3 x 3 x 2) contingency model (see Table 7). We chose in this instance to use hierarchical log-linear analysis because this is a relevant test for the analysis of multi-dimensional and multi-factorial categorical data, particularly when testing possible interactions among two or more categorical variables (Agresti, 1996). The

log-linear model used the backward elimination method from a full saturated model containing all one-way and higher order associations (see Table 7). Despite the significant correlations in Table 6 and the apparent relationship between recognition and production profiles in Table 7, the log-linear model revealed, once year group was taken into account, that the interaction between recognition and production profiles was not significant (X^2 (4) = 3.48, p =.481). Partial associations did, however, reveal a significant interaction between children's recognition profiles and their year group (X^2 (2) = 16.76, p <.001). Children in Year 1 were predominantly allocated to the E1A recognition group (60%), while those in Year 2 were allocated to the E2 recognition (44%) and E1B recognition (38%) groups. Similarly, there was a significant interaction between production profiles and year group (X^2 (2) = 15.10, p <.01) showing that while children in Year 2 were more likely to be *rule-based spellers* (63%), while those in Year 1 were likely to be among the *Phonological spellers* (57%) or *Implicit spellers* (30%). Overall, the results show how relations between recognition and production profiles are strongly moderated by prior spelling experience and schooling.

Insert Table 7 about here

4. Discussion

The present study brought together the principles of cognitive development proposed by the RR model (Karmiloff-Smith, 1992) and OW model (Siegler, 1996) for the first time to explore relations between early spelling representations and spelling production. Three key findings emerged. First, there was strong evidence of children applying implicit and explicit levels of representation to their spelling recognition leading to the identification of three distinct profiles. Second, distinct profiles were identified in relation to children's spelling production revealing three different groups based on the sophistication of their spelling production strategy choice. Third, while these recognition and production profiles appear to be somewhat related among children in Years 1 and 2, the strength of the relationship was moderated by spelling experience and schooling.

4.1. Spelling Representations and Procedures

The first key finding was the application of the RR model in relation to children's spelling using a recognition spelling task. Our findings showed that while children between 5-to-7 years had a strong explicit understanding of both phonological and morphological theory (E1B and E2) this was accompanied by a very low occurrence of either fully implicit or fully explicit (E3) representations (see Critten et al. 2007; 2013). However, unlike past studies which analysed predominant levels of knowledge and restricted one child to one representational type (Critten et al., 2007; 2013), we analysed their self-explanations across each individual recognition trial to explore individual differences in children's spelling knowledge. In doing so, three distinct profiles were identified based on their implicit/explicit spelling knowledge. Children in the *E2 recognition* group were the most sophisticated as they showed a flexibility and variety in the type of knowledge they demonstrated as well as having the highest recognition scores. They provided explanations that showed an advanced understanding of both morphological and phonological rules (indicative of E1B and E2 levels) as well as explanations that were devoid of conscious insight signifying access to automatized implicit representations for some words. Those in the *E1B recognition* profile showed a predominance of morphological theory signifying that these children were less flexible in how they approached the spelling task leading to morphological over-application errors of the –ed rule. Finally, those in the *E1A recognition* group were largely constrained to the E1A representational level and were therefore the least sophisticated as their spelling knowledge was dominated by phonological theory only leading to phonological over-application errors (see Table 2).

Similar variation in spelling ability was also evident in our analysis of children's performance on the spelling production task. In line with the OW model of development (Siegler, 1996), children showed variability in their choice of spelling strategies, with each child relying on at least three or more spelling strategies across all production trials. In line with past studies (Chen, Anderson, Li, & Shu, 2014; Nunes et al., 1997), there was a developmental trend with a move from

early phonological attempts to the use of more consolidated orthographic units, including the application of analogies and morphological rules across year both groups. A unique feature of the current work was our analysis of children's retrieval strategies by including explicit retrieval, implicit correct and implicit incorrect retrieval categories. In doing so, we found that while implicit retrieval was adopted fairly frequently, explicit retrieval was less common and largely occurred among the children in Year 2. That is, explicit retrieval as well as large phonological units and the application of morphological rules were most common among more competent spellers who had already built up correct orthographic representations required for automatised access (Ehri, 2000).

To explore variation of production strategies, cluster analysis identified three distinct and partially-ordered groups based on children's use of explicit spelling procedures (Farrington-Flint, 2015; Farrington-Flint et al., 2008). Children identified as *Implicit spellers* had relatively low levels of spelling accuracy and relied primarily on either implicitly retrieving words (more incorrectly than correctly) or occasionally sounding out using small grapheme-to-phoneme correspondence (GPC) rules. The *Phonological spellers* showed similarly low levels of spelling accuracy but relied almost exclusively on using a small unit phonological strategy while those in the *Rule-based spellers*, were the most accurate overall and drew on a range of co-existing strategies including both implicit retrieval as well as other procedures, including analogy and morphology. These different groups, indicating individual differences in spelling performance, suggest different pathways to children's spelling production which emphasise the increasing importance of acquiring phonological and morphological knowledge (Kemper, Verhoeven & Bosman, 2012; Nagy, Berninger & Abbott, 2006).

4.2. Relations among Spelling Representations and Spelling Procedures

An important contribution of the current work was the comparison made between children's recognition and production profiles. A pattern emerged suggesting that advanced levels of explicit

knowledge and understanding of spelling derived from the recognition task could also be associated with the most sophisticated and greatest variety of strategies used in the production task. For example, most children in the E2 recognition cluster were also predominantly classified as 'rule-based spellers'. However, as identified in the log-linear analysis, the relationship between recognition and production profiles was largely moderated by children's spelling experience (represented by year group). That is, once year group was included into the model, any previous association between recognition and production profiles could be accounted for by year group.

As expected, we found that children in Year 1 were among the least advanced profiles (the *E1A Recognition* cluster and the *Phonological spellers*) while those in Year 2 were often among the more advanced profiles for both spelling recognition (the *E2 and E1B profiles*) and spelling production (the *Rule-based spellers*). While age-related differences, or effects of schooling, have not previously been explored in relation to spelling and the RR model (see Critten et al., 2007), this finding does support past studies which have consistently found age-related improvements in children's procedural spelling strategies across similar year groups (Farrington-Flint et al. 2008; McGeown et al, 2013). Therefore, in developing spellers there is an interaction between level of conceptual knowledge and the ability to apply strategies effectively that is strongly moderated by children's age and spelling experience. However, one finding that should be noted here and taken into consideration regarding the effect of year group are the 17 children from Year 2 in the E1A recognition group (68%) that were classified as 'rule-based spellers'. This was a surprising finding in light of the trend present in the rest of the data, i.e. that conceptual knowledge may be equal to or lead procedural knowledge and may have prevented the relationship between recognition and production profiles from reaching significance once year group was taken into account. The implications are further discussed below.

4.3. Implications for Spelling Theories

While descriptive accounts of spelling elucidate the skills and knowledge required for success (Ehri, 1999, 2000; Frith, 1980), often the cognitive processes, and the representations underlying spelling development, are overlooked. In the current study, while we have supported the flexibility described in past studies of spelling, we have also identified the potential benefits of applying both the RR and OW models to define spelling within a cognitive context (Critten & Pine, 2009) by considering how conceptual knowledge and task-related procedures might interact. This provides a better focus on the multi-representational and multiple-strategy aspect of this domain and provides a more detailed understanding of why children spell in certain ways. For example, past studies into spelling production have often noted that children persistently use time-consuming back-up strategies that do little to improve their spelling performance (Rittle-Johnson & Siegler, 1999) or often make over-generalisation errors during spelling (Nunes et al., 1997; Varnhagen, McCallum & Burstow, 1997) despite showing, on other occasions, more advanced spelling procedures. However, with the inclusion of the RR model, it is likely that Karmiloff-Smith's notion of early theory abstraction and decrement in performance (U-shaped curve), may account for such performance with production being constrained to E1 rather than E2 levels of spelling representation. This would suggest that some internal reorganisation and active processing needs to take place for these explicit spelling representations to translate into effective procedural strategies (Critten & Pine, 2009).

The comparison of spelling performance on the recognition and production tasks has exposed the likely transitions that occur as developing spellers incorporate spelling knowledge and acquire schooling experience. For the majority, children showed a high level of consistency between E1B and E2 recognition levels and sophisticated spelling production skills whereby enhanced explicit representations could be seen to drive the production of spelling strategies. For others, their implicit levels of spelling knowledge might be constraining their ability to use advanced sophisticated spelling procedures on production tasks. This was largely dependent on year group and spelling experience. However, despite the suggestion that explicit forms of spelling knowledge might

drive the acquisition of spelling procedures; the current study was correlative, so no firm conclusions about possible concept-procedure interactions can be made without further detailed investigation. Certainly, within other domains such as mathematics, there is evidence that conceptual and procedural skills can develop iteratively over time whereby conceptual knowledge can develop first which further facilitates the acquisition of procedural skill (Rittle-Johnson, Schneider & Star, 2015). It is therefore likely that similar interactions might be found within the context of spelling.

However, the finding that a proportion of Year 2 children demonstrated procedural applications that was more advanced than conceptual understanding further complicates this theoretical position somewhat. This suggests that there may be differing interactions between concept and procedure exposing different routes to children's spelling success. Studying the transition between implicit/explicit spelling knowledge and spelling procedures is therefore likely to help inform our understanding of the underlying cognitive mechanisms that drive early spelling acquisition more clearly and should be the focus for future work.

4.4. Limitations and Future Directions

Although the current study has provided important information regarding the relations between children's implicit/explicit spelling representations and their spelling production strategies, it was correlative and focussed on a narrow age range of abilities. Despite some suggestion that spelling representations might drive forward children's production strategies, these concept-procedure interactions require further investigation. Furthermore, given the strong influence of year group, future work that explores the importance of spelling experience in relation to these concept-procedure interactions may also be required. For example, little is known about how younger children come to acquire these implicit representations and how they change over time (Critten et al., 2007) or how schooling experience and knowledge of spelling representations can influence spelling acquisition among other year groups (Critten et al., 2013). Future work might start to consider the

connections between these different forms of knowledge among different-aged children using a longitudinal design. For instance, given the early introduction of explicit literacy instruction within UK schools, and its strong emphasis on synthetic phonics, it is possible that implicit levels of spelling knowledge could be identified from a much earlier age (between 4-6 years) which might provide a far better understanding of young children's transition between their pre-implicit and E1A representational levels of spelling knowledge. A closer examination of spelling instruction in future training studies might also provide a better understanding of how these concepts and procedures interact over time and through explicit instruction (McGeown, Johnston & Medford, 2012). Within longitudinal training approaches, there is an opportunity to further examine the contribution of other cognitive measures, including vocabulary, non-verbal reasoning and morphological awareness, each of which has been found to predict spelling performance (Johnston, McGeown & Moxon, 2014). Again this would help to uncover what is driving the interaction between knowledge and procedures of spelling in addition to age effects. The present study indicated the importance of age but clearly it is those underlying skills that develop with age that are determining this finding and require further investigation.

Finally, there is an important consideration of the wider applicability of our findings both within the English orthography and beyond. The current word items (and recognition foils) were chosen in line with past studies (Critten et al. 2007; Nunes et al. 1997) indicating a relevance for 5-to-7 year-old's who have the appropriate phonological and morphological knowledge (and understanding of their exceptions) to complete these spelling activities. However, these items including verb spelling and adjectives within an English sample. It is also likely that changes in representational knowledge and spelling procedures may be further influenced by subtle changes in the orthographic features contained within regular, and irregular word items (Coyne et al., 2012; McGeown et al., 2013; McNeil & Johnston, 2008), and items that contain additional grapho-syllabic and morphemic spelling-sound units (e.g., *-ump, -tion, -ed, -ing*) (Devonshire, Morris & Fluck,

2013). Furthermore, although our findings are currently situated within English it is entirely plausible that the relationship found between recognition and production and the moderating influence of year group and spelling experience could be replicated in other orthographies. Past studies have found evidence of implicit versus explicit learning of morphological rules (e.g. Pacton, Fayol & Perruchet, 2005) and the need for both phonological and morphological production strategies (Jaffre & Fayol, 2006) in French. Given that English is considered an opaque orthography, it would prove beneficial to carry out cross-cultural comparisons between English and other morphologically complex orthographies (e.g. French) and shallow orthographies (e.g. Finnish) to assess how implicit and explicit knowledge and procedures vary for spelling more broadly.

Conclusion

In an attempt to apply the principles of the RR and OW model to children's spelling acquisition, we have shown a strong connection between children's emerging implicit/explicit spelling representations and their use of explicit spelling procedures. Children not only demonstrate flexibility in their representational knowledge of spelling, they also show flexibility in drawing from a range of different co-existing strategies to aid their spelling production. This relationship between children's recognition profiles and production profiles indicate that young children's spelling abilities might be underpinned by the acquisition of implicit/explicit forms of representations. The identification of different groups may underscore some of the different pathways to achieving spelling success and these profiles may have educational implications concerning how children are taught to spell (Gentry & Gillet 1993). Finally, a key finding concerns the relative importance of age and spelling experience which appear to moderate the relations between spelling representations and procedures. Both recognition and production profiles were influenced by year group suggesting that both constructs of spelling are highly dependent on children's exposure to words items and their own spelling experience.

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Table 1

Means (and SDs) for the Frequency of Justifications Allocated to Each of the Six Representational Levels on the Recognition Task According to Year Group

	Year Group	
	Year 1	Year 2
Pre-implicit	0.87 (3.02)	0.09 (0.34)
Implicit	0.69 (1.76)	0.31 (1.03)
E1A level	23.69 (7.43)	13.38 (9.43)
E1B level	4.21 (6.72)	13.98 (9.01)
E2 level	0.54 (2.08)	2.05 (4.03)
E3 level	00 (00)	0.16 (0.83)

Note. Maximum frequency score out of 30.

Table 2

Means and (SDs) for the Frequency of Representational Levels on the Recognition Task as a Function of Cluster

	E2 Recognition	E1B Recognition	E1A Recognition
Pre-implicit	0.72 (3.03)	0.04 (0.20)	0.30 (0.59)
Implicit	0.85 (2.01)	0.13 (0.34)	0.27 (0.72)
E1A level	16.31 (5.64)	4.87 (2.79)	28.61 (1.73)
E1B level	9.36 (5.16)	23.37 (3.08)	0.79 (1.41)
E2 level	2.56 (4.96)	1.46 (1.96)	0.03 (0.17)
E3 level	0.21 (1.01)	0.04 (0.20)	00 (00)
n	24	33	39

Table 3

Means (and SDs) for the Overall Accuracy Scores of the Spelling Recognition Task According to Recognition Profile and Year Group

		E2	E1B	E1A
	n	Recognition	Recognition	Recognition
Year 1	39	21.50 (4.95)	17.00 (5.37)	19.29 (8.17)
Year 2	57	24.14 (4.67)	25.60 (6.17)	24.88 (4.7)

Note. Maximum score out of 30.

Table 4

Means (and SDs) for the Overall Frequency of Spelling Strategies on the Spelling Production Task According to Year Group

	Year Group	
	Year 1	Year 2
Explicit retrieval	0.05 (0.22)	0.07 (0.32)
Implicit retrieval (correct)	4.10 (4.94)	5.82 (5.14)
Implicit retrieval (incorrect)	3.44 (4.49)	2.63 (4.10)
Small phonological unit	18.33 (8.87)	15.30 (7.71)
Large phonological unit	0.54 (1.19)	0.58 (1.32)
Analogy	0.51 (1.14)	2.14 (2.84)
Morphology	0.54 (1.41)	3.19 (4.00)
Other	1.59 (2.43)	0.14 (0.48)

Note. Frequencies based on all responses across thirty trials. Maximum score out of 30.

Table 5

Means and (Standard Deviations) for the Frequency of Reported Spelling Strategies on the Spelling Production Task as a Function of Cluster

	Rule-based spellers	Phonological spellers	Implicit spellers
Spelling Accuracy	22.78 (3.55)	10.83 (5.77)	10.55 (3.90)
Explicit retrieval	0.15 (.42)	00 (00)	00 (00)
Implicit retrieval (correct)	7.34 (5.75)	1.34 (1.71)	7.20 (3.74)
Implicit retrieval (incorrect)	1.39 (2.12)	1.09 (1.38)	9.45 (4.66)
Small phonological unit	13.32 (5.99)	24.46 (4.55)	9.25 (6.10)
Large phonological unit	0.80 (1.52)	0.60 (1.22)	00 (00)
Analogy	2.29 (2.99)	1.11 (2.00)	0.45 (0.95)
Morphology	4.44 (4.17)	0.54 (1.22)	0.10 (0.31)
Other	0.17 (0.54)	0.63 (1.52)	2.05 (2.78)
n	41	35	20

Table 6

Pearson Bivariate Correlations among Performance Measures on the Spelling Recognition and Spelling Production Tasks according to Year Group

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. WASI Vocabulary		0.15	-0.03	0.13	-0.14	-0.36	0.372	0.22	0	0.22	0.21	0.19	0.11	-0.01	-0.16	0.09	0.24
2. BAS III Spelling	.49**	--	0.48	0.27	0.27	0.43	-0.574	0.27	0	0.47	0.29	0.57	0.64	-0.63	-0.44	-0.05	0.25
3. Recognition score	0.3	.662**	--	-0.27	-0.18	-0.06	0.188	0.15	0	.61**	.36*	.37*	-0.12	-0.29	0.17	0.26	.54**
4. Pre implicit level	-0.05	-.338*	-.41**	--	0.17	-0.30	-0.145	-0.04	0	-0.30	-0.07	-0.11	-0.07	0.18	-0.13	-0.13	-0.11
5. Implicit level	0.09	-0.06	-.37**	0.22	--	-0.1	-0.21	-0.05	0	-0.15	-0.09	0.09	0.21	-0.17	-0.12	-0.05	-0.12
6. E1A level	-0.04	-0.03	0.04	.27*	0.19	--	-.83**	-.37*	0	-0.32	0.09	-0.13	0.15	-0.03	-0.01	-0.12	-0.22
7. E1B level	-0.08	-0.07	-0.13	-.29*	-.28*	-.88**	--	0.13	0	.47**	-0.03	0.18	-0.16	0.01	0.02	0.18	0.12
8. E2 level	0.25	0.25	.29*	-0.12	-0.08	-.39**	-0.06	--	0	0.19	-0.06	-0.03	-0.09	-0.06	0.29	0.07	.64**
9. E3 level	-0.01	0.02	0.19	-0.05	-0.06	-0.14	-0.13	.41**	--	0	0	0	0	0	0	0	0
10. Production score	.32*	.80**	.83**	-.45**	-.32*	-0.08	-0.02	.29*	0.2	--	.41**	.47**	-0.18	-0.25	0.25	.43**	.53**
11. Explicit retrieval	-0.08	0.27	0.21	-0.06	-0.07	0.08	-0.24	.40**	-0.04	0.25	--	0.21	-0.18	-0.10	0.09	.41**	.33*
12. Implicit Correct	-0.10	-0.09	0.14	-0.18	-0.18	0.08	-0.01	-0.09	-0.11	0.17	0.16	--	0.31	-.72**	-0.31	-0.23	0.13
13. Implicit Incorrect	-.32*	-.48**	-0.26	-0.07	-0.08	0.03	0.10	-0.25	-0.12	-.41**	-0.10	.44**	--	-.61**	-0.22	-0.20	-0.23
14. Small Unit	0.12	0.01	-.33*	.36**	.311*	0.18	-0.16	-0.18	0.03	-.29*	-.26*	-.69**	-.51**	--	0.08	0.05	-0.14
15. Large Unit	0.07	0.14	.28*	-0.11	0.01	-0.20	0.01	.42**	0.13	0.25	0.03	-0.19	-0.21	-0.12	--	.57**	.37*
16. Analogy	-0.03	0.01	0.18	-0.18	-0.19	-0.18	0.08	.31*	-0.02	0.22	.28*	-0.14	-0.23	-0.25	0.05	--	.36*
17. Morphology	0.223	.53**	.45**	-0.21	-0.14	-.32*	0.19	.36**	0.177	.50**	0.12	-.27*	-.37**	-0.25	.326*	0.14	

Note. Bivariate correlations (Pearson) are presented for Year 1 above the diagonal and for Year 2 below the diagonal. * = <.05, ** = <.01

Table 7

Percentage (and Number) of Children in the Spelling Recognition Profiles as a Function of Spelling Production Profiles According to Year Group

Year			Production Profiles		
			Rule-based spellers	Phonological spellers	Implicit spellers
Year 1	Recognition	E2	50 (1)	0 (0)	50 (1)
		E1B	9 (2)	56 (13)	35 (8)
		E1A	14 (2)	65 (9)	21 (3)
Year 2	Recognition	E2	64 (14)	18 (4)	18 (4)
		E1B	50 (5)	40 (4)	10 (1)
		E1A	68 (17)	20 (5)	12 (3)

Appendix 1: Alternative Word Sets used in the Spelling Recognition Task (Spelling Items Taken from Critten et al., 2007; 2013)

Word sets						
birded	bired	bird		felted	felt	feltd
called	caled	calld		dressed	dressd	dresed
founed	founded	found		toled	tolded	told
coverd	covered	covvered		leftd	left	lefted
filld	filled	filed		kissd	kissed	kised
cold	coled	colded		losted	losed	lost
fielded	fieled	field		Sent	sentd	sented
heard	hearded	heared		except	exceped	excepted
kiled	killed	killd		larfed	laughd	laughed
openned	opend	opened		sleped	slepted	slept
held	heled	helded		learnd	learned	lerned
soled	solded	sold		stoppd	stopped	stoped
ground	grouned	grounded		next	nexed	nexted
beltd	belt	belted		paintd	paint	painted
gold	goled	golded		softed	sofed	soft

Appendix 2: Representational Levels Coded for the Spelling Recognition Task (Coding Scheme Taken from Critten et al. 2007)

Level	Performance	Characteristics and typical verbal explanations
Pre-implicit	Accuracy <70% of the time	Total inability to justify any choices. Child has only a rudimentary understanding of letters and sounds. Will often not look properly at flashcards or will just continually pick a word in the same place on the cards, for example, all the words in the middle
Implicit	Accuracy in recognition is high, >70%	Inability to justify the correct choices or explain why error alternatives are incorrect: 'I don't know', 'It looks right', 'I have seen it before'. Other responses indicate a need to make any response: 'Why is filld wrong' (exp), 'because it has an l' (child). Of course, the correct spelling of filled has an l as well
E1A	Some correct recognition but also phonetic errors, for example, filld instead of filled, performance may drop from the I-level	Focus on aspects of phonology while morphological units, for example -ed, are not recognized. 'Why is filld correct?'(exp), 'because it has two l's' (child). 'Why is filled not right?' (exp), 'because it has an e' (child). Children remain at this level despite correct recognition if they only explain why words are correct/incorrect via phonology and not refer to –ed
E1B	Some correct recognition but also morphological errors for example, solded instead of sold	Focus on the morphological theory, for example, related to the rule of -ed that is consistently and sometimes inappropriately referred to: 'Why is slept wrong?' (exp), 'it hasn't got -ed' (child), 'Why is slepted correct?' (exp), 'it has an -ed' (child). Children remain at this level despite correct recognition explanations of errors via reference to the morphological rules if they fail to explain why words are correct
E2	Performance improves from E1 and is accompanied by understanding	More explicit verbal explanations of phonological and morphological knowledge. However, some inconsistency in explaining why words are correct. 'Why is filled correct?' (exp) 'it has two l's and an -ed' (child). Although the above response is by no means incorrect, further information could have been provided, for example, -ed was attached to the word fill
E3	Accuracy on par with the I-level. Absence of overgeneralisation errors	Complete understanding of the appropriate use of aspects of phonology and the -ed rule and the ability to fully verbalize these. 'Why is filled correct?' (exp), 'it has the word fill with an -ed on the end to make it past (tense)' (child). 'Why is solded wrong?', 'it has -ed and sold should not have it' (child)

Appendix 3: Strategy Explanations and Coding Explanations for the Spelling Production Task (Coding Scheme Adapted from Sheriston et al., 2016)

Strategy	**Explanation**
Explicit retrieval	Accurate spelling and clear justification of knowing the word already and having retrieved from memory 'I just knew how to spell it'. 'I have seen it before'. 'It's in my books' but when pressed can also provide a full answer as to how the word is spelt referring to aspects of phonology/morphology/analogy detailed below.
Implicit retrieval correct	Accurate spelling but cannot explain why or how they came to this answer and cannot explain how the word is spelt. 'I just knew it'.
Implicit retrieval incorrect	Incorrect spelling and cannot explain why or how they came to this answer and cannot explain how the word is spelt. 'I just knew it'. Further prompting does not elicit any further information
Phonology: Small-unit	Sounding out each individual phoneme separately, also known as letter-by-letter spelling: 'I sounded it out', 'I used the sounds', 'sold is spelt s-o-l-d'.
Phonology: Large-unit	A combination of sounding out a few phonemes individually and then a larger unit from memory 'I sounded out s-l to make sl and then added ept to make slept'.
Analogy	A similar word is used to inform the spelling of the target word 'I know the word ____ and this rhymes with it' or 'sold is like cold because they both have old at the end'
Morphology	Knowledge of a morphological rule is used to inform the spelling, 'I know this word ends in –ed', 'Filled has an –ed at the end even though you can only hear –d'.
Other	Unspecified strategy giving response of 'Don't know' or providing no response for incorrect answers.