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Spelling Development in Young Children: A Case of Representational-Redescription?

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Sarah Critten*, Dr Karen Pine* and Dr Dorothy Steffler**

*School of Psychology
University of Hertfordshire
College Lane
Hatfield
Herts
AL10 9AB
England

**Assistant Professor Psychology
Chair, Social Sciences Division
Concordia University College of Alberta
7128 Ada Blvd
Edmonton, Alberta
T5B 4E4
Canada

Author for correspondence: Email S.Critten@herts.ac.uk Tel +44 1707 284000

Abstract

Two experiments explored children's spelling development in the context of the Representational-Redescription Model (Karmiloff-Smith, 1992). Fifty-one 5-7 year old children (experiment one) and 44 5-6 year olds (experiment two) were assessed, via spelling production and recognition tasks, for phonological to morphological spelling development and representational levels derived from the RR model respectively. Children were allocated to one of the Nunes, Bindman and Bryant's (1997) stages for spelling production and to one of the representational levels derived from the RR model for spelling recognition and accompanying verbal justifications indicating their knowledge and understanding of spelling. These results are discussed in terms of how the R-R model accounts for the, hitherto unexplained cognitive mechanisms that underlie spelling development and the notion of multi-representation in spelling.

Key phrases: Spelling development, RR model

Spelling development in young children: A case of Representational-Redescription?

This study focuses on spelling development in young children and whether this can be understood in the context of Karmiloff-Smith's (1992) Representational-Redescription (RR) model (see Steffler, 2001). The RR model describes how knowledge is represented in the cognitive system and how this knowledge changes with development. This is the first study to investigate the validity of the model for understanding spelling development. We will briefly discuss current views from the spelling literature about how spelling develops in young children. Early stage models (e.g. Frith, 1985) proposed that children gradually become more sophisticated in their spelling passing from an early "alphabetic stage" based on phonology and letter-sound correspondences to a later more sophisticated "orthographic stage" where higher order knowledge about spelling is acquired.

Drawing upon this evidence and other more recent studies, Steffler (2001) concluded that a consensus has been reached within the literature, that spelling progresses from a visually based, phonological level, to a higher-order morphological level and then to a level where both of these aspects are taken into account, resulting in the correct production of spelling.

Nunes, Bindman and Bryant (1997) provided support for this progression with a longitudinal study over three years using groups of children, aged 6, 7 and 8. At each of three sessions, participants did a spelling test of 30 words consisting of 10 regular past tense verbs, e.g. *called*; 10 irregular past tense verbs, e.g. *slept*; and 10 nonverbs, e.g., *bird*. Their results suggested that children progress through five developmental stages when learning the spelling of word endings. At stage one the spelling of word endings

was found to be unsystematic and with little resemblance to either the end sound or to the conventional *-ed*. In some cases the last sound was not *spelt* at all. At stage two endings were frequently phonetic (i.e. *spelt* as they sound) and the conventional *-ed* was not yet used e.g., *kist*. This provided the evidence for the phonological stage Nunes et al. (1997) anticipated that is prior to the development of morphological understanding.

Stage three consisted of the use of some *-ed* endings but with overgeneralizations to irregular verbs and nonverbs, e.g., *sleped, sofed*. Nunes et al (1997) claimed these overgeneralization errors were of real significance and reported an unexpected finding. Although the 7 year-olds made more of these errors than the 8 year-olds, which would be expected, they also made more than the 6 year-olds which was not expected. Therefore some of the 7 year-olds, who could spell a word such as *soft* in the previous session, spelled it as *sofed* in the next session. This provided evidence for the possibility that spelling development progresses in a U-shaped manner.

Children in stage four of their model produced *-ed* spellings just in the past tense verbs with generalizations made only to irregular past tense verbs but not to nonverbs, so children at this stage might produce *sleped* but not *sofed.* Children in stage five correctly used the *-ed* ending for just the regular past tense verbs; no generalizations were made to irregular verbs or nonverbs e.g,. *kissed, slept, soft.* These last two stages reflect growing morphological understanding.

Thus it appears that spelling development follows a phonological to morphological pattern via a U-shaped developmental curve (as demonstrated by the apparent regression at age 7). However relatively few attempts have been made to describe the cognitive mechanisms underlying these descriptive stages of spelling

development or how the knowledge is represented in the cognitive system. Steffler (2001) made the case for understanding spelling development in the context of Karmiloff-Smith's (1992) RR model. This model has been shown to account for learning in other domains, such as physics, math and language (Karmiloff-Smith 1992), which can also follow a U-shaped developmental path. Not only does this model provide an explanation for cognitive development, in contrast to the age-determined stage models proposed by Piaget for example, the RR model advocates domain specific rather than domain general change. For example, development through the levels of the RR model for spelling would be specific to spelling (and possibly reading) but would not be indicative of similar development in other domains of learning such as numeracy.

The model will be outlined in brief together with Steffler's recommendations and its potential for explaining spelling development. Karmiloff-Smith (1992) argues that humans learn new facts and increase their knowledge by forming new representations of those already stored in the mind (innate or acquired) within specific domains. Therefore the representation is gradually redescribed, growing in knowledge and explicit understanding. She proposes a model with four levels of development whereby *understanding* follows a linear path but *ability* follows a U-shaped route.

The first level of representation is the Implicit level. Information is encoded in a procedural data-driven format, directly responding to stimuli in the environment. Characteristics of this level include:

- Task success or "behavioral mastery" which is achieved without understanding.
- Absence of conscious access to knowledge.
- An inability to verbalize knowledge or analyze it in terms of its component parts.

Steffler (2001) suggests this describes initial spelling ability where correct output can be achieved without any insight or understanding of the rules underlying the spelling system. For example, the ability to spell words correctly but without insight into *how* the different sounds fit together to form those words.

The second level of the RR model is Explicit level 1 (E1), where the process of redescription from implicit to fully explicit knowledge representations begins to take place. Characteristics of this level include:

- A change in emphasis from external data to internal representational change.
- The child focuses on abstracting a theory that takes precedence over any information in the environment leading to inflexible behavior and perhaps a decrement in performance.
- Absence of conscious access to knowledge or verbal report.
- The decrement in performance can be demonstrated by a U-shaped developmental curve as performance drops even though understanding has increased.

In terms of spelling Steffler (2001) proposed that level E1 is an explanation for the overgeneralization errors found by Nunes et al. (1997) e.g., *sleped, sofed,* as the morphological rules of *–ed* endings have been over applied.

The third level of Karmiloff-Smith's model is Explicit level 2 (E2). Characteristics of this level include:

- The achievement of balance as the representations held internally, (i.e., the theories formed) are integrated with the external data in the environment.
- An improvement in performance but with understanding – the child's internal theory no longer dominates entirely.

Steffler (2001 suggested that in spelling, children's overgeneralization errors will start to decrease and morphological rules will be applied correctly with greater regularity.

The final level of Karmiloff-Smith's model is Explicit level 3 (E3). Characteristics of this level include:

- Fully explicit knowledge representations that can be consciously accessed and verbalized to others.
- Flexibility and creativity in the use of knowledge and application to other micro-domains.

Steffler (2001) proposed that at this level, spelling performance improves again with but with more explicit understanding of the rules of spelling. At this level both explanation of the rules can occur and recognition of the exceptions to the rules, i.e., *-ed* is only for regular verbs and not for irregular verbs again as reflected in the Nunes et al. (1997) model (stage 5).

Steffler (2001) put forward an interesting case of how representational-redescription may underlie the development of phonological to morphological understanding in spelling and explaining why there may sometimes be a U-shaped development. Studies have tested the RR model in other domains and these may serve to highlight issues relating to spelling development. Karmiloff-Smith (1992) said that knowledge at level E1 and to some extent level E2, was not available for verbal report. However, more recent studies of the RR model (Pine & Messer, 1999) suggest this may not be the case.

Pine and Messer (1999) wanted to establish whether children's behavior on a balance beam task does indeed correspond to RR levels as suggested by Karmiloff-Smith

(1992) and Karmiloff-Smith and Inhelder (1974). In order to do this, 168 children (ages: 4-9 years) were asked to balance a series of beams on a fulcrum, some were symmetrical (would balance in the middle) and some were asymmetrical. The children were then asked to explain their success, or lack of. It was discovered that behavior on this task did correspond to RR levels. Implicit behavior was denoted by task success without conscious access to representations or verbal explanation. Fully explicit (E3) behavior demonstrated task success accompanied by verbal explanations as to how the different types of beams were to be balanced.

The most interesting finding was the behavior displayed at level E1. A high proportion of errors were demonstrated on the asymmetrical beams as children stubbornly placed all beams on the fulcrum at their center claiming that asymmetrical beams "could not be balanced". Children at E1 had therefore abstracted a "center theory" that was leading to errors. However, despite Karmiloff-Smith's (1992) belief that the abstracted theory at E1 would be unavailable for verbal report, 45% of children classified at E1 could explain their "center theory" referring to placing beams "in the middle" or "having both sides equal". Pine and Messer (1999) therefore suggested that E1 would take two forms: Abstraction non-verbal and Abstraction verbal. In studies of spelling, it might therefore be inferred that even at E1 children may be able to verbalize or articulate the rule they are using.

Another aspect of the model is the notion of a multiple-representational system whereby representations of differing levels of explicitation can be accessed. In the RR model even when representations are redescribed, the original representation still remains intact from the initial Implicit representations onwards. Support for this comes from the

finding that reading tends to be better than spelling (Holmes & Davis 2002). Are different representations being accessed for the reading and spelling of a word or different alternatives within one representation and is this why it is possible to read a word but be unable to spell it? It is therefore possible for children at level E1 to fall back on an implicit representation if the task faced is a difficult one. As Murphy and Pine (2003) explain, the RR model is not based on cognitive economy and all representations will continue to co-exist and may be available to the child. This could be applicable to spelling as children may hold more than one representation for words or even be at different levels for different types of words.

Studies by both Holmes and Davis (2002) and Murphy and Pine (2003) found that children's recognition of the correct way to spell words exceeds their ability to spell that word. Karmiloff-Smith's model may predict that, for recognition, an earlier implicit representation could be accessed, but when spelling the word or having to talk about the spelling, a more explicit representation at E1 may be accessed which may give rise to overgeneralization errors. These particular aspects of spelling will be investigated in terms of the RR model in the study to be described here.

The issue of how representational knowledge is organized within the cognitive system is also addressed by other models of cognitive development most notably Siegler's (1996) Overlapping Waves model. This model describes learning via a development of multiple strategies placing emphasis upon "cognitive diversity" (Siegler 1996, p.38). Rittle-Johnson and Siegler (1999) attempted to understand spelling development in terms of this model by exploring the different strategies that children use when they are spelling. Results demonstrated two main types of strategy: automatic

retrieval, (this may be similar to Karmiloff-Smith's (1992) Implicit level) and backup strategies where children had to work out the answers (e.g., sounding out, analogy etc.) Although these backup strategies produced a much lower rate of accuracy, children persisted in their use. Rittle-Johnson and Siegler regarded this as "surprising" (p. 345) but found it difficult to account for.

Questions arise from the spelling literature for which the RR model may provide answers. Stubborn use of a strategy or theory that actually decreases accuracy is explained by Karmiloff-Smith's E1 level. Children persisting in employing the spelling strategies that were failing to result in accuracy, for example, sounding out, may have emerged from an Implicit level by abstracting the theory that all words could be successfully spelled using this strategy. The fact that this is not the case is demonstrated by many words in the environment but the E1 child would not be assimilating this information: he or she would simply be over-applying that theory (resulting in errors) until the next level of explicitation is reached. This point is consistent with Pine and Messer's (1999) E1 level children who stubbornly used their "center theory" even for balancing asymmetrical beams. The RR model can account for this stubborn use of ineffective strategies in a way that Rittle-Johnson and Siegler (1999) could not.

In the present study, we tested a number of predictions arising from these theoretical questions. In experiment one, the first aim was to see whether spelling development does follow the phonological to morphological development pattern with the overgeneralization errors as specified by the Nunes et al. (1997) model. To do this, children aged 5-7 were first given a spelling test adapted from the Nunes et al. study. A further aim was to find empirical support for the levels of the RR model in the children's

understanding about spelling, in particular, when to apply the morphological convention of adding *–ed* to represent past tense, as well as exceptions to this rule. To this end, we gave the children a recognition test using the 15 words from the spelling test and their choices and justifications were used to assign each child to one of the RR levels. We predicted that each participant could be allocated to a level reflecting the possible mechanisms underlying spelling development as suggested by Steffler (2001). Children at the Implicit level would be characterized by behavioral mastery devoid of understanding. Children at level E1 would show evidence of overgeneralization errors and the use of an overriding theory such as the *–ed* morphological rule. Children at level E2 would show improvement in performance but incomplete understanding. Children at level E3 would show good performance and a full understanding of spelling rules and exceptions to those rules.

The third aim of the study was to compare recognition of the spelling words to how the children actually spelled them on the test. We predicted that recognition would be better than spelling as suggested by Holmes and Davis (2002) thus providing support for the notion of a multiple-representational system underlying spelling development.

In experiment two we address issues arising from the original study and extend the investigation to younger children. This will be fully presented and discussed following analysis of experiment one.

It is the aim of the present research therefore to build upon what has been achieved to date in understanding how spelling occurs, most notably in descriptive models such as that by Nunes et al. (1997). The difference here is that the reasons *why* change occurs will be explored and not just *how*. By using a framework of the RR

model, the notion of implicit to explicit change in spelling will be explored for the first time and the novel methodology of using children's explanations of their own understanding will play a large role in this. Finally this research will concern domain specific change in the spelling context rather than a more global pattern of intellectual development as proposed in the past by Piaget.

Experiment One

Method

Design

The participants were allocated to representational levels of spelling understanding post experiment, using the RR model as a framework. There were four dependent variables: Score out of 15 on the spelling production test, score out of 15 on the spelling recognition test, stage of spelling development (from 1 to 5) according to the Nunes et al. (1997) model and level of knowledge representation (from Implicit to E3) according to the Karmiloff-Smith (1992) model of Representation-Redescription.

We predicted that: Participants' performance on the spelling test would correspond to one of the five stages on the Nunes et al. (1997) model of spelling development, participants explanations would correspond to one of the levels derived from the RR model (Karmiloff-Smith 1992) in terms of their understanding of spelling and children's ability to recognize a correct spelling would exceed their ability to produce the correct spelling.

Participants

Parents gave written consent for the 51 children that took part from two different schools: Year 1: 23 participants (13 males and 10 females), age range 5 years 11 months

to 6 years 11 months, Year 2: 28 participants (16 males and 12 females), age range 6 years 4 months to 7 years 4 months. Data collection took place in June for the Year 1 children in the final term of Year 1 and in December for Year 2 children in the first term of Year 2. The overall mean age was 6 years 7 months. All children took part in both spelling production and recognition tests and all were tested with the same materials. Both schools were State-run mixed Infants schools in Hertfordshire where families are predominantly white. The children were all English-speaking and received spelling instruction in their schools in accordance with the UK National Literacy Strategy set down by the Department for Education and Skills (2001).

Materials

Spelling test.

The spelling test given to the 51 children in the first part of the study was administered to them in their class groups, one of 25 children and one of 26 children. The test itself was adapted from that given by Nunes et al. (1997) but reduced to fewer words due to the age of the children and at the request of the head teachers of the schools. The test consisted of five words from each of three categories, regular past tense verbs, irregular past tense verbs and nonverbs ending in /d/ and /t/ (15words overall) taken from Nunes et al. (1997) and five simple words that would not be included in the analysis. The latter ensured that even the least able children would achieve some degree of success. The 15 target words are included in Table 1. Simple sentences were also developed that included each word so that the word could be presented in context as well as alone. For the test the children were provided with a recording sheet that had 1-20 written down the

side. For the 51 children that completed the study, their performance on this spelling test was categorized at one of the stages of development described by Nunes et al. (1997).

Recognition test/Spelling alternatives

For the second part of the study the children worked with the experimenter on a one to one basis and were presented with 15 sets of spelling alternatives. All of the 15 words had been included in the first spelling test and therefore consisted of five words from each of the three categories. Each set contained three spelling alternatives of that word only one of which was correct (see Table 2). The errors were derived from those reported by Nunes et al. (1997). Each set was presented on a separate flash card approx 21cm (width) by 5.5cm (height) to prevent distraction. The position of the correct word on the card was randomly allocated in order to prevent a biased response set, as was the presentation of words from the three categories. The children were asked to point to the alternative on each card that they believed correct and these choices were detailed on a scoring sheet by the experimenter. The children were also asked to explain why they believed their chosen alternative to be correct and why they believed the other two alternatives to be incorrect and these verbal responses were tape-recorded. Each child's performance accuracy and recorded responses were then transcribed and coded in terms of Karmiloff-Smith's (1992) RR model

Procedure

The spelling test was presented to the children in their year-groups. The recording sheets numbered 1-20 were given to the participants who were informed that there would be 20 words they should try to spell. Words were presented in a suitable time according to the task, first in isolation, then in the context of the sentence and then in isolation

again. The words were presented in random order so that no patterns would be apparent. The spelling recognition part of the study took place over two days, one week after the spelling test. The participants were taken individually from their classes by the experimenter to another room and presented with the 15 sets of spelling alternatives one at a time. Participants were then told the target word they had to find on each card, e.g., *sold* and were asked to point to the alternative they believed it to be. They were then asked to explain why they thought it was correct. After this, the experimenter pointed to the other two alternatives on the card in turn and asked the participants to explain why they thought those spellings were wrong. Participants were informed that their contributions would remain confidential, and were thanked and returned to their classes.

Results

Spelling Test

Analyses of the spelling test were only performed on the 15 words taken from Nunes et al (1997) and found that the mean number of words correctly spelled was 6.53 (SD = 4.03). The children's spellings were coded according to the five stages of spelling development proposed by Nunes et al. (1997) so that each child could be allocated to one stage. The focus was on the word endings of each of the 15 spellings rather than whether the whole word was correctly spelled. Allocation to these was based on the numerical totals of three main aspects: number of correct phonetic endings, number of *–ed* endings, number of *–ed* overgeneralizations to irregular verbs and nonverbs (for full coding details see Nunes et al. (1997)

- Stage 1: No systematic approach towards spelling of word endings (less than half of the endings of irregular verbs and nonverbs to be spelled correctly).

- Stage 2: Word endings were phonetic but made no use of *-ed* at all e.g., *kist*. (more than half of the endings of irregular verbs and nonverbs to be spelled correctly, at least 3 phonetic transcriptions of regular past tense verbs, no use of *–ed*).
- Stage 3: Use of *-ed* endings but overgeneralization to both irregular verbs and nonverbs, e.g., *sleped* for *slept, sofed* for *soft.* (more than half of the endings of irregular verbs and nonverbs to be spelled correctly, at least three *–ed* endings at least one of which an overgeneralization).
- Stage 4: Improvement in the use of *–ed*, i.e. only applied to regular past verbs sometimes overgeneralized to irregular verbs but not to nonverbs. (more than half of the endings of irregular verbs and nonverbs to be spelled correctly, at least three *–ed* endings one of which can be an overgeneralization to an irregular verb).
- Stage 5: Use of *-ed* appropriately for regular past verbs and no examples of overgeneralization. (more than half of the endings of irregular verbs and nonverbs to be spelled correctly, at least three –ed endings but only for regular past tense verbs).

Table 3 shows that it was possible to allocate each participant to a stage of development as described by Nunes et al. (1997). Their longitudinal study used stages to plot a phonological to morphological development of spelling that they assessed from their data. Although we did not track development, in the present study we found evidence for the stages that Nunes et al. described therefore lending support to their phonological to morphological developmental spelling pattern. As expected, a chi-square Goodness of Fit test resulted in no significant differences in numbers of children at each

stage, χ^2 (4 n =51) = 5.57, $p < .05$, thus indicating that the children in our study were at varying degrees of development of phonological and morphological knowledge in spelling words ending in /d/ and /t/. It was important to have children at each stage of spelling development in order to test the validity of the RR model. Although not statistically significant, participants did have a tendency to spell words phonologically (stage 2). However, the frequency of participants in stages 3-5 shows some children had a growing understanding of the morphological aspects of spelling as well.

Table 4 indicates the number of correct spellings for children at each stage of spelling development. A one-way ANOVA was computed on the number of correct spellings at each stage indicating a main effect for stage, $F (4, 46) = 37.33$, $p < .05$. A Scheffé post hoc test demonstrated that the differences lay between stage 1 and stages 2-5 and between stage 2 and stages 4-5. This result seems to indicate two main steps in ability from stage 1 to stage 2 and from stage 3 to stage 5, encompassing a development that is initially phonological in nature, which then incorporates morphological knowledge and leads to a correct use of both.

A One Way ANOVA was also conducted upon the number of words correctly recognized at each stage and was also found to be significant: $F (4,46) = 9.06$, $p < .05$. A Scheffé test indicated that the differences lay between stage 1 and stage 5 and stage 2 and stages 4 and 5. This makes an interesting comparison to the production scores as even though progress through the stages is relatively linear again, even stages 1 and 2 have a success rate of above 50%. This rises to 80% at stage 5 thus indicating the greater recognition ability compared to production as highlighted in the earlier t-test which is

particularly apparent at stage 1 where production success is practically at floor compared to recognition success which is much more competent.

Recognition/ Spelling alternatives test

Analysis of the recognition aspect of the study began with a comparison of how well the children spelled the 15 words in the original spelling test and then how well they recognized them in the second part of the study. A paired sample t-test on number of correct responses indicated children performed better on the spelling recognition task than the spelling production task, $t(50) = 8.11$, $p < .05$ ($M = 6.53$, $SD = 4.03$ for spelling production and $M = 9.96$, $SD = 2.23$ for spelling recognition).

Participants' responses concerning why they thought certain words were either correctly or incorrectly spelt, were coded according to the levels of the RR model (Karmiloff-Smith 1992). Karmiloff-Smith's model consists of four levels as previously described: Implicit, E1, E2 and E3. Apart from level E1, coding for the levels corresponded to the original predictions derived from Steffler's (2001) recommendations. Implicit responses showed a complete lack of insight into spelling rules. Children were able to identify the correct alternative but failed to justify their choice or explain why the other two alternatives were incorrect. For example: girl aged 5 years

"Why is *laughed* correct?" (experimenter)

"I just know how to spell it" (participant)

"Why is *laughd* not spelled right?" (experimenter)

"I don't know" (participant)

In terms of the E1 level we originally thought that typical responses made by participants at this level may consist of the abstraction of a morphological rule such as -

ed. This rule would be stubbornly applied and result in overgeneralization errors to irregular past tense verbs and nonverbs. However, as the experiment was being conducted and the participants responses were being transcribed from the tapes, it became apparent that for many of the participants, level E1 was too broad and that actually, two distinct types of E1 seemed to exist. They are labeled here as E1A and E1B. This is not the first time that Karmiloff-Smith's model has been extended in this way, as described earlier (Pine & Messer 1999).

E1A described those participants who were not at an Implicit level as they were able to talk about spelling but were instead at a purely phonological level. Information about phonology had been abstracted from previous experiences but was overgeneralized resulting in children choosing alternatives that included phonetic errors as the correct spelling, e.g., *calld* instead of *called* The "theory" these participants were following was phonetic and *-ed* was hardly ever recognized as a unit in children's verbal justifications. For example: boy aged 6 years

"Why is *calld* correct?" (experimenter)

"because it has two l's" (participant)

"Why is *called* not right?" (experimenter)

"because it has an e" (participant)

E1B corresponded to the original prediction of what level E1 would be like. E1B describes those participants who again, were not at an implicit level as they could talk about spelling but had abstracted knowledge of the morphological rule *-ed* and had formed a theory based upon this. These participants tended to over apply *-ed* to nonverbs and irregular verbs and therefore chose alternatives as the correct spelling that included

morphological errors, for example, *solded* instead of *sold*. Children at this level also commonly referred to the –ed rule in their explanations for why spellings were correct or incorrect when it was not always relevant to do so, unlike E1A participants who did not refer to the –ed unit at all. For example: girl aged 6

"Why is *slept* wrong?" (experimenter)

"it hasn't got –ed" (participant)

"Why is *slepted* correct?" (experimenter)

"it has an –ed" (participant).

Participants were coded at E2 if their responses indicated they were on the brink of full phonological and morphological understanding but their knowledge was still incomplete at times, for example, the ability to fully explain why words were wrong but lacking in information when explaining why a word was correct. For example: boy aged 7

"Why is *called* correct?" (experimenter

"it has two l's and an *–ed*" (participant).

Although the above response is by no means incorrect, further information could have been provided, such as, *–ed* was attached to the word *call*. However participants at E2 did demonstrate an improvement in performance, as children at this level were more likely to identify the correct answer. Children coded at E3 again showed an improvement in accuracy accompanied by complete understanding of when and when not to use the *–ed* convention, absence of overgeneralization errors and the ability to verbalize complete explanations as to why words were correct and incorrect. For example: girl aged 7

"Why is *called* correct?" (experimenter)

"it has the word *call* with an *–ed* on the end to make it past (tense)" (participant).

During the coding process each of the verbalizations derived from the 15 sets of alternative spellings were transcribed for each participant. Each set was then separately analyzed and allocated to one of the representational levels (Implicit, E1A, E1B, E2, E3) according to the criteria described above. The level that was allocated to the participant most out of the 15 sets then became the participant's overall representational level. For example, a participant's verbalizations for two out of the 15 sets may have been allocated to E1A but because the other 13 sets were coded as E1B, the participant would be coded as E1B overall. Every participant had a predominant level that accounted for his or her knowledge and understanding in more than 50% of the 15 spelling alternative sets. As discussed later, some participants did seem to be in transition between two levels and therefore the predominant level occurred just over 50% of the time. However the majority of participants displayed their predominant level more than 75% of the time.

Table 5 shows that it was possible to allocate each participant to a level of knowledge representation thus indicating the RR model is appropriate for understanding spelling development: a notable finding for this exploratory study. An independent rater, a researcher with experience in coding RR levels for the balance beam task used by Pine & Messer (1999) tested for inter-rater reliability. The rater was given the verbal responses and performance accuracy of 25 of the children and was asked to allocate each child to a representational level as the experimenter had. Results were then compared and produced a Kappa coefficient of .73, $p < .05$ (0.6-0.8 is regarded as an indication of good reliability). A chi-square Goodness of Fit test was computed on the number of participants at the four levels of explicit knowledge, χ^2 (3 n=51) = 15.27, $p < .05$. The

implicit level was excluded from this computation as no children were at this level. As shown in Table 5, most of the participants were at either the E1A or E1B level of early theory abstraction, and demonstrated evidence of over-applying their internal theory of spelling. However, some participants were at E2 or E3 showing that, even at this young age, there are some children with full, or close to full, understanding of when and when not to use the *–ed* morphological convention to indicate past tense.

Interestingly, no participants were found to be at the implicit level, overall, which was predicted to manifest behavioral mastery but without any insight, for example, "I just know how to spell it". There were however 11 participants who, although were allocated to levels E1A and E1B did produce some isolated responses that could be classed as Implicit. For example, out of the 15 sets of spelling alternatives the predominant behavior was either level E1A or E1B representational knowledge, but on one or two of the sets the understanding displayed was deemed to be Implicit. However, due to the lack of predominant Implicit level understanding the notion of U-shaped performance as discussed by Karmiloff-Smith (1992) cannot be commented upon.

It is also important to emphasize that although each child demonstrated a predominant level of representational knowledge and understanding which allowed them to be allocated to one representational level, there were some children whose allocation was less clear-cut than the majority. For example, there were six children who appeared to show evidence of multi-levels and six children who seemed to be in transition between two levels (usually E1B and E2). The implications of this apparent variability in some individuals will be discussed in more detail later.

We also examined the performance of participants at each representational level in terms of their spelling production and spelling recognition abilities to see whether accuracy improves as the explicitness of knowledge increases.

Table 6 shows that both spelling production and spelling recognition improve from level E1A to level E3. One-way ANOVAs were significant for both the mean number of words spelled correctly ($F(3, 47) = 18.36$ $p < .05$) and the mean number of words recognized correctly ($F(3, 47) = 11.12$ $p < .05$). Scheffé post hoc tests indicated that in terms of spelling production the significant differences lay between E1A and E1B and E2 and E3. In terms of spelling recognition the significant differences lay between E1A, E2 and E3 and E1B and E3. Overall as explicitness of understanding increases, so does accuracy, which is probably due to the phonological and morphological knowledge that was over applied in the E1 levels being used more appropriately as it becomes more explicit.

Given that this research hopes to provide some insight into the mechanisms underlying the development described by Nunes et al. (1997) it will be useful to explore the possible relationship between allocation to the stages of the Nunes et al. model and the representational levels that have arisen from the present study as displayed in Table 7. Does the stage a child is allocated to in the Nunes et al. model tell us anything about their likely level of representational understanding? A Chi-squared Goodness of Fit test proved to be significant: $\chi^2 (N = 51, 12) = 39.91$, $p < .05$ however there are a number of empty cells which should be mentioned. Despite this, it is important to explore the nature of this relationship if only for descriptive purposes.

As indicated by Table 7, most of the children allocated to the early stages of phonological development on the Nunes et al. (1997) model (stages 1 and 2) are also allocated to the E1A representational level characterized by a dominant phonological theory, explanations and errors. In contrast, most of the children at stage 3 of the Nunes et al. model which signifies developing morphological skill and –ed errors are also allocated to the E1B representational level which is characterized by a dominant morphological theory and explanations and errors centered around –ed. Finally many of the children who achieved the later stages of the Nunes et al. model (stages 4 and 5) proficiently using phonological and morphological knowledge have also been allocated to the later and more explicit representational levels of E2 and E3 characterized by fully explicit explanations that reflect appropriately applied phonological and morphological knowledge. This promising finding will be discussed further but it cannot be forgotten that many of the cells are empty and there are anomalies in the data, for example, the six children at stage 5 on the Nunes et al. model and the E1B representational level.

Discussion

The first aim of experiment one was to confirm that spelling development could be characterized in the phonological and morphological manner depicted in the Nunes et al. (1997) model and that overgeneralization errors occur.

The second aim of the study was to apply Karmiloff-Smith's (1992) RR model to children's spelling knowledge. In the context of the RR model we were particularly interested in the explicitness of the children's knowledge and the extent to which they could access and justify their spelling representations. The third aim of the study was to compare spelling recognition and justification of spelling choices to spelling production

and if this method could provide evidence for variability of representations in the cognitive system.

Our data indicates that children in the early years of their schooling can be characterized as having various forms of phonological and morphological knowledge of spelling, as suggested by Nunes et al. (1997). This was important to our study in order to investigate the children's various levels of implicit and explicit knowledge as described by the RR model. Participants' performance on the spelling test revealed a fair spread across the stages of the Nunes et al. model showing that different levels of ability were present. The presence of overgeneralization errors suggests a U-shaped development of spelling performance, although this conclusion must be treated with caution given the lack of longitudinal data

Previous research has established that spelling development follows a progression from phonological to morphological knowledge (Nunes et al., 1997). Our research explored the cognitive mechanisms underlying this developing knowledge and the appropriateness of Karmiloff-Smith's RR model as a theoretical framework to explain how spelling development occurs. Support for the levels described in the RR model was found, particularly the presence of level E1 and the fact that it appeared to be comprised of two different sub-levels. Such refining of this early level of explicit representation supports the findings from work in other domains, such as children's acquisition of a new concept (Pine & Messer, 1999).

Although children at level E1 displayed overgeneralization errors and stubborn theory-led explanations of spellings, there did seem to be two distinct types of knowledge representation within this one level. Children emerged from the implicit level to abstract

simple phonological rules. Correct answers were likely to be given for those words spelled phonetically, for example, *left* and this phonological rule was often overgeneralized to every kind of word, for example, *calld* instead of *called*.

Further evidence for children being at an E1 phonological level comes from the lack of recognition of the morphological *–ed* rule. This is consistent with Karmiloff-Smith's (1992) description of E1, where external input or data is ignored, as these children seemed not to see *-ed* as a unit at all. A typical response might be:

"Why is *lefted* wrong?" (experimenter)

"because it has two *e's*" (boy aged 6) or…

"because it has a *d*" (boy aged 6)

Although neither of these responses are actually wrong, the children failed to recognize the use of a rule and just focused on the phonological aspects of the word.

The second sub-type of level E1 reflects children's beginning knowledge of morphology. Participants at this level seemed to have abstracted information about the *-ed* rule and formed a theory about its application. Therefore at this level, phonological errors, although present, are reduced and seem to have been replaced by morphological overgeneralization errors, directly accounting for Nunes et al.'s (1997) findings and the findings of this study, for example, *sofed (for soft)*. Again there is evidence here for Karmiloff-Smith's (1992) assertion that E1 is driven by internal theories, ignoring external input, as participants would never have actually seen the word *sofed* but have formed this rule-based theory of spelling (based on *–ed*) which is not yet fully understood. Typical examples include:

"Why is *sofed* correct?" (experimenter)

"because it has an -*ed*" (girl aged 6)

"Why is *left* wrong?" (experimenter)

"because it doesn't have -*ed*" (girl aged 6)

Most participants were in E1A or E1B as their knowledge representation of spelling consisted of either a phonological or morphological theory that was over applied, seemingly ignored external data and resulted in predictable errors.

E2 was a difficult level to define in terms of spelling before the study but evidence for it did emerge from the data. Children at this level seemed to be on the brink of full understanding of the *–ed* convention although not yet demonstrating full, level E3, knowledge. As Karmiloff-Smith (1992) describes, the theory and the environment (input data) are beginning to become integrated but full explicit access has not yet been achieved. A typical characteristic of children's E2 responses was their lack of completeness. For some words, both recognition answers and understanding were accurate and accompanied by the ability to recognize exceptions to rules but for other words justifications were incomplete, for example:

"Why is *opened* correct?" (experimenter)

"because it has *n* and then *ed*" (girl aged 6.5)

Again this response is by no means wrong but when compared to an E3 answer a subtle difference becomes apparent:

"because it has the word *open* which you add *ed* to and then it is *opened*" (boy aged 7 classified at level E3)

At level E2 participants are beyond the level of adhering to an internal theory but full integration with the environmental (input) data has not yet been established

The final level, level E3 was also demonstrated in some of the children's understanding of spelling. They could talk about phonology:

"Why is *left* correct?" (experimenter)

"it sounds *l-e-f-t*" (boy aged 7)

-the use of morphological rules:

"Why is *called* correct?" (experimenter)

"It has the word *call* which you then add *-ed* to" (boy aged 7)

-and the exceptions to those morphological rules:

"Why is *sofed* wrong?" (experimenter)

"The word *soft* should not have *-ed* it should just have a *t*" (boy aged 7)

Therefore not only did these children have theories of phonology and morphology (as those in the prior levels) they had appropriately used them in conjunction with external data so that, as Karmiloff-Smith (1992) described, they could recognize exceptions to those rules. There was also evidence of children starting to show definite flexibility in their understanding, for example:

"Why is *dressed* correct?" (experimenter)

"If you have *dress* and add *-ed* you make *dressed*. If you wanted *dressing* you take off the *-ed* and put *-ing* instead" (girl aged 7)

This evidence of flexible understanding of stem use is consistent with the claims of the RR model that once full explicit (E3) understanding has been reached, knowledge representations can then be used to make inferences across other micro-domains.

No other model to date accounts for this process of development in the understanding of spelling. All our participants fit into a representational level on the

basis of their understanding of spelling. Furthermore, the emergence of a possible relationship between allocation to stages on the Nunes et al. (1997) model and the representational levels of understanding is also very encouraging for this new approach. Results suggested that children's proficiency in phonological and morphological aspects of spelling as reflected by their allocation to a descriptive stage on the Nunes et al. model is mirrored by their representational understanding of spelling in terms of how explicit it is and how well it can be verbally expressed.

Children at phonological stage 2 on the Nunes et al. (1997) model tended to be at the E1A level of an phonological theory abstraction and those at stage 3 which sees the incorporation of morphological knowledge resulting in overgeneralization of the rule –ed tended to be at level E1B characterized by an abstracted morphological theory. Stages 4 and 5 of increasing proficiency were linked to the later E2 and E3 levels of explicit awareness, correct application and the ability to reflect this via explanations.

It therefore seems that the descriptive stages of the Nunes et al. (1997) model can be built upon using the representational levels. The type of information children are using in their spelling is mirrored across the stages and the representational levels, e.g. phonology at stage 2 and E1A but the representational levels also provide more than this. They attempt to explain how this knowledge changes and grows; via a process of increasing explicitation and representational-redescription. The representational levels also help to us to understand the overgeneralization errors (e.g. solded) described in stages 3 and 4; they are a reflection of the abstraction and over-application of a theory regarding the use of –ed as explained by level E1B. The other promising aspect to representational levels is the use of children's explanations as this provides a different

method of assessment that is not solely associated with accuracy, explanation of errors are just as informative as explanations of correct choices.

We believe this provides insight into the cognitive mechanisms that may underlie development and marks improvement over other models that have been used to explain spelling development. Rittle-Johnson and Siegler (1999) attempted to explore spelling in terms of Siegler's (1996) Overlapping Waves Model but failed to explain some of the children's behavior. Rittle-Johnson and Siegler (1999) could not explain: "why children persist in using time-consuming backup strategies that initially do little to improve performance" (p. 345). This production of errors and stubborn use of particular strategies or theories, such as "sounding-out" are the exact characteristics of those participants classified in the present study as evidence of E1 representational levels. In levels E1A and E1B, children would stubbornly pick the alternative that was either a phonological error, such as *filld* or a morphological error, such as *solded* and this would also be reflected in their explanation, for example:

"It always has to end with –ed" (child at E1B)

This can be explained by the RR model as abstraction of a theory that is stubbornly applied and therefore produces errors that are not present in the environment. What Rittle-Johnson & Siegler are describing therefore can also be explained by level E1 knowledge.

It is true that the variation or multiple-representations displayed by some of the children could also be accounted for by the Overlapping Waves model as evidence of different strategies. However, this instance where the RR model could account for the behavior displayed in Rittle-Johnson and Siegler's study in a way that other models could

not shows its value as it addresses hitherto unanswered questions about spelling development.

Although our first study failed to find children at the implicit level there remains the outstanding issue of U-shaped development. If an Implicit level had been uncovered it would have been predicted that spelling accuracy would have been higher at this level compared to the E1 levels. However, the age of the children in the study and their exposure to explicit teaching methods may account for the lack of children with overall Implicit representations. However, if younger children were studied Implicit level representations might be uncovered.

Nonetheless, given that the RR model can be used to describe the mechanisms underlying spelling development it was of interest to explore other predictions of the model in respect of spelling. The third main aim of the study was to see whether recognition ability would be better than spelling ability following the studies by Holmes and Davis (2002) and Murphy and Pine (2003) and this was the case. It has already been noted that Holmes and Davis (2002) believe there to be a joint representation for the reading of a word and the spelling of it but it will be informative to address this question within the context of the RR model.

At this point it is worth discussing some of the other findings of the study as they rest on the same issue. It was found that all children could be coded overall as one representational level, however the coding process highlighted some children that appeared to show evidence of multiple levels and some that seemed to be in transition between two levels (usually E1B and E2). Although the latter phenomenon can be explained in terms of capturing representational-redescription as it occurs, the former

point appears to suggest evidence of variability within the cognitive system. Those participants in E1A and E1B who produced some isolated responses that could be classified as Implicit further evidence this.

In terms of the RR model these points provide evidence of multiple-representations co-existing in the cognitive system. Karmiloff-Smith (1992) states that even though representations are redescribed, the original ones still remain intact and accessible for use under certain conditions. Therefore recognition ability exceeds spelling, because for the purposes of quick retrieval, implicit representations are accessed that would match what the participant had encountered in the environment, and thus would lead to a correct response. If errors are made in recognition then this could be a sign that an overriding E1 representation is being accessed instead of implicit representations. Although speculative at this stage, this seems the most plausible explanation for the differences observed. In terms of spelling production E1 representations are accessed, sometimes producing the overgeneralization errors observed. However, for the purposes of recognition, the same child may tap into an implicit representation, then when asked to explain verbally revert to the E1 explanation, thus switching between representations. This notion of a fallback on earlier representations also explains why isolated implicit responses are observed in some children at this level. Siegler's (1996) description of cognitive variability is relevant here as our data supports the notion that multiple strategies are used.

A strong case can also be made for multiple-representations within domains, for example knowledge of the –ed convention. Some participants were inconsistent across similar words. For example, some children correctly choose and verbally justified the

use of –ed in *opened* but then failed to apply the rule correctly for *called* and chose *calld* instead.

In conclusion experiment one has demonstrated children's phonological and morphological knowledge of spelling. Karmiloff-Smith's RR model (1992) can be used to describe the type of cognitive representations underlying phonological and morphological spelling development. We found evidence of all representational levels although there was no overall classification of predominantly implicit knowledge. Overgeneralization errors were explained in terms of the theory-led E1 level that fails to consider external data. Interesting possibilities have also been discussed in terms of the multiple-representations of spelling in the cognitive system with regards to recognition and multiple levels of understanding.

Experiment Two

As outlined above, the results from experiment one provide supporting evidence that the levels of the RR model can explain the knowledge representations underlying the phonological to morphological development of spelling.

The purpose of the second study was to explore further whether children initially have Implicit level representations for spelling. Younger children than those in experiment one were tested to see if this earlier level of spelling development would provide evidence for Implicit knowledge representation and therefore, the U-shaped performance curve may be identified. The second aim of this subsequent study was to extend the methodology employed in order to test the veracity of the original method. This will establish whether the representational levels identified are stable across tasks even if spelling knowledge tests are modified.

To address the primary aim of identification of the Implicit level, 5-6 year old children were used in the hope of tapping into this early stage of development. We used the same spelling test (adapted from Nunes, Bindman & Bryant 1997) as experiment one. We modified the recognition test by dividing it into two parts. Part one followed the exact procedure used for the recognition task in Experiment one except that only nine of the previous 15 word sets were used. Again, each set contained one target word and two error alternatives. As before, participants were told the target word and were asked to explain why they believed one alternative to be correct and the other two incorrect. In part two the remaining six words from the original 15 were presented but this time without the error alternatives. Three of them were spelled correctly and the remainder spelled incorrectly. Participants were told the target word and asked to identify the spelling as correct or incorrect and then verbally justify their choice.

The prediction was that verbal justifications gained from both parts of the recognition test would reveal the child's representational levels. However it was also predicted that parts one and two of the test could elicit different levels, as the different tasks may tap different degrees of implicit/explicit knowledge. It was possible that part one would elicit more explicit understanding, as the two alternatives would act as a catalyst for comparison. In contrast part two may elicit more implicit knowledge as only one possible spelling would prevent comparison and therefore may reduce the amount of explicit knowledge provoked. This latter point was considered, as it was important to rule out the possibility that results were simply an artifact of the original methodology. The new recognition test was therefore included to test the veracity of the original method.

The other major change to the methodology of the recognition test was the replacement of the flash card method with touch-screen technology. Due to the younger age of the children studied, the introduction of the touch-screen was carried out with the hope of gaining their interest and making the task enjoyable.

Method

Design

There were three dependent variables: Score out of 15 on the spelling test, a score out of nine for the first part of the recognition test and a score out of six for the second part of the recognition test and level of knowledge representation out of five (Implicit, E1A, E1B, E2, E3) for both parts of the recognition test

We predicted that participants' explanations would correspond to one of the representational levels derived from the RR model (Karmiloff-Smith 1992) in terms of their understanding of spelling but the verbalizations derived from the first and second parts of the recognition test could provide evidence for different representational levels as the two tasks may tap different degrees of implicit/explicit knowledge.

Participants

Forty-four children took part in this study: 28 from one school and 16 from a second school; 21 males and 23 females with an age range of 5 years 7 months to 6 years 6 months. All children were in the second term of Year 1 of their schooling. Both schools were state-run mixed infant schools and situated in Hertfordshire where families are predominantly white.

Materials

Spelling Test.

The spelling test was the same as in experiment one (adapted from Nunes et al. 1997)

Recognition test/Spelling alternatives.

This part of the study consisted of two parts that were implemented using touch-screen software connected to a MacIntosh laptop. In the first part children were presented with one practice set and nine tested sets of spelling alternatives, three from each of the word categories (regular past tense, irregular past tense and nonverbs) that had been included in the first spelling test. Each set contained three spelling alternatives of that word only one of which was correct. The sets used were for the words: *laughed, dressed, opened, slept, sold, left, soft, ground* and *gold,* see table 2 for full details. Each set was presented on its own on the screen to prevent distraction. The three spelling alternatives were evenly spaced across the screen and were presented in bold type with font 18. The position (left, center or right) of the correct word on the screen was randomized to prevent a biased response set. Verbalizations from the children were recorded using a separate tape recorder.

In the second part of the recognition test children were presented with one practice word and six test words that appeared in isolation on their own on the screen. These words were the remaining six from the previous spelling test (the other nine were used in the first part of the recognition test) and consisted of two of each of the word categories (regular past tense, irregular past tense and nonverbs). In this part three of the words were correctly spelled (*next, heard and filled*) and the other three were incorrectly spelled (*coled* for *cold, losted* for *lost, calld* for *called*). Two boxes appeared on the screen below each single word, one of which contained the picture of a cross (colored

red) and the other contained the picture of a tick (colored green). Again verbalizations were recorded using a separate tape recorder.

Procedure

Spelling test.

As in experiment one.

Recognition test/Spelling alternatives.

Both parts of the recognition test took place over a week after the spelling test. Participants were taken individually from their classes to a room where the laptop, touch-screen monitor and tape recorder had been set-up at a desk with two chairs.

The procedure for the first part of the recognition test was the same as in experiment one except the word alternatives appeared on a screen instead of on flash cards The tape recorder was active through the entire procedure. In the second part of the recognition test the experimenter demonstrated the procedure using the practice trial. Each of the six words was presented in isolation (with the tick and cross boxes underneath). As each word appeared on screen an audio file saying the word in isolation, in the context of a sentence and then in isolation again accompanied it. Participants were asked whether they believed the spelling of the word to be correct or incorrect and to indicate their choice via pressing either the tick or cross box. Participants were then asked to verbally justify their choice.

Results

Spelling Test

Analyses of the spelling test were only carried out on the 15 words taken from Nunes et al. (1997). The mean number of correctly spelled words was calculated not only

for the 15 words overall but also for the nine used in Part One of the recognition test and the six used in Part Two of the recognition test (see Table 8)

Recognition/Spelling alternatives test

As a new recognition test was added to experiment two it seemed important to compare recognition ability in the two different parts. Part two could have been regarded as more difficult because participants were asked whether one word was correct/incorrect without any alternatives to make a comparison with as in Part one. A paired sample t-test on percent correct failed to find a significant difference in performance for the two recognition tests, $t(43) = -1.33$, $p > .05$. Therefore recognition ability was not affected by the differing format of the two tests.

Representational Levels

Participants were allocated to two representational levels according to their verbalizations in the recognition tests. See experiment one for the criteria for categorization at each level.

Table 9 shows that in parts one and two of the recognition test it was possible to allocate all participants to one of the RR levels on the basis of their verbal justifications. A chi-squared Goodness of Fit test was computed on the number of participants at the four representational levels (Implicit, E1A, E1B, E2) for Part one of the recognition test, χ^2 (3 n=44) = 45.46, $p < .05$, and Part two of the recognition test, χ^2 (3 N=44) = 42.73, $p < .05$. Level E3 was excluded from this computation as no children were at this level for either recognition test. This result indicates that for both parts of the test the majority of participants are at the E1A level of early theory abstraction based predominantly on phonological knowledge. The highest level of E3 is not represented but fully explicit

phonological and morphological spelling representations would not be expected at this early age. However E1B and E2 are represented providing evidence for the beginnings of explicit morphological knowledge.

One finding of particular note is that some participants were found to be at the Implicit level. Characteristics of this level were accuracy in the ability to recognize a correct spelling but an inability to justify their correct choice or to explain why the error alternatives were incorrect. Children at this level therefore demonstrated a lack of any explicit insight for example:

"I don't know"

"It looks right"

"I have seen it before'

or, were inconsistent and made little sense indicating that the participant was just saying anything in order to respond rather than accessing any explicit knowledge. For example, one participant in Part one was shown the three alternatives of the word *laughed.* He chose the correct alternative but when asked why it was correct he replied: "It looks right" and when he was asked why *laughd* was incorrect he replied: "It's got a h". Of course the correct spelling of laughed has an h as well indicating an Implicit answer as the participant seems to have just picked any letter in order to make a response. Some participants were not exclusively at one level, occasionally their understanding was similar to an E1A level providing evidence for either a multiple-representational state or transition between two levels. However children in this age group on the whole were far more likely to produce isolated Implicit responses than children in older groups, again providing evidence for early Implicit representations in development. To qualify for the

Implicit level, children had to correctly recognize more than 50% of the items and be unable to justify their choices.

We also predicted that participants would differ in the representational level they were allocated to in Part one compared to part two of the recognition test. We expected that the difference in methodology could affect the level of explicitness extracted from the participants in their verbalizations.

Table 10 shows that out of the 44 participants, 34 were allocated to the same representational level regardless of the form of the recognition test and 10 were allocated to different levels. However those 10 were equally divided between being more explicit in part one or part two, so no systematic bias was evident. It seems that the representational level is robust in the face of changing methodology although it must be acknowledged that 23% of the sample did not match. Whether words are presented with two incorrect alternatives (as in part one) or in isolation (as in part two) the representational level of participants' responses remains the same. This finding suggests that the results of the first study were not an artifact of the methodology, as the representational level remained stable across both versions of the recognition test for the majority of participants.

The search for U-shaped development

The finding that participants in this study could be allocated to the implicit level means that the possibility of a U-shaped development can be explored in terms of the participants' spelling and recognition abilities. If a U-shaped development was to occur we would expect a significant drop in performance at the E1A level compared to the scores at the implicit level and then a subsequent rise in performance again at E1B/E2

reaching implicit level performance again at E3 (had children been allocated to this level) but this time with understanding. In contrast linear performance would just show a steady improvement from the implicit level to the highest explicit level. This was explored for parts one and two of the recognition test.

Part one

Figure 1 shows that spelling production improved in a linear rather than a U-shaped fashion. A one-way ANOVA was carried out on the number of words spelled correctly at each representational level in part one of the recognition test: $F(3, 40) = 7.03$ $p < .05$. A Scheffé post-hoc test indicated that the significant difference lay between E1A and E1B indicating that spelling does improve overall with the introduction of morphological theory even though overgeneralizations can occur at this level. In terms of recognition performance, although there was a trend towards a U-shaped pattern, with a drop in performance at E1A, a one-way ANOVA indicated no significant differences between the levels: $F(3, 40) = 1.73$ $p > .05$.

Part two

Figure 2 indicates a trend towards a U-shaped pattern in terms of both spelling and recognition ability as in both instances there is a drop in performance at E1 level before subsequent improvement to level E2. One-way ANOVAs were significant for both the mean number of words spelled correctly ($F(3, 40) = 5.93$ $p < .05$) and the mean number of words recognized correctly ($F(3, 40) = 3.86$ $p <. 05$). However, Scheffé post-hoc tests indicated that in both cases the significant difference lay between levels E1A and E2. Therefore only the linear improvement in the later levels proved significant rather than the U-shaped drops in performance between the Implicit and E1 levels.

Despite the lack of statistical significance we see the possibility of discovering U-shaped performance in spelling and recognition in future studies.

Discussion

The findings from experiment two confirm those from experiment one but also offer some exciting new findings. Participants' verbal justifications on the recognition test allowed allocation to levels of knowledge representation and the nature of understanding displayed in each level again endorses the original findings. However, an important purpose of this second study was to try the different methodology (in the recognition test) of using isolated words alongside the original alternative sets of three words. This manipulation was to see whether this change would affect the representational level that participants were allocated to. However 34 out of 44 participants were allocated to the same level regardless of the methodology. This consistency indicates that the children's level of understanding was not a function of the methodology but a reflection of their underlying representations although it should be acknowledged that 23% of the sample did not match across the recognition tasks. However, the absence of a systematic bias would still support the methodology used.

The primary purpose of conducting this second experiment with such young children (aged 5-6) was to see if more concrete evidence could be found of the Implicit level in spelling development characterized by the ability to recognize a correct word (behavioral mastery) but an inability to verbally justify that choice. More children showed evidence of being at this level than in Experiment one. Sometimes an attempt at a justification was made but the answers were often inconsistent and displayed a lack of knowledge as to why they had made the choice they had.

A further important aspect of this level was that participants were not showing evidence of an implicit representation on every word. Sometimes responses and errors were made that were characteristic of E1A and therefore it was an overriding behavior that was reported. Interestingly in this age group there was even greater evidence than previously of access to multiple-representations. In some cases it was difficult to allocate participants to one stage for this reason. In experiment one with the older children, allocation was much more clear-cut. This indicates that at a younger age the use of earlier representations (sometimes Implicit) was much more likely as children are grappling with new concepts such as phonology and the first hints of morphology.

In this second experiment because of the discovery of the implicit level, u-shaped development can be discussed in terms of spelling and recognition. It had previously been expected that performance would significantly drop at E1 compared to the implicit level as this is where an overriding theory emerges that the children use explicitly when spelling, be it phonological or morphological. This will affect recognition ability as error alternatives will be chosen instead of the correct word in accordance with these theories, e.g., *filld* instead of *filled* or *losed* instead of *lost*. This is in contrast to the implicit level where children do not recognize words correctly on the basis of any conscious knowledge that they have, they simply respond to what they have seen in their environment. Some evidence was found in terms of slight declines in performance between Implicit and E1A before subsequent improvements at E1B and E2. Although these instances were not statistically significant as the differences were quite small, it would be useful to look at again in the future perhaps with even younger children.

Conclusion

The two experiments reported in this study demonstrate that the phonological to morphological development of spelling in young children can be understood in the context of the Representational-Redescription model (Karmiloff-Smith 1992). By studying children aged 5-7 evidence of underlying knowledge representations have been uncovered for all the levels of the RR model, and the first evidence of the implicit level. The extension of level E1 into two levels is particularly interesting as it demonstrates the complexity of spelling representations and the tools that children have to develop. However, a clear development of representational knowledge does emerge from a young age and a U-shaped developmental pattern is suggested.

The other interesting notion that has emerged concerns multiple-representations. As well as providing further support for the RR model (and Siegler's 1996 Overlapping Waves model) our research has provided enhanced insight into the nature of the representations children are accessing as they develop. What is especially important here is the prevalence of multiple-representations with the youngest children (shown in experiment two) supporting Karmiloff-Smith's (1992) assertion of the fallback on to earlier representations when faced with a difficult problem. The RR model provides an explanation for Rittle-Johnson and Siegler's (1999) findings that children persist in using unsuccessful spelling strategies and Nunes et al.'s (1997) findings that children will overgneralize the –ed past tense rule to nonverbs. Evidence for multiple-representations is complemented by the finding that recognition ability exceeded spelling production, supporting the findings of Holmes and Davis (2002) and Murphy and Pine (2003).

Importantly the use of representational levels has not only supported the stage model proposed by Nunes et al. (1997) it has built upon it and deepened it theoretically speaking. The representational levels reflect the content of the stages within the model but beyond this they attempt to explain *how* the knowledge and level of understanding becomes more explicit over time and can also account for the types of errors children make as this occurs. Nunes et al. used measures of accuracy to form their stages; representational levels use both performance and children's understanding derived from explanations within the context of the RR framework.

Another important finding of this study is the stability of the knowledge representations in terms of their elicitation when different methodologies were used. This signifies that the original methodology was indeed tapping into these knowledge representations and the RR levels that emerged were not an artifact of the methodology. However it is important to acknowledge here an issue regarding the use of verbal explanations as a tool of the methodology. It is possible that the ability to make these explanations does require greater awareness on behalf of the children compared to tasks such as analogy for example. However, whilst this is true, we believe explanations to be a powerful component in distinguishing between differing levels of explicit knowledge and going beyond not just what a child can do but what they understand as they are doing it.

Many possibilities for future study arise from this research most notably in terms of further investigation of how children begin to represent words implicitly and the issue of subsequent U-shaped development. By investigating spelling in terms of the RR model a significant insight has been gained into the cognitive mechanisms that underlie

its development and the nature of how the knowledge is stored in the cognitive system. These findings suggest that spelling development follows a U-shaped route that involves implicit representations becoming more rule-based and finally more explicit. Clearly, a better understanding of the cognitive mechanisms underlying spelling development will assist educators in developing teaching methods to assist learning.

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Table 1

Words used for the spelling and recognition tests

Regular past tense verbs	Irregular past tense verbs	Nonverbs
called	left	next
opened	sold	cold
filled	lost	gold
laughed	slept	ground
dressed	heard	soft

Table 2:

Alternative word sets presented in the recognition task. Words and errors derived from Nunes et al. (1997)

called	caled	calld
leftd	left	lefted
openned	opend	opened
nexed	next	nexted
sold	soled	solded
herrd	hearded	heard
coled	cold	coldt
losted	losed	lost
dressed	dressd	dresed
laughed	laughd	larfed
golled	goled	gold
fild	filled	filed
slept	slepted	sleped
ground	grouned	groned
softed	sofed	soft

Table 3

Number of participants allocated to each of the five stages of spelling development from the model by Nunes et al. (1997)

Stage of model	Frequency of allocation
1	6
2	16
3	10
4	8
5	11

Table 4

Means and standard deviations of the number of words (out of 15) correctly produced and recognized at each stage of the Nunes et al. (1997) model.

Stage	Mean correct production (SD)	Mean correct recognition (SD)
1	0.33 (0.52)	8.33 (0.82)
2	4.63 (2.03)	8.56 (0.97)
3	5.7 (2.26)	9.90 (1.85)
4	9.25 (1.17)	11.00 (2.0)
5	11.46 (2.7)	12.18 (2.53)

Table 5

Number of participants allocated at each representational level

Representational Level	Frequency of allocation
Implicit	0
E1A	18
E1B	21
E2	8
E3	4

Table 6

Mean number of spellings (and standard deviation) correctly produced and correctly recognized out of 15 at each representational level

Representational level	Production	Recognition
E1A	2.94 (2.53)	8.44 (0.86)
E1B	7.38 (3.02)	10.04 (2.18)
E2	9.75 (3.28)	11.5 (2.33)
E3	11.75 (1.5)	13.25 (0.5)

Table 7

Frequency of allocation to stages from the Nunes et al. (1997) model of spelling development (1-5) and representational levels of spelling understanding (E1A-E3)

Nunes et al. Stages	Representational Levels			
	E1A	E1B	E2	E3
1	6	0	0	0
2	11	4	1	0
3	1	7	2	0
4	0	4	3	1
5	0	6	2	3

Table 8

Mean number of correctly spelled words. Standard deviations are shown in brackets.

Test	Mean number of correct words (SD)
Overall spelling test (/15)	4.16 (3.4)
Words used in Part One (/9)	2.61 (2.26)
Words used in Part Two (/6)	1.55 (1.35

Table 9

Allocation of participants to representational levels derived from the R-R model (Karmiloff-Smith, 1992) in Parts one and two of the recognition test.

Level	Part one	Part two
Implicit	2	3
E1A	30	29
E1B	8	2
E2	4	10
E3	0	0

Table 10

Participants who remained in the same representational level in parts one and two of the recognition test or whether they differed in level according to the part of the recognition test.

Representational levels in parts one and two	Frequency
Allocated to the same level in both parts	34
More explicit in Part one	5
More explicit in Part two	5

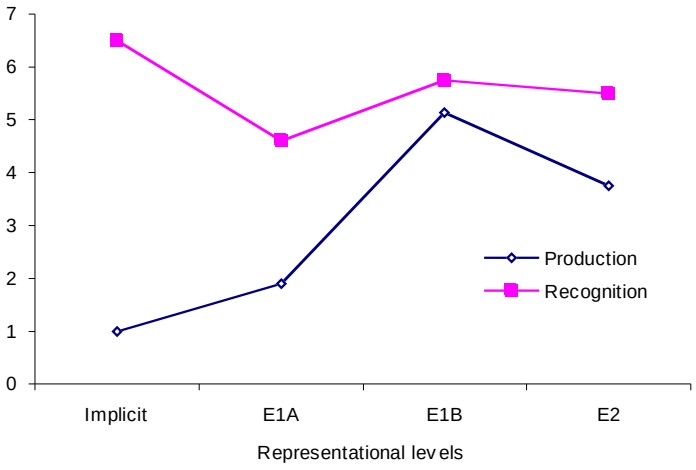

Figure 1. Mean number of words (out of 9) spelled/recognized correctly according to the allocated representational level in Part one of the recognition test.

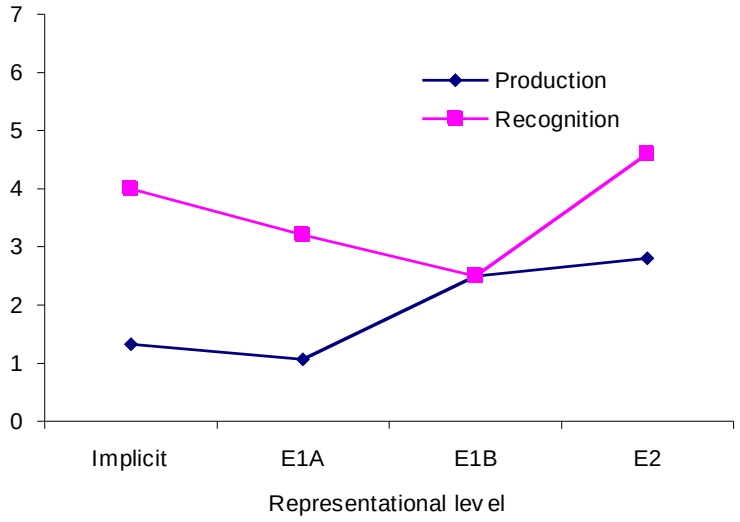

Figure 2. Mean number of words (out of 6) spelled/recognized correctly according to the allocated representational level in Part two of the recognition test.