Spelling and Reading Representations in Children

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Abstract

This thesis sought to conceptualise children's spelling and reading representations in a novel way based upon the implicit-explicit framework proposed by the Representational-Redescription (RR) model (Karmiloff-Smith, 1992). The children studied were aged 4-7 years.

Existing models of spelling and reading (e.g. Frith, 1985, Ehri, 1998, 1999, 2002) describe the developmental process as a series of stages/phases. An alternative approach adopted here is derived from the author's previous research (Critten et al. 2007). It employs a coding scheme that analyses children's explanations of and performance on, recognition tasks that reveal varying levels of explicitness in understanding of spelling. In this thesis the levels are empirically validated for both spelling and reading. It begins with an attempt to show that young children represent spelling knowledge implicitly. A longitudinal study then elucidates the developmental trajectory of both spelling and reading over the course of a year demonstrating that changes occur in the explicitness of children's underlying representations. By comparing the co-development of spelling and reading it was possible to demonstrate that phonological information is often explicitly used first in spelling before reading, lending support to Frith's (1985) "pace maker" notions. The final study examined how context, previously known to facilitate children's reading ability can also facilitate their spelling development. This effect occurs not just for reading and spelling performance but for explicit understanding, building on the Lexical Quality Hypothesis (Perfetti & Hart, 2002) that proposes a role for semantic information in successful spelling and reading.

These findings are integrated into a proposal for a new model of development: the Spelling and Reading Explicitation Model (SREM). This model postulates that children develop beyond implicit recognition to form "active" explicit representations, accounting for generalisation errors and characterised as being consciously accessible and verbalisable. It proposes that the development of reading and spelling skill is based upon processes of abstraction, interpretation and application of phonological and morphological knowledge.

Chapter One
Literature Review

"And so they (children) discovered the paradoxical virtue of reading, which is to abstract ourselves from the world in order to make sense of it" (p.19 The Rights of the Reader, Daniel Pennac, 1992)

As a child learning to read I experienced a wonderful moment of clarity and freedom as I realised that the content of any book was now accessible to me. Essentially the whole world, encapsulated in bound volumes could now be mine for the taking. This is the power of reading for children: the gate way to fantastical stories that enrich the imagination and sources of reference and information for anything you can think of. The advent of the Internet means that information is no longer limited to books although reading is still the primary method of access. Learning to spell provides children with a different power. The ability to form words, to make up sentences, paragraphs, pages is a way of imposing your own inner thoughts, opinions, and feelings upon an outer medium. To communicate and express internalised processes in a concrete and lasting manner is to have an effect upon the world and allow others access to your inner world.

The empowering gifts that literacy bestows upon children can be considered to be unparalleled and that is why it is so important to understand as much as possible about how spelling and reading is represented and how it develops within a child's cognitive system. As Daniel Pennac indicates, reading is not a passive process and the same is true when children are learning to read and spell. Information is abstracted, interpreted and applied. Therefore in this thesis the levels of the Representational-Redescription (RR) model (Karmiloff-Smith, 1992) will be used as a tool to gain insight into the representations and possible cognitive processes underlying spelling and reading development in children. This model of cognitive development describes an endogenous process of learning whereby initial implicit representations are redescribed to become increasingly explicit. This perspective will allow examination of spelling and reading representations in a completely novel way to see whether they can be understood within

an implicit to explicit framework, whether children consciously access knowledge as they spell and read, what they can communicate about their understanding of reading and spelling and the type and nature of errors made.

The RR approach provides an alternative to traditional stage models, (e.g. Piaget, see Flavel 1963). There is a distinction between performance and understanding, verbal explanations are used as a source of information and the focus is upon domain specific rather than general change. The levels of the RR model have been previously applied to understand learning in different domains, e.g. children's understanding of balance (Pine & Messer, 1998, 1999, 2003) and more recently basic numerical principles (e.g., Chetland & Fluck, 2007, Butler, Pine & Messer, 2007).

In this thesis for the first time the implicit-explicit continuum of the RR model will be applied in order to examine the nature and development of children's underlying spelling and reading representations following initial work in spelling by Critten, Pine & Steffler (2007). Traditional models describing the joint development of spelling and reading (e.g. Frith, 1985, Ehri, 1998, 1999, 2002) describe stages/phases where early reading and spelling could be construed as implicit and later development as a gradual explicitation of this knowledge. Furthermore researchers in spelling (e.g. Steffler, 2001, Critten et al. 2007) and reading (e.g. Ellis, 1997, Thompson, Cotterell & Fletcher-Finn, 1996) have also emphasised the importance of implicit processes in spelling and reading development. Despite this, no attempt has been made to integrate these strands of research and apply a general model of cognitive development comprising an implicit-explicit continuum to this domain. If achieved this could provide a new perspective of spelling and reading development as the nature of underlying representations could be revealed, the differences between implicit and explicit representations more fully defined and children's explanations of their reading and spelling understanding can provide a new and rich source of data.

The first study in this thesis will build upon Critten et al's identification of a number of different explicit levels of understanding for spelling to seek empirical evidence for a

forerunner to these levels, i.e. an implicit level of spelling. This will be used as a tool to compare children's performance and ability to verbalise knowledge on different spelling tasks. The second study is the first to document children's spelling and reading representational development over the course of a year. This longitudinal study has three main aims: (i) to see whether RR levels can be developed and applied to reading in a similar way to spelling; (ii) to test the RR approach as a model of development to see whether children's spelling and reading knowledge does become more explicit over time and (iii) to see how spelling and reading understanding develops in relation to each other. This third aim will examine the pace maker notions of Frith (1985) using this new theoretical framework and coding scheme and provide insight into the nature of developing representations following studies with adults (e.g. Holmes & Davis, 2002). The third study will address the role of context in relation to spelling as well as reading building upon the Lexical Quality Hypothesis (Perfetti & Hart, 2002) to investigate understanding as well as accuracy to see if and when context facilitates. Finally the findings of these studies will be used to propose a new model of spelling and reading development that focuses on explicitation of knowledge.

The relevant literature will now be reviewed in this introductory chapter to identify the key research issues that will be addressed throughout the thesis. This review will be divided into five main parts.

1: The RR model

Overview of the Representational-Redescription Model (Karmiloff-Smith, 1992). Its levels of increasingly explicit knowledge and differences to classic stage models of cognitive development will be described. Previous applications of the model to different domains will then be considered. e.g. the balance beam (Pine & Messer, 1999)

2: Models of spelling and reading development

Rationale of the literature used in terms of how the RR model can contribute to our understanding. Description of stage, (Frith, 1985), phase (Ehri, 1998, 1999, 2002) and

item based (Share, 1995) models of reading and spelling development and studies that support and refute their claims.

3: Implicit processes in reading and spelling
Further rationale for the application of the implicit to explicit continuum of the RR model to the domain citing evidence of implicit spelling (Steffler, 2001, Critten et al, 2007) and reading (Thompson et al, 1996, Ellis, 1997).

4: Shared representations and how they develop
Discussion of how the application of the RR model to reading and spelling could provide insight into the nature of developing representations in relation to shared representations for spelling and reading (e.g. Holmes & Davis, 2002) and pace maker notions originating from Frith (1985).

5: Contextual facilitation for reading and spelling
How the application of the RR model could be used to investigate the influence of context upon children's understanding of spelling and reading following studies predominantly focussing on facilitation of reading accuracy (e.g., Nation & Snowling, 1998, Reimer, 2006).

1: The RR model

The main theoretical influence upon the thesis, the RR model will be introduced and its differences to classic stage models and previous applications will be discussed.

1.1: The RR Model

This model of cognitive development describes learning as a process whereby initial implicit representations (Implicit level) are redescribed to become increasingly explicit (levels E1, E2 and E3) as knowledge becomes consciously accessible, verbalisable and can be generalised across and within domains of learning. Representational development can be triggered by events in the environment but the emphasis is placed on endogenous

change or self-generation. Cognitive development follows a linear path via these levels but importantly this model also identifies a U-shaped development in *performance*.

The first level of representation described by Karmiloff-Smith is the **Implicit level**. Information is encoded in a procedural data-driven format, directly responding to stimuli in the environment. These representations are stored separately from one another and although they can be accessed as a whole, leading to task success or "behavioural mastery", the knowledge cannot be *consciously* accessed, as analysis of the component parts is not possible. Therefore children at this level are often successful at a task but this is achieved without understanding or the ability to provide an appropriate explanation of their success. Throughout this thesis, Karmiloff-Smith's description forms the basis for the operational definition of what an implicit representation is: the procedures to perform a task correctly but a lack of conscious access to this knowledge and inability to explain how success was achieved.

The second level of the RR model is **Explicit level 1 (E1)**. In contrast to the implicit level where children adapt their responses, this level marks a departure in emphasis to internal representational change. In fact, external data is ignored as connections are built up between existing representations and often an over-general theory or strategy is adopted which can result in a decrement in performance. The latter can be seen as a U-shaped performance curve. Karmiloff-Smith believes at this level that knowledge still cannot be consciously accessed and is not available for verbal report.

The third level of the RR model is the **Explicit level 2 (E2)**. At this level of development, a balance is achieved as the E1 representations comprising overgeneralised theories formed internally become more integrated with the external information provided by the environment. As the child's theory is no longer dominating performance begins to improve again but this time and in contrast to the implicit level, success occurs with understanding.

The final level of Karmiloff-Smith's model is **Explicit level 3 (E3)**. At this point of development fully explicit representations have been formed and performance improves again. However in contrast to the implicit level, knowledge can be consciously accessed and verbalized to others. Furthermore, knowledge can be analysed in terms of component parts, shared within domains and applied to other domains marking a flexibility and creativity in its usage.

The RR model of cognitive development with its implicit to explicit continuum therefore involves a distinction between performance and understanding: success is not necessarily accompanied by conscious access to knowledge. Furthermore the process it describes does not just consider the knowledge we have and whether success is achieved or not on a given task, it concerns whether there is explicit understanding of the task and whether this knowledge can be explained.

It provides an alternative to traditional stage models (e.g. Piaget, see Flavel, 1963) that describe blanket developmental changes across all domains as the RR approach advocates domain specific change. This allows for differing abilities in different fields of learning. The model describes a multi-representation system. When redescription occurs, the original representations still remain intact and available within the cognitive system. The representation that is accessed may depend upon the task at hand. Implicit representations may be used when speed or automaticity is required, however explicit representations may be accessed if knowledge needs to verbalised or generalised to a new situation. The developmental nature of this model provides insight into how knowledge changes over time to form fully explicit representations.

1.2: Previous applications of the RR Model

The RR model has been previously applied post-hoc to account for development in language, notation, maths and physics (Karmiloff-Smith, 1992). However Pine & Messer (1999) were the first to apply the RR levels in an empirical study. Many of their findings support the model but they also make suggestions about possible modifications

particularly regarding Karmiloff-Smith's suggestion that knowledge at level E1 and to some extent level E2 was not available for verbal report.

In the first of these studies Pine & Messer (1999) examined children's behaviour on a balance beam task to see whether it would correspond to RR levels as had been suggested by Karmiloff-Smith (1992) and Karmiloff-Smith & Inhelder (1974). They asked 168 children (aged 4-9 years) 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 justify verbally why they had been successful or unsuccessful in balancing the beams. Results indicated that behaviour on this task did correspond to RR levels. Implicit behaviour was characterised by task success without conscious access to representations or verbal explanations whilst fully explicit (E3) behaviour also displayed task success but was accompanied by verbal explanations as to how the different types of beams were to be balanced.

However it was the children allocated to level E1 that displayed the most interesting behaviour as they stubbornly placed all beams on the fulcrum at the centre declaring that asymmetrical beams "could not be balanced". This "centre theory" was therefore leading to errors. However despite Karmiloff-Smith's belief that knowledge at this level was unavailable for verbal report, 45% of those children allocated could explain their "centre theory" making reference to: "having both sides equal", for example. As a result Pine & Messer suggested a modification to the original model; that level E1 can take two forms: Abstraction non-verbal and Abstraction verbal. When applying the RR model to other domains therefore, it might be inferred that even at E1 children may be able to verbalise or articulate the rule they are using. This study also followed Karmiloff-Smith's example by coding the predominant behavioural response that children make as the RR level of their underlying representations, for example if out of 15 balance beam trials a child was E1 for 11 of the trials and E2 for the remaining four, then the child would be allocated to level E1.

More recently the application of the RR model has been considered in relation to mathematical principles. Chetland & Fluck (2007) tested children (aged 3-5 years) on the "Give x" task where children are asked to provide five counters for example, out of a large jar of counters. They found that even when children had achieved task success (i.e., implicit representations) they progressed beyond this and developed new strategies to perform the task. Chetland & Fluck argue this is a demonstration of explicitation of knowledge advocated by the RR model.

Butler, Pine & Messer (2007) have also used RR levels to describe the representational development of the one-to-one counting principle and the principle of cardinality again in young children aged 3-5 years. They considered children's verbal explanations as a measure of understanding alongside task performance and also discovered that knowledge could be verbalised to a certain extent at level E1.

Thus far application to the domain of literacy has come via a theory of metalinguistic development linking the RR principle to accessibility of linguistic knowledge when learning to read. Gombert (1992) made a distinction between different types of control that an individual may have over their linguistic knowledge. At the epilinguistic level, control over linguistic processing is automatically determined by the linguistic organisation in memory. At the metalinguistic level, the individual is able to consciously control what linguistic information they will access and apply in any given situation. He points out the parallels between this and the distinction made in the RR model between knowledge that is accessible and that which can be verbalized. He also sees the progression from epilinguistic to metalinguistic control as developmental in nature.

In terms of his model for reading development, Gombert (1992) suggested three phases of development. In the initial phase of acquisition of first linguistic skills, Gombert describes how children start to form implicit type representations of written-word structure in the manner of Karmiloff-Smith that can lead to recognition success in lexical decision tasks. In the second phase, in accordance with Karmiloff-Smith's E1 level is the acquisition of epilinguistic control and while used for cognitive control of linguistic

behaviour, is not yet consciously accessible. Goswami (2000) suggests that typical linguistic knowledge at this point would consist of syllable and rime knowledge. In the third phase in accordance with Karmiloff-Smith's E3 level of acquisition of metalinguistic awareness, children will gain control over phonological structures and the ability to manipulate them in response to external factors. At this point Goswami suggests that children develop explicit knowledge of grapheme-phoneme correspondences.

Gombert's model provides important insight into how using an implicit/explicit distinction could provide a cognitive perspective for viewing literacy development. However these levels have not yet been empirically tested. Furthermore the nature of children's explanations and reading/spelling performance at all the implicit and explicit levels is underspecified, as is the method that might be used to assess this. Furthermore, Pine & Messer's (1999) discovery that knowledge can sometimes be accessible and verbalisable at level E1 suggesting a modification to the original model would certainly merit empirical study in the literacy domain to see if this is also the case here. An important part of Karmiloff-Smith's approach was also the notion of theory abstraction at E1 leading to overapplication and errors. Empirical work is necessary to understand the types of theory(ies) children may abstract when spelling and reading as this may explain the errors produced when overgeneralization occurs (see later discussion of Nunes et al. 1997).

Therefore empirical application of the RR model to the domain of literacy can only be seen in relation to spelling (Critten, Pine & Steffler, 2007) and this will be discussed in more detail in Part Three of this review. The implicit to explicit continuum has not yet been empirically applied to reading and as later discussion will suggest, spelling and reading are interconnected and should be studied simultaneously (Ehri, 2000). If this can be achieved then a more coherent joint model for spelling and reading development incorporating this mechanism can be formed.

One potential limitation of the RR framework that should be acknowledged is whether it has been successfully demonstrated as a model of "development". The developmental aspect of the RR model has not been fully tested in any domain, i.e. do children follow the suggested course of learning and progress through the RR levels? Pine & Messer (1998, 2003) and Pine, Messer & Godfrey (1999) have conducted short-term intervention studies (of a week or so) to facilitate children's explicit knowledge of the balance beam task and a microgenetic study over the course of a week but a non-interventionist longitudinal study of development through the RR levels has not been attempted. The actual process of redescription itself also remains somewhat undefined. While the different types of representation have been found in previous domains, how representations become more explicit, i.e. what might facilitate this change is less certain. Although it is beyond the scope of this thesis to fully answer these questions, a longitudinal study of development and examination of the facilitative effect of context may elucidate some of the likely processes of change.

Briefly it should be acknowledged that this thesis is not the first research to explore the domain of literacy in relation to a general model of cognitive development as an alternative to traditional stage models of global development. The Overlapping Waves model (Siegler, 1996) model tries to directly account for the way children learn and like the RR model, also considers change from a domain specific, rather than domain general perspective. The model assumes that to solve a problem, children will think in more than one way and use a variety of strategies. All of these strategies and ways of thinking co-exist in a parallel fashion over a long period of time, not in short or specific changes. Experience will influence which strategies are used and how often, as well as introducing new and more advanced ones. Therefore this model describes learning via the development of multiple strategies in which frequency of use changes and simple strategies lead to more advanced ones. The main emphasis of this theory is "cognitive diversity" (p.38, Siegler, 1996). Children may alternate between strategies within single tasks by linking more than one strategy or employing different strategies on different parts on the task.

In relation to literacy researchers have explored the variability of procedures children employ in spelling (e.g. Rittle-Johnson & Siegler, 1999, Kwong & Varnhagen, 2005) and more recently in reading (e.g. Farrington-Flint & Wood, 2007). However using the implicit-explicit continuum of the RR model could provide insight into unanswered questions raised by these studies. Rittle-Johnson & Siegler (1999) reported that children's use of strategies demonstrated two main types: automatic retrieval and back-up strategies employed by children to decode an unknown word (e.g., sounding out the word, analogy, application of a morphological rule, etc.) However Rittle-Johnson & Siegler could not explain:

"why children persist in using time-consuming back-up strategies that initially do little to improve performance" (p.345).

This stubborn application of strategies or theories that can result in error production matches the defining characteristics of Karmiloff-Smith's (1992) first Explicit level (E1). The RR model could therefore potentially account for the behaviour displayed in the Rittle-Johnson & Siegler study in a way that the Overlapping Waves model could not and the findings of Critten et al. (2007) would support this (see later discussion of this study).

The RR model could also provide insight into whether task success is due to implicit or fully explicit knowledge. Rittle-Johnson & Siegler (1999) and Farrington-Flint & Wood (2007) both explain that the automatic retrieval strategy will often produce correct spelling and reading, however by analysing the underlying representations using the RR approach the nature of the knowledge underlying this task success can be elucidated. Therefore, for the purposes of this thesis the Overlapping Waves model will no longer be referred to, however it will be returned to in the General Discussion (Chapter 6) in terms of how principles from the two models could be integrated in future research.

2: Reading and spelling models

2.1: Rationale

Parts Two and Three of this review will discuss how the RR model could be used to aid the understanding of underlying representations and their development in relation to

classic models of spelling and reading development (Frith, 1985, Ehri, 1998, 1999, 2002, Share, 1995) and studies of implicit spelling and reading (e.g., Steffler, 2001, Critten et al, 2007, Thompson et al, 1996, Ellis, 1997). However first it is necessary to explain why this literature will be considered. The study of literacy is widespread and full of complexities so it is important to specify where the RR model could contribute the most.

Much of the focus has been the study of specific but crucial aspects of phonology, e.g., speech prosody (e.g., Wood & Terrell, 1998, Wood, 2006) and rhyming and segmentation (e.g., Muter, Hulme, Snowling & Taylor, 1997). This is doubly true in the study of reading disorders such as dyslexia where researchers have explored problems in phonemic awareness and development of phonological representations (e.g., Swan & Goswami, 1997) and verbal short-term memory (e.g., Brady, 1997) among other things. In addition to phonological deficits, studies of dyslexia have also examined the importance of reading fluency as measured by rapid access naming (RAN) and difficulties in physical coordination: the triple deficit account (e.g., Needle, Fawcett & Nicolson, 2006, Nicolson & Fawcett, 2006). However in order to specify how the RR model could be most useful in providing insight into underlying representations studies of phonology, as well as morphology and orthography will be limited here to those that support or refute the models considered and/or concern implicit processes. Furthermore children's typical development is being studied in this thesis and indeed the RR model has only been used as such in its applications thus far. That is not to say that it could not be used to explore atypical development in spelling and reading in the future.

There are of course other notable models of development in literacy that employ computational principles, e.g. the Dual Route Cascade model (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001) and Parallel Distributed Processing models (e.g. Plaut, McClelland, Seidenberg & Patterson, 1996, Harm & Seidenberg, 2004). However as Castles & Nation (2006) explain the former is a model of skilled performance, i.e. about adults and says nothing about the process of acquisition. As the focus of this thesis is developing representations, this model will not be referred to. As regards the latter

models they are primarily models of reading development rather than spelling but will be considered in relation to semantic facilitation in Part Five of this review.

The literature to be discussed has been chosen for three main reasons:

1) This thesis is looking at the development of spelling and reading representations so it is logical to use joint models of these processes as a reference point (Frith, 1985, Ehri, 1998, 1999, 2002, Share, 1995). Ehri (2000) draws attention to the similarity of processes and mutual dependence in development and is therefore perplexed that reading and spelling are often seen as two separate acts. She outlines some of the crossovers, for example, the two meanings of spelling. Firstly it can be referred to as writing out the spelling of a word correctly: spelling production. Secondly it can be referred to as recognizing whether words are spelt correctly as they are being read: spelling recognition. Ehri points out that both of these tests of spelling involve reading and therefore the two cannot be easily separated:
"People read spellings of words. People spell spellings of words. People read the spellings they have spelled" (p.20 Ehri, 2000).
Ehri explains that although the processes may not be identical they are extremely difficult to separate and there are well-documented correlations of ability of .70. It is therefore important to study both spelling and reading simultaneously.

2) As discussed below initial stages/phases in the Frith (1985) and Ehri (1998, 1999, 2002) models could be construed as implicit while the development of phonological and morphological knowledge beyond this and the errors that are made could be construed as explicit processing. Furthermore separate studies have documented implicit processing in spelling and reading (e.g., Steffler, 2001, Critten et al. 2007, Ellis, 1997, Thompson et al. 1996). The use of the implicit-explicit framework of the RR model can therefore build upon and integrate these strands of research for the first time.

3) With the exception of the pace maker notions of the Frith (1985) model (discussed below) the stages/ phases of joint models of spelling and reading (e.g. Frith, 1985, Ehri,

1998, 1999, 2002), although based on empirical research (Sadoski & Paivio, 2007) tend to *describe* the knowledge that children acquire as they learn, almost like a curriculum given to teachers for what needs to be taught. The RR model could build upon this by suggesting the nature of underlying representations and cognitive processes providing a new developmental perspective: children could be using implicit or explicit representations, knowledge may not be consciously accessible or communicable, errors may be systematic in their nature for an underlying cognitive reason. As shown in Part Three this is akin to how Critten et al. (2007) used the findings of Nunes et al. (1997) as a basis to work from.

Indeed Sadoski & Paivio (2007) have recently argued that there is a need for the application of generalised models of cognitive development to aid our understanding of reading development. They describe reading research as fragmented, a problem that could be resolved if frameworks from generalised cognitive theories were utilised. Interestingly they suggest that Piaget's stages could be one such theory, however as discussed earlier in the review, more recent developmental models such as the RR model offer advantages over global stages of development.
Further discussion of these points will take place in the summary sections of Part Two and Part Three following examination of the literature chosen.

2.2: Stages and Phases: Descriptions of the development of literacy

In the classic stage theory Frith, (1985) proposed three main stages to describe how reading and spelling develops. Ehri's (1998, 1999, 2002) model possesses many similarities but employs a more flexible approach describing four main phases. She argues that mastery of a phase is not a pre-requisite for progression. The type of knowledge applied may depend on the words being read or spelt.

Frith's initial "logographic" stage and Ehri's Pre-Alphabetic phase would suggest that early lexical processing is purely visual referring to automatic recognition of familiar words and the development of a sight word vocabulary. The child does not apply

phonological knowledge to decipher the word, e.g. letter names, letter sounds or any form of blending, they simply pronounce the word after it has been recognised. Salient visual features or cues provided by the context may aid this recognition process, as demonstrated by Masonheimer, Drum & Ehri (1984). They studied very young children who could not read many frequent words but could read common signs that they would encounter in their environment, e.g. McDonalds, Pepsi. Masonheimer et al. altered the spelling of these words, e.g. Xepsi and asked children to read them again. Most were still able to identify the words and didn't notice the mistakes even when prompted. Furthermore they could only name 60% of the letters contained within the words showing these were not used as a tool for identification. In addition to this, Bloodgood (1999) found that children could recognise their own names and the names of their friends from only the initial letter suggesting this was the salient cue: they would identify another name beginning with the same first letter as their own. Instances of logographic spelling have been studied on a smaller scale but Treiman & Broderick (1998) showed that even when young children are able to write their names they cannot always name the letters they have written. The researchers argue that the letters have been remembered for their visual shape rather than as representations for sounds.

Given this description of the logographic stage and pre-alphabetic phase it seems logical suggest that these initial processes could be construed as implicit therefore justifying the use of the implicit-explicit continuum to understand spelling and reading representations. However it should be pointed out that according to Karmiloff-Smith's (1992) definition of an implicit representation as used in the thesis, that unlike the Masonhemier et al. study where children read errors as real words, e.g. Pepsi instead of Xepsi, correct spelling recognition and reading would be a requirement of identifying this level. Treiman & Broderick's findings are a very good example of correct application of implicit procedures, i.e. writing names correctly, without explicit insight into the process itself. However it is also reasonable to suggest that a child could know and name all the letters in a word but still not have explicit insight into how to spell it, i.e. how the sounds blend together to form segments in that word or apply the knowledge of letter names to spell unfamiliar words.

As development progresses the models start to differ slightly as Frith describes the development of the 'alphabetic" stage where Ehri suggests two more finely grained phases: Partial Alphabetic and Full Alphabetic. Children are now starting to learn letter names and letter sounds and realise that there is a connection between spellings and pronunciations: phoneme-grapheme and grapheme-phoneme correspondences, referred to as phonemic awareness. Decoding ability develops gradually as children try to read novel and nonsense words using their phonemic knowledge. Ehri (1998) indicates that children may remember how to read the word jail by realising the connection between the initial and final letters to their letter names, e.g., jay for j and el for l. Similarly in spelling Ehri explains that children will detect salient consonants and vowels in a word they can hear and attempt to spell it, e.g. br or bvr to represent beaver. As grapho-phonemic knowledge increases so does the ability to decode and spell longer words.

In Frith's third "orthographic' stage and Ehri's Consolidated Alphabetic phase again there is a slight difference. Frith argues it is only when alphabetic skills have been fully mastered that internalised representations are accessed containing common word units or patterns without phonemic conversion, e.g. consonant doublets (e.g. the double "l" in filled), and morphological rules (e.g. the suffixes –ed, -ing, -er, -est). However more recent research indicates that contrary to this sequential stage development, phonology may be involved in access to orthographic representations (e.g., Ehri, 1992, 1995) and aid in their creation (e.g., Rack, Hulme, Snowling & Wightman, 1994) much earlier in the process: in effect a mutually beneficial relationship.

This development of phonological and morphological information and its accompanying errors could be construed as reflecting the development of explicit representations. Children start to abstract and interpret information endogenously and apply it creatively as they try to make sense of how to spell and read words. Clearly children do go beyond task success of the recognition skills described in the initial stages/phases of these models and the RR model can aid our understanding of these processes. However it may be more appropriate to view the acquisition of these different types of information as phase-

like rather than stage-like, as discussed below, again making the RR model an appropriate tool for investigation.

2.3: A more interactive development?

Rack et al (1994) explored the issue of how phonological skills lead to recognition of printed words and following research by Ehri (1992) refer to the "direct-mapping" hypothesis. According to Ehri children form partial associations between letters in a printed word and the phonemes to which they correspond in the early stages of learning to read (her partial alphabetic phase). These associations are derived from letter sounds and letter names. Ehri argues that the ability to recognize letter-sound associations facilitates the reading process before the use of traditional letter-sound decoding procedures, e.g. the "sounding out" procedure (Jorm & Share, 1983) in which the word CAT would be read as "cuh-ah-tuh".

Rack et al. (1994) explored this direct-mapping mechanism and discovered that 5 year-old children learned cues that were phonologically similar to a target word more easily than control cues, for example; dbl for table (phonetic cue) versus kbl for table (control cue). This indicates that children were sensitive to the overlap between phonetic features of phonemes and the phonemes in the target words. Rack et al conclude that phonological processes are involved in reading from the start.

Support for the importance of phonemic awareness (PA) in the formation of accurate orthographic representations was also found by Dixon, Stuart & Masterson (2002). By comparing children (aged 5) with high levels of PA to those with hardly any on lexical decision tasks (including the words that had been previously learnt) it was discovered that the former had much more detailed representations of the target words as they could discriminate them from similar alternatives.

Other studies have also shown that orthographic knowledge does not have to follow completion and mastery of a phoneme-grapheme stage as suggested by Frith. Lehtonen & Bryant (2005) explored the difference between knowledge of orthographic form, which

refers to patterns within written words and the constraints, i.e. what is possible and what is not and knowledge of orthographic function; how the orthography relates back to phonology and morphology. Frith (1985) argues that knowledge of both form and function will only follow once phoneme-grapheme and grapheme-phoneme correspondences have been learnt. However Lehtonen & Bryant suggest that it is possible to have knowledge of orthographic form, if not function of what letter sequences are possible without knowing all connections between phoneme and graphemes. They explored the orthographic form of consonant doublets, in Finnish. Their function is to stand for long consonants. Children aged 6-7 years were able to recognize incorrect use of this form even if they didn't know its function. In conclusion they argue against the traditional notion that orthographic knowledge has to be "sophisticated" (p. 216 Lehtonen & Bryant, 2005) and can only ever follow the phoneme-grapheme stage. They believe that children use different types of information in their early reading and spelling.

This view is echoed by Bernstein & Trieman (2004). They explored difficulties that may occur in the pronunciation of digraphs: phonemes made up of two letters that may differ in the sound they make, e.g. the different sounds of "ea" in *meal* versus *break* versus *bread*. The consonantal context of the word provides the important clue in how the digraph should be pronounced and it has been argued that the rime has more influence than the onset is these situations, e.g. the rime of *l* in *meal* versus the onset of *m*: The "Rime context-first hypothesis" (Goswami & Bryant, 1990). This hypothesis argues that this will be true whatever the age of the reader. In contrast the "Rime context-last hypothesis" as purported by the Frith (1985) model would argue that as this influence of context is drawn from stored knowledge it can only occur in the orthographic stage and therefore only in older readers. However the children's behaviour did not totally support either of the hypotheses, as although younger children did show the influence of consonantal context, there was an equal influence of both onset and rime on both younger and older children. The authors therefore look for an explanation from the consolidation hypothesis (Ehri, 1994) that explains that context sensitive spelling to sound relationships are learnt on the basis of recurring patterns, e.g. *–est* in *nest*, that occurs unit by unit. The order of acquisition of these units depends on the experience the child has had rather than

their age or the stage of development they are in. This provides evidence for Ehri's (1998, 1999, 2002) phase theory of development.

Phonological processing is clearly vital for word recognition. However Ferguson & Besner (2006) argue that it is not always necessary for visual word recognition and that orthographic processing can be sufficient on its own. They explored this using a priming technique employing pseudohomophones. They used phonological primes, e.g. *knooz* for *news* relative to orthographic controls, e.g. *snaid* that is as equally orthographically similar to *news* as *knooz* is. They also used morphological primes, e.g. *marked* for *mark* relative to the control prime *tack*. In a second task participants were asked to search the primes for a target letter and then make a lexical decision on a letter string. This second task showed evidence of the morphological priming but not the prior phonological priming. They therefore argue that visual word recognition can be just as influenced by orthographic input as by phonological.

Therefore when considering the development of phonological and morphological information in explicit representations for spelling and reading it should be viewed as an interactive process rather than simply one following the mastery of the other, e.g. phonological and morphological errors can occur simultaneously

2.4: Pace makers

Support for the sequential nature of the Frith (1985) model is weak. However the model also suggests how the skills of reading and spelling develop in relation to each other, a relationship also discussed to a degree by Ehri (1998, 1999, 2002). Frith explained that as children progress through the stages there is an interaction of the skills. The logographic stage involves an early whole-word approach to reading. This acts as a pacemaker and leads to a similar strategy being adopted in spelling. In the alphabetic stage the emergence of phonological awareness triggers alphabetic spelling which acts as a pace maker for alphabetic reading. It is at this point that internal orthographic representations acquired through reading can lead to orthographic spelling.

Support for these notions was found in a long-term study of development. Caravolas, Hulme and Snowling (2001) examined the developmental relationship of spelling and reading ability in children throughout their first three years of schooling. They aimed to explore predictors of spelling skill relative to reading and the relationship between the skills in terms of reciprocity or whether reading provides the foundation of spelling. They discovered that in the early years (aged 4-5.5 years) phonological spelling ability (mappings between phonemes and graphemes) drives the development of reading skill. However later on as the children progress (aged 5.5+) this influence is no longer exerted and reading becomes the "pacemaker" (p.710 Caravolas et al, 2001) for spelling. Therefore it would seem that the pattern of influence shifts early on, as whilst phoneme isolation skill and letter sound knowledge initially predict both spelling and reading; after the first year and a half, letter-name ability appears to be much more important for reading.

Ellis (1997) concludes that in the development of spelling and reading representations Frith (1985) describes a clear interaction whereby spelling is sometimes driving the progress of knowledge acquisition and sometimes it is reading. Furthermore echoing the studies described earlier (e.g. Lehtonen & Bryant, 2005, Bernstein & Trieman, 2004, Ferguson & Besner, 2006) his most important conclusion is that it seems impossible to separate alphabetic and orthographic aspects of reading and spelling throughout development.

The interaction of the two skills in development therefore highlights the importance of studying underlying spelling and reading representations simultaneously.

2.5: Share's Item Based model

A slightly different approach is provided by Share's (1995) Self Teaching hypothesis. Share argues that contrary to describing development using broad stages or phases it is more useful to examine the development of a sight reading vocabulary item by item, that is word by word. He explains this it is a more plausible way of understanding why children can read and spell some words but not others: they simply haven't acquired the

knowledge specific that word. Furthermore he does not consider initial reading and spelling in terms of the visual and contextual cues in the way Frith and Ehri does, concentrating instead on how the development of phonological knowledge (e.g., letter-sound correspondences) enables the use of decoding processes to identify novel words. Share argues that decoding forms word-specific orthographic information that is retained in memory: thus self-teaching. Share (1999) provides support for this hypothesis with children learning to read Hebrew. Children were given short stories to read containing non-words such as yait. In a recognition test these non-words were presented with homophonic foils, e.g., yate. The target word was identified 70-90 % of the time and children were also more likely to use the target spelling patterns when asked to spell the words.

However Castles & Nation (2006) argue that phonological decoding cannot account for all children's learning as the English orthography is far less transparent than Hebrew and many words cannot be correctly read or spelt using just this form of knowledge. They also explain that the extent to which self-teaching operates in beginning reading has not been fully explored as the children thus far have been mostly aged 8 years and over. Only one study has been conducted with younger children (aged 7 years) by Share (2004). Of interest here is the finding that although these children had no difficulty in reading the non-words they were just as likely to choose the homophonic foil in the recognition task. Orthographic learning had not occurred to the same extent in these younger children contrary to the predictions of decoding. It is unlikely that the earliest representations are formed when children try to decode words and this is supported by the initial stages/phases of Frith and Ehri and by predictions made by the RR model about the nature of initial learning, i.e., that it is implicit. Share's hypothesis may be more useful when trying to understand slightly later development of more explicit representations. Having said this, its item-specific approach does provide an alternative viewpoint to models detailed thus far.

2.6: Summary

Traditional models of reading and spelling (Frith, 1985, Ehri, 1998, 1999, 2002) describe a development initially based on recognition triggered by salient visual and contextual cues. Gradually though as phonemic knowledge is acquired (e.g. letter names, letter sounds, phoneme-grapheme/grapheme-phoneme correspondences) children attempt to decode and spell unfamiliar words. As shown by studies refuting Frith's sequential structure (e.g. Lehtonen & Bryant, 2005, Bernstein & Trieman, 2004, Ferguson & Besner, 2006) these phonological processes interact with the development of common word units and patterns leading to the formation of internalised orthographic representations. Furthermore studies of development (e.g. Caravolas et al. 2001) support pace maker notions suggested by Frith showing how reading and spelling skill interacts and lead development at different times in young children's literacy. From a slightly different viewpoint Share (1995) also argues the usefulness of studying word specific knowledge rather than broader stages/phases.

How can the RR model contribute to the understanding of the representations underlying this development? First we could surmise from Frith (1985) and Ehri's (1998, 1999, 2002) descriptions of initial reading and spelling that it is largely implicit in nature. Children may recognise or produce a word because they have seen it before but be unable to analyse the words in terms of component parts and understand how they were able to spell or read the word. Secondly the subsequent development of phonological and orthographic knowledge that can lead to errors when children are reading or spelling unfamiliar words could be seen as the development of representations gradually increasing in level of explicitness. The mechanism of an implicit to explicit continuum may therefore prove a useful developmental framework for understanding spelling and reading development. Furthermore the traditional models are concerned with what children can do and have not focussed on what they understand and can verbally explain as they read and spell. Reading and spelling errors are described but why is it certain types occur and persist? The RR model provides a new perspective to explore this domain. The added flexibility of its phase-like structure and advocation of multi-representations provides the same advantages as Ehri's (1998, 1999, 2002) and Share's

(1995) models compared to Frith's (1985) stages, thus providing a more plausible framework for children's real-world development. Furthermore Sadoski & Paivio (2007) argue that the application of a generalised model of cognitive development may help to resolve some of the fragmentation within current reading research.

3: Implicit processes in spelling and reading

It has already been suggested that the initial stages/phases of the Frith (1985) and Ehri (1998, 1999, 2002) models may infer that early spelling and reading is implicit, a notion also explored by other researchers. However although there is great overlap in the skills some researchers have focussed just on spelling (e.g. Nunes, Bindman & Bryant, 1997, Critten, Pine & Steffler, 2007) or reading (e.g., Thompson, Cotterell & Fletcher-Flinn, 1996) and it is this fragmentation that the application of the RR model would also help to resolve.

3.1: Implicit and explicit spelling

In a review of the spelling literature Steffler (2001) concluded that a consensus had been reached as regards the nature of spelling development. Steffler describes development as progressing from a visually based, phonological level, to a higher-order morphological level and then to a level where both of these factors are taken into account thus resulting in the correct production of spelling. Furthermore she explained that stage models (e.g., Nunes, Bindman & Bryant, 1997) are typically used to characterize the growth of spelling knowledge at various points in development. This model does offer understanding of the development of spelling errors something joint models refer to but in less detail.

In a three-year longitudinal study using children aged 6-8 years Nunes et al. (1997) were able to demonstrate the phonological to morphological development of spelling as characterised by typical spelling errors. Spelling tests comprising regular past tense verbs, e.g., *filled*, irregular past tense verbs, e.g. *sold* and non-verbs, e.g. *soft* were given to the children. As expected from the joint models early stages in spelling development

(e.g. stages 1 and 2) are phonological in nature as words that can be phonetically spelt such as *sold* are produced correctly but words such as *kissed* are commonly expressed as the phonetic error *kist*; the morphological rule of –ed is not used as yet.

However in stages 3 and 4 morphological knowledge of spelling is applied alongside phonological knowledge often resulting in what Nunes et al. (1997) referred to as overgeneralization errors. This focus on morphological spelling development is lacking in joint models, a fact acknowledged by Ehri (2005). Their most significant finding was that the morphological rule of –ed was not just applied to regular past tense verbs but to irregular verbs and non-verbs as well, e.g., *solded* instead of *sold*, *colded* instead of *cold*. These previously unreported errors were of particular interest to Nunes et al. because they signified a u-shaped performance curve. As 6-year olds many participants could correctly produce words such as *sold* and *cold* but as 7-year old, overgeneralization errors were intruding only to disappear again at the age of 8.

Steffler (2001) highlighted the importance of studies such as Nunes et al's (1997) for exploring the nature of spelling errors in understanding how spelling develops, however she concluded that accounts thus far (including Frith, 1985 and Ehri, 1998, 1999, 2002) had been primarily descriptive. She then raised two fundamental issues: 1) What about implicit spelling? 2) What are the cognitive mechanisms that underlie this phonological to morphological development of spelling? In relation to the first point, Steffler explains that we may not always be aware of the spelling conventions we are following, unsurprising, given the number that exist: 2000 phoneme to grapheme correspondence rules to represent a corpus of 17,000 words (Hanna, Hanna, Hodges & Rudorf, 1966). This resembles Karmiloff-Smith's (1992) definition of the nature of implicit representations, just because we can employ procedures correctly when spelling, does not mean we possess explicit understanding of them.

Furthermore Steffler referred to a range of studies that suggested implicit processes in spelling, e.g., Goswami's studies on the importance of analogy. Goswami (1988) showed that if children (aged 7 years) are shown clue words such as beak they prime spelling of

analogous words such as peak. Although there is now some doubt that very young children use analogy explicitly, it is a valid example of a possible implicit process. In conclusion Steffler suggested that the RR model could help address both of these issues by highlighting the role of implicit as well as explicit knowledge in learning to spell.

3.2: The RR model and spelling development

Critten, Pine & Steffler (2007) tested Steffler's notion that spelling development could be understood using representational levels derived from the RR model. This study was also designed to build upon and try to account for Nunes et al's (1997) findings that the –ed rule could be overgeneralised producing u-shaped development. It is necessary here to explain why there was a concentration on just this specific set of words and the development of one morphological rule as this will also be repeated throughout the course of the thesis. There are so many rules in English that it would be difficult to study the development of all of them and the –ed rule is a particularly good example as it highlights the complexity in the orthography between regularity and irregularity that children routinely make errors regarding. It would therefore be possible to extrapolate the findings of the development of this rule to others in the orthography. Furthermore, the errors that children make regarding this rule have been clearly documented by Nunes et al. therefore providing a solid basis to build upon when studying the underlying representations.

The words used by Critten et al. (2007) were therefore derived from this study and included regular past tense verbs e.g. *called*, irregular past tense verbs, e.g. *sold* and non-verbs, e.g. *soft*. Children aged 5-7 years were given alternative spelling of words (e.g., sold, solded, soled) and told the target word to identify. Then they were asked to verbally justify which alternatives they believed to be correct and incorrect. On the basis of recognition performance and coding of verbalisations all participants were allocated to a representational level of spelling understanding (Implicit, E1A, E1B, E2 or E3) derived from the levels of the RR model.

This was the first study to formulate representational levels for spelling derived from the RR model and also to consider children's explanations as a reflection of their understanding of spelling supporting the use of an implicit to explicit continuum as a mechanism underlying representational change. As explained earlier this is not a mechanism previously considered in relation to literacy.

Children displaying implicit understanding of spelling demonstrated task success as they consistently identified the correct spelling alternative of the word but failed to verbally justify why their choice was correct or why alternative spellings were incorrect, as they cannot consciously access knowledge. For example, when asked to explain why they believe a word is spelt correctly:
"I don't know"
"It looks right"
"I've seen it before"
If participants did try and justify a choice it was apparent that they were simply trying to make any response rather than accessing any explicit spelling knowledge. For example when asked why the alternative spelling for filled: filld, was incorrectly spelt, a child at the I-level might reply: "because it has i". Of course the correct spelling of filled has "i" as well.

Critten et al. (2007) also found support for the explicit levels in children's understanding of spelling. Following Pine & Messer (1999) modification of level E1 was also required. Two distinct types emerged: labelled E1A and E1B. Children at level E1A were not implicit, as they could verbally justify answers and also made recognition errors. Instead information regards phonology had been abstracted but was being over-applied resulting in phonetic recognition errors, e.g., choosing filld instead of, filled. Verbal justifications provided at this level were also phonologically based, for example:
"Filld is correct because it has two l's"
The morphological rule of –ed was not recognized as important and was not referred to. In fact children could be kept at this level even if they made a correct recognition if they

failed to mention –ed as a unit in any of their explanations, for example when justifying why solded is an incorrect spelling:
"It has two d's".

Children at level E1B had abstracted morphological information in relation to the rule of –ed but over-applied it to irregular past tense verbs and to non-verbs producing morphological recognition errors, e.g., choosing solded instead of sold. Verbal justifications again focussed on the presence or absence of –ed:
"Solded is right because it has –ed"
"Sold is wrong because it is missing –ed".
Children could also be kept at this level even if they made correct recognitions and could explain why spellings were incorrect (making reference to the –ed unit) if they failed to explain why they believed a spelling to be correct.

Children at level E2 displayed better recognition performance than those in level E1 and a growing integration and correct application of phonological and morphological knowledge. However performance was a little inconsistent and verbal explanations, as to why words were correct were sometimes lacking:
"Filled is correct as it has two l's and –ed"
when compared to a level E3 answer:
"Filled has the word "fill" and an –ed to make it past (tense)"
The latter answer indicates that those participants allocated to level E3 have a more fully explicit understanding of phonological and morphological aspects of spelling applying them appropriately without overgeneralization errors and verbalising knowledge thoroughly.

This study provided new insight into the representations underlying the phonological to morphological development of spelling and the overgeneralization errors described by Nunes et al (1997). Also unlike their longitudinal study that looked purely at spelling accuracy or the lack of, Critten et al. (2007) employed a method that used children's explanations to infer their understanding providing a new source of data.

It should be acknowledged that there are potential difficulties associated with relying on children's verbal self-reports, not least how difficult it may be for young children to explain quite complex concepts in an experimental situation with an unfamiliar experimenter. This could then lead to underestimations of children's knowledge and ability. However steps were taken within Critten et al's study to minimise this possibility as the spelling recognition task examined performance in *conjunction* with children's verbal reports. Therefore correct/incorrect recognition in combination with, responses to the remaining spelling alternatives and the explanations produced, led to characterisation of the underlying representations. This multi-faceted approach to assessment combined with inter-rater reliability measures increases the likelihood that a valid model has been produced. This can be demonstrated when examining how incorrect recognition is assessed: an error would suggest either E1A or E1B representations. If there is a phonological error accompanied by some basic phonological knowledge in the verbal explanation then level E1A is likely. However if it is a morphological recognition error and the verbal explanation refers to the aspect of morphology then level E1B is likely. This balance between assessment of performance and verbal explanations increases the likelihood of exposing the actual content and nature of children's representations.

Critten et al.'s results also provided support for the multi-representation system described by Karmiloff-Smith (1992). Although all the children tested could be allocated to one representational level of spelling understanding, the coding process highlighted some individuals that appeared to show evidence of multi levels and some that seemed to be in transition between two levels (usually E1B and E2). The latter could be explained in terms of capturing representational-redescription as it occurs, whilst the former suggests evidence of variability within the cognitive system. As mentioned earlier, Karmiloff-Smith states that even though representations are redescribed, earlier versions still remain intact and available for use. Depending upon the words they were presented with, children were accessing representations at different representational levels within the domain thus causing the resultant variability. For example, some children correctly chose

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

However issues remain unsolved from the Critten et al. (2007) study that will be addressed in this thesis particularly in extending the application of the RR model to reading. Only three children were found to have an implicit level for spelling, so further work with younger children is required to see whether it is possible to identify children at the earliest level in the implicit to explicit continuum. Furthermore the nature of implicit level understanding versus explicit level understanding of spelling can be tested on more than one spelling task, i.e. if a child is deemed to be at an implicit level for spelling on one task will this be the case on other similar tasks?

3.3: Does reading involve an implicit level of representation?

The notion that initial reading may indeed be implicit in nature and could be understood using the framework of the RR model is unsurprising when consideration is given to studies that explore the influence of print exposure. Cunningham & Stanovich (1997) explain that print exposure refers to children's experience of written materials within home and school environments and from this researchers can infer the more general reading experience of the child. It is typically measured using lists of common titles of books, magazines etc and children are asked to indicate those familiar to them. Studies by Cunningham & Stanovich have shown a relationship between the amount of print exposure and word recognition abilities and as Castles & Nation (2006) point out, orthographic information cannot be abstracted without experience of the written forms of words. This would echo Karmiloff-Smith's (1992) description of initial implicit representations that are formed via environmental input; in the case of reading, written words within the children's home, school and surrounding area, for e.g., 'Open" signs on a shop.

Ellis (1997) would also support the inclusion of an implicit/explicit dynamic within a model of reading as he explains that early phonemic awareness in the development of reading is implicit, for example in children's early experience of nursery rhymes as

supported by Stanovich, Cunningham & Cramer (1984). They discovered that there was actually no correlation between explicit non-rhyming tasks that required children to manipulate word sounds and rhyming tasks that required perception of word sound similarity. Ellis explains that an important distinction should therefore be made between implicit and explicit phonemic awareness and proposes that early reading and spelling make use of implicit PA.

Fletcher-Finn and Thompson (2000) provide support for this view. They studied a precocious 3 year-old reader with a word reading age of 8 years 6 months but undeveloped productive spelling. Maxine had some phonological sensitivity (rime awareness) and could segment words presented aurally into syllables but could not identify phonemes. Therefore explicit awareness of phoneme-grapheme relations was lacking. Maxine was followed up again at the age of 5 (Fletcher-Finn & Thompson, 2004) and was found to have a reading age of 11 years despite the fact that she was home-schooled and had never had explicit phonics instruction. Like Karmiloff-Smith's (1992) definition of an implicit representation, Maxine was able to apply procedures to read correctly but did not necessarily have explicit insight into these procedures. Based on the "Knowledge Sources" account of reading (Thompson, Cotterell & Fletcher-Flinn, 1996) the authors suggested that her reading ability was due to an implicit form of phonological recoding and therefore conclude that traditional models of reading (e.g. Frith, 1985, Ehri, 1998, 1999, 2002, Share, 1995) are lacking as they do not make this distinction between implicit and explicit knowledge and the fact that explicit phonemic awareness is not always necessary when learning to read. It is telling that this theory was developed by researchers working in New Zealand as for the last thirty years the teaching of reading in schools has never included explicit phonics instruction and yet children learn how to read familiar words, unfamiliar words and non-words just like children in countries that do receive explicit instruction.

The knowledge sources account (Thompson et al. 1996) fails to fully explain how children can read unfamiliar words and non-words. As Karmiloff-Smith (1992) explains knowledge that has been acquired implicitly leads to behavioural mastery but the contents

of the implicit representations cannot be consciously accessed or generalised. As shown by Critten et al. (2007) children at the implicit level for spelling could recognise words correctly but could not generalise their knowledge to explain why the error alternatives were incorrect or break words into segments by the same token. Yet, this is exactly what is required when approaching unfamiliar words: a break down into component parts, e.g. *in-telli-gent.* So knowledge acquired implicitly cannot account for this but if children have not received explicit instruction how will they achieve this? The RR model would argue that endogenous explicitation of knowledge into a more flexible and generalisable format has occurred. Children form theories as they abstract regularities from written words and through this can see words as component parts. So this provides further support for using representational levels derived from the RR model as a framework for understanding reading development.

3.4: Summary

Clearly there is support for an implicit component in the development of spelling (e.g. Steffler, 2001 Critten et al. 2007) and reading (e.g. Thompson et al. 1996). By using the implicit explicit continuum of the RR model these research strands can be integrated into a more coherent structure for both spelling and reading to see whether these initially implicit or logographic representations are redescribed to become increasingly explicit enabling children to communicate phonological and morphological theories. Reading representational levels may also be able to account for errors made in reading (akin to the spelling representational level E1 identified by Critten et al. 2007) if children have formed error representations of words based on the theories they have formed and overgeneralised.

4: Shared representations and how they develop

If reading representational levels can be identified in a similar manner to spelling and it is possible to track children's representational development longitudinally, this application of the RR model can be used to provide insight into other important issues within spelling and reading research

Do similar and interconnected domains of learning such as reading and spelling draw upon knowledge from separate representations or shared representations? Ehri (2000) describes the dual-representational view of reading and spelling used to explain discrepancies in ability, whereby superior reading representations are stored separately from spelling representations. This view of reading stems from research conducted with brain-damaged individuals that report dissociations in spelling and reading ability (e.g., Weekes & Coltheart, 1996).

However this view is not supported by recent research conducted with typical adults (for example, Holmes & Carruthers, 1998, Holmes & Davis, 2002, Burt & Tate, 2002). These studies provide evidence for the single-representational view and employed similar procedures. Adult participants' own misspellings were presented with correct forms in recognition tasks. Results showed a failure to recognise the correct spelling instead of their own error spelling. This suggests access to one common spelling and reading representation as the error was maintained across spelling production and recognition. There was no superior reading information in these cases. Holmes & Davis (2002) suggest therefore that the "quality" of the representation in terms of the information it contains can only really be inferred by how a person spells that word.

A compromise between the single and dual representational views referred to by Holmes & Davis (2002) is the mixed position whereby multiple alternatives of a word could be contained within a single representation for the reading and spelling of that word. Depending upon which alternative was accessed discrepancies in reading and spelling ability could result. Unfortunately it is beyond the scope of this thesis to establish whether representations are shared for reading and spelling but this new theoretical approach and method may be able to demonstrate more clearly the nature of developing representations in children. It may be that children have representations resembling those of poor adult readers/spellers as shown by Katz & Frost (2001).

Katz & Frost (2001) explored the possibility of "unstable" representations when there is more than one phonologically plausible way of spelling a word e.g. *anihilation* instead of *annihilation*. In some words, certain graphemes are vulnerable in this way and this instability may lead to spelling errors. For example in their study participants sometimes correctly identified a word as a misspelling on its first presentation but on its second decided that the word was in fact correctly spelled. Katz & Frost accounted for this by saying that that the unstable representation of the word had replaced the correct alternative with the error alternative. However is it not plausible that both alternatives were being held simultaneously and superiority was not placed on either because the representation was "unstable"? Interestingly access to either alternative of the spelling of *annihilation* would not prevent correct reading of the word; there would not necessarily have to be a superior reading representation.

This is also supported by Dietrich & Brady (2001) who compared adult skilled readers and adult poor readers on picture naming and spelling tasks that employed the same words. The same tasks were given on two separate occasions. In both tasks the less skilled readers showed more inconsistency in the responses given from time one to time two compared to the other two groups. Dietrich & Brady concluded that the representations of the less skilled readers were less distinct and more impoverished in comparison. If a representation is incomplete then alternative answers could be provided that will not always lead to the correct answer.

Further support for underspecified representations is provided by Frankish & Turner (2007) who looked at letter transposition using anagrams such as SIHGT (for *sight*) and SUNOD (for *sound*). Their participants sometimes mistakenly identified these anagrams as real words even when there was no time pressure and regardless of whether they were pronounceable or not. Frankish & Turner therefore argued that word recognition can be tolerant of minor positional errors contained within the representation and perhaps vice versa with errors in the written print. This can be understood in tandem with the "mixed position" that can explain a discrepancy in spelling and reading ability: a representation does not have to be complete to read correctly but it does have to be to spell correctly.

4.1: Match or mismatch*?*

Although caution should always be shown in extrapolating results with adults to children these studies (e.g. Katz & Frost, 2001, Dietrich & Brady, 2001, Frankish & Turner, 2007) suggest that even if there are shared representations for reading and spelling children may not be expected to match across spelling and reading representational levels: inconsistencies between them in performance and understanding may be expected and this is what a longitudinal study using the RR model may be able to demonstrate. In relation to this are Frith's (1985) "pacemaker" notions already given support by the longitudinal findings of Caravolas et al. (2001). By applying the RR model these can be examined within a new theoretical framework that may help to account for the underlying representations and a new method that uses children's explanations to gain insight to their understanding. Therefore the RR model can be used to provide a new perspective on issues in spelling and reading research.

5: Contextual facilitation for reading and spelling

Application of the RR model to the domain of literacy could also prove to be useful in examining a further major issue: the influence of semantic information or context upon children's reading and spelling. As this brief review will demonstrate, research in this area has tended to relate to children's reading, similar studies of facilitation of spelling are rare. Furthermore, the main focus has been whether semantic information facilitates accuracy. Use of RR levels for reading and spelling may also provide insight into whether children's *understanding* as evidenced by their verbal explanations can also be facilitated by context

5.1: Word recognition and semantic information

Joint models of spelling and reading development discussed earlier (e.g., Frith, 1985, Ehri, 1998, 1999, 2002, Share, 1995) and models of reading development (e.g., the Knowledge Sources Account, Thompson et al. 1996) refer to contextual cueing particularly in initial reading and spelling. However scant attention is paid to how

context may influence development beyond this, when it is most facilitative etc. It is predominantly in the reading literature that these issues are addressed. Connectionist modelling typically shows that semantic information plays an important role in word recognition. The PDP (Parallel Distributed Processing) model of word recognition (Plaut et al. 1996) explores the interaction between phonological and semantic processes during reading. They refer to this interaction as a "division of labour".

Building upon this work by Plaut et al. (1996) a more fully realized "triangle" model comprising phonological, orthographic and semantic information was then proposed by Harm & Seidenberg (2004). This model suggests the development of dual pathways that can be used to extract meaning from written words. First one where phonology acts as a mediator between orthographic and semantic information and later there emerges a more direct pathway linking orthographic and semantic information. It had been assumed that younger readers primarily use the former as in early development it is easier to make connections between orthography and phonology rather than orthography and semantics due to more systematic mappings. However, Nation (2007) has recently suggested that children as young as 7 years may be able to activate word meanings directly from orthography, without the need for phonological recoding.

Connectionist modelling is not however without criticisms. Karmiloff-Smith (1992) argues that connectionist models can simulate the initial implicit representations that she describes but they do not account for how the representations develop beyond this in the way that redescription can. Steffler (2001) supports Karmiloff-Smith's view when assessing connectionist accounts. She explains that we acquire implicit level knowledge by gathering information on the patterns within stimuli, for example, through exposure to printed words in our environment. However competence cannot be solely explained by knowledge acquired implicitly and this is one aspect that the RR model can be used to extend upon with its framework of representational levels growing in explicitation.

Furthermore Castles & Nation (2006) identify three main problems with the nature of the models that Plaut et al. (1996) and Harm & Seidenberg (2004) have developed. First

they argue that the learning of the model is essentially supervised as it employs a back-propagation algorithm. Consequently if there are any differences between the output the model produces and the correct output, feedback is immediately given. In a real-life situation this would mean that children would receive feedback each time they tried to decode a word, not reflecting children's true experiences of learning to read. Their second reservation with the model is that the training set was presented thousands of times to the model whereas they argue children may only require three or four exposures to a word in order to learn it. Thirdly they argue that a substantial concern is that although the model was thoroughly trained on phonology and semantics there was not similar training for orthography. Children from a very young age acquire knowledge of orthographic structure and constraints and so the model fails to take account of this. Despite the success of these connectionist models it is apparent that many questions remain unanswered and the use of representational levels that reflect children's internalized knowledge may elucidate the influence of semantic information upon spelling and reading.

Despite these limitations, many studies have supported the model's claims of the importance of semantic knowledge in reading. Typically studies of word recognition in adults have employed a semantic priming paradigm. Farrar, Van Orden & Hamanz (2001) for example, explored the importance of semantic knowledge in the priming of a word's phonology and found the most robust effect of semantic mediation occurred when the mapping between the spelling and sound had a degree of ambiguity. This result is intuitive as where spellings are not phonologically transparent semantics have a greater role to play in the process of disambiguation.

Interestingly a more recent study by Reimer (2006) using a similar paradigm broadened the focus to examine developmental changes into the influence of semantic feedback in word recognition. As reported by Farrar et al. (2001) semantic feedback seems to prime phonological knowledge in recognizing a word for older children (aged 12 years) and adults. However there is a more complex picture with younger children (aged 9 years) as semantic feedback appears to prime orthographic knowledge as well. Reimer believes

that as early representations of young children are incomplete in their mappings between phonological and orthographic information, semantic information is having a facilitative effect on both in order for word recognition to occur. However as these mappings become increasingly consolidated, there is a change in allocation whereby it is only necessary for the phonological knowledge to be facilitated by the semantic information.

Nation & Snowling (1998) used Plaut et al's (1996) model in order to account for the results of their study comparing typical children to those with poor reading comprehension on tasks employing predominantly phonological skills (rhyming judgements) versus tasks requiring more semantic ability (synonym judgements). Interestingly they found that whilst that the two groups showed comparable performance on the phonological tasks, the poor comprehenders did not perform nearly as well on the synonym judgements. They proposed that the relative difficulties of the poor comprehenders in assessing and retrieving semantic information, was due to impairment of the specialised semantic pathway of word recognition as described in the Plaut et al. model. This was further supported by the results from word recognition tasks as the poor comprehenders whilst displaying similar accuracy on high frequency, regular words did show difficulties in terms of low frequency exception words: the latter is regarded as the specialism of the semantic pathway. Findings indicate that there is more to successful reading than decoding and phonological skills.

Other studies looking at reading ability in children (e.g. Laing, Hulme, Grant & Karmiloff-Smith, 2001) also support the combined input of phonology and semantic information for successful reading. Again this study compared a typical group to a special population. Children with Williams Syndrome were similar in their reading difficulties to the poor comprehenders as the reading ability they possessed was due to phonological decoding skills. Attaining the reading ability of the typical group was prevented by weak semantic skills.

To summarise, the literature suggests that both phonological and semantic information are required if children are to develop successful reading ability. This thesis will extend

previous research by looking at the possible facilitative effect of context upon accurate spelling as well as reading.

5.2: Context and spelling

It is only in neuropsychological research looking at brain-impaired adults that an exploration of the relative importance of phonology and semantics in both reading and spelling has been widely conducted, examples include Ward, Stott & Parkin (2000) who studied a patient with semantic dementia and Cortese, Balota, Sergent-Marshall & Buckner (2003) who examined two patient groups (Primary Semantic Impairment and Dementia of the Alzheimers Type). However, although these neuropsychological studies indicate the role semantic information may play in the facilitation of spelling, they are not studies of children.

Few have been conducted, although a longitudinal study by Lewis, Freebairn & Taylor (2000) is one example. Pre-school age children with speech sound disorders were followed to discover possible predictors of language, reading and spelling abilities at school age. Traditionally these are skills the group experience problems with. Lewis et al. used various tests to achieve this: phonological (e.g. phonological analysis, word discrimination, nonsense word repetition), semantic (picture/oral vocabulary) and syntactic (grammatical understanding, sentence completion). They discovered that although later reading ability was predicted by a generalised pattern of influences including phonological, semantic and syntactic skills, later spelling ability was predicted by phonological and syntactic skills. Pre-school semantic skill had no relationship with later spelling ability. So it could be concluded that although semantics are an important part of spelling they play a greater role in reading, or alternatively that the importance of semantics comes into play later in spelling development (6 years +).

The Lexical Quality Hypothesis (Perfetti & Hart, 2002) is one model that can be more readily applied to understanding how context may facilitate spelling as well. This hypothesis also follows the triangular structure mentioned earlier in relation to Harm & Seidenberg (2004) but looks more broadly at representations of words. Perfetti & Hart

(2002) suggest that for the representation to be of a high quality enabling rapid and correct word reading and word spelling, the word constituents of orthography, phonology and semantics must be closely connected. Their definition of semantics refers to syntactic information as well as meaning. If one or more of these constituents is lacking then the quality of that representation is reduced and errors in reading and spelling may occur. They suggest that semantic information can compensate for underspecified phonological and orthographic information while spelling and reading (also shown by Reimer, 2006).

Perfetti & Hart (2002) also try to account for how the three constituents develop in relation to each other and why the development may not always lead to successful reading and spelling. They propose that the key to successful spelling and reading representations is continued integration between the phonological, orthographic and semantic constituents over time. They compared the performance of undergraduates on a variety of tasks tapping phonological, orthographic and semantic knowledge to see what association could be found between the tasks using Factor Analysis. They discovered that good readers demonstrate coherent links between phonology and orthography (characterized as word form) and phonology, orthography and semantics (characterized as word form + word meaning) enabling both accuracy and fluency. However in contrast low skill readers do not show a proper integration of orthographic knowledge so accuracy in identifying word form depends heavily on just phonological knowledge while fluency depends on just phonological and semantic connections. Orthographic information is present but is not being utilized efficiently in relation to the other two constituents. Perfetti & Hart suggest that this points to a developmental trajectory in children whereby success is achieved via integration. They believe the mechanism driving this integrative process is primarily experience with words: the more skilled the reader the more information can be added to representations, e.g. spelling, pronunciation, meaning etc.

Support for the LQH has been found in relation to reading (Berends & Reitsma, 2006) and more recently in spelling (Hilte & Reitsma, 2007). Although these studies employed poor readers and poor spellers respectively the indication is that semantic information can

facilitate spelling as well as reading particularly if representations contain underspecified phonological and orthographic information.

5.3: Summary

Despite recent work by Hilte & Reitsma (2007) and the theoretical framework provided by the LQH (Perfetti & Hart, 2002) research is still needed to see whether context can facilitate spelling in a similar manner to reading in typical children. The application of the RR levels will be able to provide information about the nature of contextual facilitation: does it only aid accuracy or can it also make children's understanding more explicit? Furthermore by examining children's knowledge of spelling and reading we may be able to see when context is most facilitative building on the LQH to form a more coherent understanding of the relationship between phonological, orthographic and semantic information.

6: Research Questions

This first chapter will be concluded by outlining the rationale for research questions that have arisen from the review of the literature.

6.1: Can spelling and reading representations be conceptualised using the implicit-explicit continuum of the RR model?

As detailed earlier the RR model (Karmiloff-Smith, 1992) provides a useful alternative to traditional stage model of cognitive development (e.g. Piaget) as its implicit-explicit representational framework describes domain specific change and makes a distinction between procedural and conceptual change. It has previously been applied to domains as diverse as children's understanding of balance (Pine & Messer, 1998, 1999, 2003) and more recently children's understanding of basic numerical principles (e.g., Chetland & Fluck, 2007, Butler et al. 2007). The cognitive processes described in the model could therefore account for learning in different domains. Indeed Sadoski & Paivio (2007)

have argued that the application of a generalised cognitive model of development could provide a more coherent framework for understanding literacy development.

In the study of literacy, Critten et al. (2007) have shown support certainly for the explicit levels of the model (E1A, E1B, E2, E3) in relation to spelling development using a novel method that accessed children's understanding of spelling via their verbal explanations. However more research is needed to identify the implicit level. Initial stages/phases in traditional models of spelling and reading (e.g. Frith, 1985, Ehri, 1998, 1999, 2002) would suggest that early reading and spelling is implicit and that development beyond this could be understood as representations becoming gradually more explicit as phonological and morphological knowledge is incorporated and errors are made (shown by Critten et al.). Furthermore Steffler's (2001) review made a strong case for implicit spelling processes, while implicit reading processes have been documented by Ellis (1997) and in the knowledge sources account of reading (Thompson et al. 1996, Fletcher-Finn & Thompson 2000, 2004). The RR model with its process of explicitation has the potential to integrate these strands of research and provide insight into the nature of children's underlying spelling and reading representations and the mechanisms underlying development.

Chapter Two will build upon Critten et al.'s (2007) findings to try and find empirical evidence of the implicit level for spelling using the same method and coding scheme but testing younger children. Furthermore by comparing children classed as implicit or one of the explicit levels on further spelling tasks a greater understanding of the distinction in terms of the ability to verbalise knowledge and analyse words with similar spelling patterns can be gained. By providing a more concrete evidence for an implicit-explicit continuum in spelling progress can be made in formulating a joint model of explicitation for spelling and reading. In the longitudinal study detailed in Chapters Three and Four the first aim is to see whether representational levels for children's understanding of reading can be identified using a method and coding scheme akin to that developed for spelling (Critten et al.). Again, applying the RR model to reading will provide insight

into representations underlying reading and will not just document what children can do but will use explanations of understanding as a new source of data.

6.2: Does children's reading and spelling representational development follow the process of explicitation described in the RR model?

If evidence can be found of an implicit level for spelling and representational levels can also be developed for reading (Implicit, E1A, E1B, E2, E3) it will be possible to follow children longitudinally over the course of a year tracking their representational development. A long-term study of non-interventionist development using the RR levels has not been attempted before in any domain although Pine & Messer (1998, 1999, 2003) did show that children's understanding of the balance beam could become more explicit in the course of a week following interventions. If children show the process of explicitation this will further validate use of the implicit-explicit framework for understanding the cognitive processes underlying spelling and reading development. Only the longitudinal study documented in Chapters Three and Four can establish this and its second aim is to see whether children can be shown to develop through at least one representational level for their understanding of spelling and one representational level for their understanding of reading. Existing longitudinal studies of spelling and reading development (e.g., Caravolas et al, 2001) have demonstrated change using various tests of children's accuracy this is the first long-term study of the development of children's understanding.

A new developmental perspective?

If the first two aims detailed above can be successfully achieved then it will be possible to use the new spelling and reading representational levels to provide a new perspective on fundamental issues in spelling and reading research.

6.3: How can using RR levels aid our understanding of the way spelling and reading develop in relation to each other?

Another advantage of the longitudinal study is it provides the opportunity to examine developing spelling and reading representations. Previous study into the possible nature of shared representations for reading and spelling (e.g., Holmes & Carruthers, 1998, Holmes & Davis, 2002, Burt & Tate, 2002) were conducted with adults who are consistent in the errors they make due to more stable and entrenched representations. However other work with adult poor readers/spellers, (e.g., Katz & Frost, 2001, Dietrich & Brady, 2001) uncovered unstable, incomplete representations where responses may be correct on some tasks but not on others.

It will be possible when comparing children's reading and spelling representational levels over a course of a year to see whether spelling and reading performance and understanding matches or whether incomplete representations will be exposed that produce differences. This relates also to pacemaker predictions made by Frith (1985) and supported by Caravolas et al. (2001) suggesting that spelling and reading may mismatch in young children as one skill sometimes leads another. By applying the RR model not only will children's spelling and reading representations be examined longitudinally for the first time, it can be seen whether this new method and use of verbal explanations uncovers the same pace maker tendencies. This will provide support for the framework while further validating Frith's original predictions. The third aim of the longitudinal study in Chapters Three and Four is to see how spelling and reading understanding develop in relation to each other.

6.4: How can using RR levels aid our understanding of contextual facilitation of reading and spelling?

Another fundamental issue in reading and spelling research is the influence of semantic information or the context. As documented earlier this has been a major focus in the study of reading through connectionist modelling (e.g. Plaut et al, 1996, Harm & Seidenberg, 2004) and many studies conducted with adults or special samples of children (e.g. Nation & Snowling, 1998, Farrer et al., 2001, Laing et al. 2001, Reimer, 2006) that draw attention to the important influence of semantic information. Joint models of

reading and spelling refer to the importance of contextual cues in initial spelling as well as reading but do not further explore its importance for later development. Therefore research looking at semantic facilitation of spelling as well as reading is much more rare. Only the Lexical Quality Hypothesis (Perfetti & Hart, 2002) can be more decidedly applied to both. Indeed studies have supported its application to poor readers (Berends & Reitsma, 2006) and poor spellers (Hilte & Reitsma, 2007).

Chapter Five will use the levels of the RR model to examine contextual facilitation of both spelling and reading so it will be possible to establish in a naturalistic literacy task using typical children whether context can facilitate accurate spelling. Furthermore as studies thus far have focussed on performance, using the RR levels will determine whether *understanding* is also facilitated by the presence of context allowing a more coherent picture of how phonology, orthography and semantic information interacts in children's representations: it is just an implicit facilitator of performance or can it explicitly effect understanding as well? Furthermore if some children's understanding benefits from context and some do not it will be possible using the RR levels to try and uncover when context facilitates the most.

6.5: Summary

The aim of the initial study of this thesis is to establish empirically that there is an implicit level for spelling. This will extend the work of Critten et al. (2007) by distinguishing between implicit and explicit understanding of spelling. In the longitudinal study an examination will be made of whether representational levels derived from the RR model can also define children's understanding of reading. By following the children for a year it will be possible to assess whether spelling and reading development involves increasing levels of explicitation and how the two skills develop in relation to each other. This will provide a new developmental perspective of the nature of children's spelling and reading representations using the implicit-explicit continuum of the RR model. This research will build upon previous descriptive models (Frith, 1985, Ehri, 1998, 1999, 2002), work examining adult representations (e.g. Katz & Frost, 2001,

Holmes & Davis, 2002) and previous longitudinal studies (e.g. Caravolas et al. 2001) In the final study, contextual facilitation of reading and spelling will be studied with a framework involving RR levels; this will build upon the Lexical Quality Hypothesis (Perfetti & Hart, 2002) and provide a more coherent picture of how semantic, orthographic and phonological information interacts in children's underlying spelling and reading representations. The findings of these studies will be used to propose a new model of spelling and reading development based on the explicitation of underlying representations

Chapter Two

Can children have implicit representations for spelling?

Previous research by Critten et al. (2007) found that children's underlying spelling representations can be characterized by representational levels derived from the RR model (Karmiloff-Smith, 1992). However one concern about using the RR levels in relation to spelling was that only three children (out of the 95 children tested) were allocated to an implicit representational level. As this is the starting point for cognitive development in the RR model it is important to establish the reasons for this finding in order to validate the use of the implicit to explicit framework for understanding spelling representations.

Evidence of implicit representations for spelling would be expected given the review of relevant research by Steffler (2001) and the descriptions of early spelling/reading in initial stages/phases in classic models by Frith (1985) and Ehri (1998, 1999, 2002) that could be construed as implicit. Indeed Ehri (2005) argues that "sight-word" recognition (as described in her model), which we would interpret in the context of the RR model, as implicit recognition, is automatic: it cannot be applied at will or outwardly controlled. She also argues that it operates in an unconscious manner again echoing Karmiloff-Smith's characteristics of implicit representations. However Critten et al. considered for the first time the notion that implicit to explicit representational development could provide a mechanism for change and could explain how early spelling develops beyond automatic recognition. The identification of explicit levels for spelling (E1A, E1B, E2, E3) supports the view that the course of learning may be a process of explicitation however more robust empirical evidence of the implicit level is required and the present study sets out to establish that.

One explanation for the difficulty found in identifying children at the implicit level is the age of the children used by Critten et al. (aged 5-7 years). These children may have already developed beyond this early type of representation. Related to this point is the nature of literacy teaching that encourages explicit understanding from the Foundation

Stage (aged 3 years) onwards. However an alternative explanation is that children simply do not have implicit spelling representations, contrary to predictions made by the RR model for cognitive development. Therefore the first aim of the present study is to provide empirical evidence to support the existence of implicit representations for spelling.

Younger children (aged 4-6 years) will be used than in previous research and it was decided to use the scheme already developed by Critten et al. to classify children as one of the spelling representational levels. The scheme was able to capture the behaviour of children in the previous investigation and corresponded to classification schemes in other domains, (e.g., Pine & Messer, 1999). In this method children are presented with three alternative spellings of a word, (derived from Nunes et al. 1997) only one of which is correct and asked to choose and verbally justify which alternatives they believe to be correct and incorrect. Coding of the recognition performance and these verbal justifications will allow allocation to a particular representational level of spelling understanding.

The criteria for categorising a child's knowledge as "implicit" are derived from Karmiloff-Smith's profile of this level in the RR model. Characteristics include the ability to recognize a correct spelling but an inability to justify the correct choice or to explain why the error alternatives were incorrect. Critten et al. explained that children at this level therefore demonstrated a lack of explicit insight. For example, when asked why they believe a word is spelt correctly typical responses included:
"I don't know"
"It looks right" or
"I have seen it before"
Another characteristic of children at the implicit level is the use of explanations that are inconsistent and make little sense, indicating that the child was just producing a post-hoc response rather than accessing any specific knowledge. For example, one boy (aged 4 years) was shown the three alternatives of the word *laughed*. He chose the correct spelling but when asked why it was correct he replied: "It looks right" and when he was

asked why *laughd* was incorrect he replied: "Its got a *h*". Of course the correct spelling of laughed has *h* as well, indicating a lack of explicit knowledge since he seems to have picked any letter in order to make a response. Whereas a child at the explicit level would have referred to the fact that the "e" was missing or that it didn't have the morphological unit of –ed.

If it can be established that there are implicit representations for spelling, then their nature will be further explored in comparison to the explicit levels. In order to do this it is necessary to characterise what is expected at the implicit level. Karmiloff-Smith (1992) explains that the implicit level is defined by procedures that respond to environmental stimuli but that any new representation is stored independently from others, thereby preventing representational links within a domain or with other domains. Essentially this means that although a procedure as a whole is available, the component parts are not. Therefore these procedures are used to respond effectively and rapidly to achieve behavioural mastery, but it is only when implicit-level representations are redescribed into explicit levels that component parts become available and can be generalized and made available to speech.

Therefore, the second aim of the present study is to further distinguish between implicit and explicit spelling representations using children's ability/inability to make links between related stimuli and then critically explain these decisions. Using the recognition task already described, children will be classified as having implicit-level (I-level) or explicit-level (E-level) understanding of spelling. Two further tasks (a pairs task and a substitution task) will be conducted using similar words to see whether children at the implicit level can identify and explain these common word patterns. There is the possibility that each word is responded to as a separate entity without explicit insight into how the spellings of certain groups of words actually works, e.g. the commonality of "old" in cold, sold, bold etc. This also acts as a further test for the RR levels particularly in terms of implicit versus fully explicit (E3) representations where performance may be the same. If a difference can be demonstrated in identification of similar word

components and consistency in implicit/explicit explanations on a range of spelling tasks then the representations will be more clearly characterised.

In the pairs task children will be given similar words (real words and non-words) to group (eg. cold and sold, lold and wold) and asked to verbally justify their word pairing choices in terms of the similarities between them. Half the words and non-words will have two common factors: initial letter, e.g., "s" in sold and some and pattern within the word, e.g., "old" in sold and cold, whilst the other half will have only one common factor: pattern within the word. This could also prove illuminating in terms of choices made and any verbalisations that emerge, e.g. if come and cold are grouped instead of come-some and cold-sold will they verbally explain that their choice is based on the initial letter? It is predicted that children with implicit-level representations will be more likely to pair words according to a common word pattern than to a common first letter compared to children with explicit-level representations. The latter may break-up words into their component parts and abstract a theory about pairing words based on either common word patterns or common first letters. Those children with implicit level representations should not be able to identify different component parts across words. A key prediction however is that children with implicit-level representations may be able to pair similar words without the accompanying ability to justify verbally their choices (i.e. by identifying the similar components within the word) compared to children with explicit-level representations.

In the substitution task children will be asked to substitute letters into a word in order to create a new similar word, e.g., change sold into cold (again half of the words used will be non-words) and then asked to explain the action they carried out to make the change and how the new word is similar to the original. It is predicted that a child at the implicit level may be able to perform the task successfully in terms of forming the new words but will be less able to explain the action they performed and the similarity between the original and new words compared to children at the explicit-level. A production task is introduced at this stage since up until now children have conveyed their understanding of

spelling in recognition tasks without having been required to reflect upon their own spelling.

In summary, the present study will investigate whether young children have implicit representations for spelling in order to establish whether the RR model is valid for gaining insight into underlying representations. If the implicit level is identified the second aim of the study is to see whether children with predominantly implicit representations differ from those with explicit representations on two additional tasks in terms of identifying and explaining similar word components. From this it can be seen whether children show consistently implicit behaviour on a range of spelling tasks.

Method

Design

This study was a within-subjects design. All participants took part in the three tasks: recognition, pairs and substitution. The order the pairs and substitution tasks were given was counterbalanced.

1. Recognition task with two dependent variables: recognition score and representational level of spelling understanding (from Pre-implicit to E3) derived from Critten et al.
2. Pairs task with two dependent variables: choice of word pairings (common word pattern, common first letter or error pair), justification type when explaining word pair similarity (full explicit-type, partial explicit-type, implicit or error).
3. Substitution task with two dependent variables: justification response type for production of new words (justification present or justification absent) and justification response types for identification for word similarity (justification correct, justification incorrect or implicit).

Participants

101 children took part from two different schools: Reception Year: 41 participants (23 males, 18 females) age range 4 years 6 months to 5 years 5 months: Year 1: 70

participants (28 males, 42 females) age range 5 years 6 months to 6 years 5 months. Data collection took place in the second term of both Reception Year and Year 1. The mean age was 5 years and 7 months. Both schools were mixed primary schools in Hertfordshire where families are predominately white and from low/middle class backgrounds. The children received spelling instruction in accordance with the UK Foundation Strategy and National Literacy Strategy set down by the Department for Education and Skills (2001)

For clarity there will be separate Method and Results section for each of the three tasks.

Task One: Spelling Recognition Task

Materials

Children were presented with 12 sets of alternative spellings. Each set contained three alternative spellings of a word only one of which was correct (Table 2.2). Each set was presented on a separate flash card approx 21cm (width) by 5.5 cm (height). The position of the correct word on the card was randomly allocated to prevent a biased response set, i.e. it could be on the right, middle or left position on the card. Groups of similar words were employed (Table 2.1) and were derived from Nunes et al. (1997) as were the type of errors also used in the alternative sets.

Table 2.1: Words used in the spelling recognition task

Regular verbs	Irregular verbs	Non verbs
Filled	Sold	Ground
Killed	Bold	Sound
Kissed	Lost	Soft
Missed	Cost	Loft

Table 2.2: Alternative word sets used in the spelling recognition task

Alternative sets:
Filled, fild, filld
Killed, kiled, killd
Kissed, kissd, kised
Missed, missd, mised
Sold, soled, solded
Bold, boled, bolded
Lost, losed, losted
Cost, cosed, costed
Ground, grouned, grounded
Sound, souned, sounded
Soft, sofed, softed
Loft, lofed, lofted

Procedure

Children were taken individually to a quiet room and presented with 12 sets of spelling alternatives one at a time. They were told the target word and were then asked which spelling they thought was correct. Then they were asked to explain why. After this the experimenter pointed to the other two alternatives in turn and asked children to explain why they thought those spellings were wrong. All verbal responses were recorded using a tape recorder.

During the coding process the verbal explanations produced for each of the 12 sets of alternative spellings were transcribed for each child. Each set was then separately analyzed and allocated to one of the representational levels (Implicit, E1A, E1B, E2, E3) according to the criteria of Critten et al and shown in Table 2.3 or to the new Pre-implicit level detailed later. The level that was allocated most out of the 12 sets then became the child's overall representational level. For example, verbalizations for 2 out of the 12 sets may have been allocated to E1A but because the other 10 sets were coded as E1B, the child would be coded as E1B overall. Every child had a predominant level accounting

for their knowledge and understanding in more than 50% of the 12 spelling alternative sets. The majority displayed their predominant level more than 75% of the time. Inter rater reliability had been obtained previously by Critten et al. producing a concordance of 70%.

Table 2.3: Spelling Representational Levels (Critten et al. 2007)

Level	Performance	Characteristics and typical verbal responses
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 make little sense indicating a need to make any response: "Why if filld wrong" (exp), "because it has an l" (child). Of course the correct spelling of filled has an l as well.
E1A	Correct choices in recognition are made but also phonetic errors, e.g. filld instead of filled so performance may drop from the I-level.	Abstraction of phonological theory means there is access to some explicit knowledge and the ability to make some verbal responses but the focus is purely on aspects of phonology and –ed is hardly recognized as a unit. "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 can be kept at this level if they correctly recognize spellings but only explain why words are correct/incorrect via phonology and not refer to –ed.
E1B	Again correct choices can be made but performance may stay lower than the I-level as	Again children are not implicit as can talk about their understanding of spelling but have abstracted a theory related the rule of –ed and 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).

	overapplication of the –ed rule to irregular and non verbs produce errors such as solded instead of sold.	Children can be kept at this level if they correctly recognize words and explain errors via reference to the –ed rule but fail to explain why words are correct.
E2	Balance forming between information in the environment (I-level reps) and internalised theories so performance improves again but this time with understanding.	Access to more explicit phonological and morphological knowledge leads to fuller verbal responses. However there is sometimes inconsistency particularly 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, such as, –ed was attached to the word fill.
E3	Accuracy returns to that of the I-level but this time with understanding. Absence of overgeneralisation errors.	Complete understanding of the appropriate use of aspects of phonology and the –ed rule and the ability to fully verbalise 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)

Note: exp = experimenter, reps = representations

Results

Initial analysis of the recognition test showed that the mean number of words correctly recognized (/12) was 6.61 (SD = 2.26). Mean recognition scores were also calculated for the Reception year children: (MEAN = 6.14, SD = 2.12) and the Year One children: (MEAN = 6.93, SD = 2.32). An Independent t-test indicated that there was no difference in recognition ability between the two year-groups: t (99) = -1.73, P = .09. Results across the year groups will therefore be amalgamated.

Table 2.4: Number (%) of children at each spelling representational level (Pre-implicit, implicit, E1A, E1B, E2)

Representational Level	Number (%) of children
Pre-Implicit	7 (6.93)
Implicit	23 (22.77)
E1A	39 (38.61)
E1B	27 (26.73)
E2	5 (4.95)

A Chi-Square Goodness of Fit test was computed on the number of children at the five representational levels: χ^2 (4, N = 101) = 40.24, P = .02. Results confirmed (Table 2.4) that most were either at the E1A or E1B levels of early theory abstraction tending to over-apply their internal phonological or morphological theory of spelling. However, 22 % of the sample was allocated to an implicit representational level of spelling providing greater empirical support for implicit representations and meeting the first aim of this study.

The other finding of note is that seven children had pre-implicit understanding of spelling. This level had not been identified by Critten et al. and was characterized by either a complete lack of spelling knowledge or only a rudimentary knowledge of letter names and phonics. Children at this level often pointed at an alternative without looking

at the flash cards or before the target word had been spoken. This suggests that the choices made did not stem from any specific knowledge base: implicit or explicit. Any correct choice seemed to be due to chance. In contrast children at the implicit level had a high recognition success rate (=>70%). Children at the pre-implicit level also failed to provide any justification for their choices and could not explain why they believed words to be spelled correctly or incorrectly:
"I don't know"
"I'm not sure"

Having allocated participants to a representational level for their understanding of spelling, do children at the implicit level perform differently to those at explicit levels in terms of the ability to identify and explain similar word components? The data from the pairs task and the substitution task can be used to address this question.

Task Two: Pairs Task

Materials

Children were presented with 12 sets of four flash cards. Each card had one word on it and the four cards consisted of two sets of pairs. Each card was approx 10 cm (width) by 5.5 cm (height). Six of the sets consisted of real words and six consisted of non-words. Three real word sets and three non-word sets included words that could only be paired according to one factor: a common word pattern e.g. *oft* in soft and loft and *ook* in book and took. However three real word sets and three non-word sets included words that could be paired according to two factors: the common word pattern or a common first letter, e.g. in the set cold, sold, come, some, participants could either pair cold-sold and come-some (common word pattern) or cold-come, some-sold (common first letter), see Table 2.5 for word pairs used.

Table 2.5: Word Pairs used for each of the four types, Real word sets with one or two common factors and Non-word sets with one or two common factors.

Word Pair Type	Word Pairs Used
Real word sets (two common factors)	cold-sold, come-some, book-cook, bold-cold, bat-fat, bit-fit
Real word sets (one common factor):	soft-loft, took-book, day-say, boy-toy, ball-fall, lost-cost
Non-word sets: two common factors	lold-wold, lome-wome, dook-pook, dold-pold, dat-jat, dit-jit
Non-word sets: one common factor	woft-toft, sook-mook, cay-tay, loy-moy dall-lall, bost-sost

Procedure

The task was given one week after the recognition task. Children were presented with 12 sets of four flash cards one set at a time. They were asked to read the words written on the flash cards and were told the correct answer if they could not produce them accurately. Children were told that some of the words were similar/nearly the same and were asked to indicate which words they thought were nearly the same and could be put together. They were then asked to justify their choices: "Why do you think those two words go together?" and responses were and recorded and coded as one of four justification types: full (explicit-type), partial (explicit-type), implicit and error. Inter-rater reliability measures were not deemed necessary due to the straight-forward nature of the coding.

1. A **full justification** could be made for both common pattern and common first letter pairings and contained a complete identification of the similarities that the word pair shared. For example:

"Sold and cold go together as they both have the word "old' in"

"Sold and soft go together as they both have s-o at the start"

This justification type shows the ability to fully generalize knowledge across similar words by communicating it.

2. **A partial justification** could also be made for both common pattern and common first letter pairings and contained identification of similarity but the description was incomplete. For example:

"Sold and cold go together as they both have l-d at the end", in this case the complete pattern of *old* has not been referred to

"Sold and soft go together as they both have "s" at the start", in this case the complete pattern of s-o has not been referred to

This justification type shows a lesser ability to communicate generalizable knowledge.

3**. An implicit justification** communicated no explicit knowledge as regards the similarity of the word pair. Therefore although a word pair had been correctly identified it was not supported by an explicit verbal justification. Interestingly, these responses were only produced when words had been paired according to a common word pattern, never when words had been paired according to a common first letter. For example:

"Sold and cold are the same"

"Sold and cold go together"

"I don't know, they just do"

This justification type indicates an inability to generalize knowledge in terms of communicating similarity across words.

4. An **error justification** identified a similarity that was simply not present. For example:

"Day and boy go together as they both have "b" at the start"

In order to compare justification type and representational level of spelling, children were coded as to their predominant justification type on the pairs task: full, partial, implicit, error.

Results

The first prediction was that children classified as having I-level understanding would be more likely to pair words according to common word patterns than common first letters compared to those children with E-level understanding. To test this each individual's choices of word pairing were examined. The frequency with which the child chose to pair according to a common word pattern, a common first letter or an error pair was calculated and then converted into a percentage for each pair type. For example, a child may have paired words according to a common word pattern 75% of the time, a common first letter 20% of the time and made errors pairs 5% of the time.

This data was then compared to the child's representational level in the recognition task in order that mean % choices could be calculated for each representational level of spelling understanding. Levels E1A, E1B and E2 were collapsed into a "blanket' E-level to compare to the I-level and the PI-level.

Table 2.6: Choice of word pairings (common word pattern, common first letter or error pair) expressed as a mean percentage (and SD) for each spelling representational level

Representational level	Word pattern (mean % and SD)	First letter (mean % and SD)	Error (mean % and SD)
Pre-implicit	55 (23)	18 (8.91)	27 (19.67)
Implicit	64 (28.93)	22 (18.59)	14 (14.26)
Explicit	66 (25.91)	26 (21.25)	10 (11.6)

Table 2.6 indicates (looking across the rows) that children paired words according to a common word pattern (e.g. old) much more often than a common first letter, regardless of whether representational level of spelling understanding was pre-implicit, implicit or explicit although, PI-level children were more likely to choose an error pair than I-level or E-level children. The percentage choices of word pattern and first letter seem very similar for the I-level and E-level children and is confirmed by One Way ANOVAs

conducted on the percentage of pairing according to a common word pattern in terms of representational level (F (2, 98) = 0.68 P = .51) and the percentage of pairing according to a common first letter in terms of representational level (F (2, 98) = 0.88 P = .42) that proved non-significant. There is no difference between I-level and E-level children in their choices of word pairings. The only comparison that proved significant between representational levels was the One Way ANOVA conducted of the percentages of pairings considered to be errors (F (2, 98) = 6.91 P = .003). A Scheffe post hoc test indicated that PI-level children made significantly more errors than E-level children.

However the key prediction of the pairs task was that children classified (on the recognition task) as having I-level understanding of spelling would produce fewer explicit-type verbal justifications and more implicit-type verbal justifications compared to children classified as having an E-level understanding.

Table 2.7: Number (%) of children at each representational level for spelling (pre-implicit, implicit and explicit) and each justification type on the pairs task (full, half, implicit, error)

Representational level	Justification type			
	Full	Partial	Implicit	Error
Pre-implicit	0 (0)	2 (1.98)	4 (3.96)	1 (0.99)
Implicit	6 (5.94)	11 (10.89)	5 (4.95)	1 (0.99)
Explicit	35 (34.65)	25 (24.75)	9 (8.91)	2 (1.98)

Table 2.7 indicates that children with PI-level understanding of spelling were most likely to produce implicit justifications. Unexpectedly, 11 I-level children produced partial justifications about why they paired certain words, therefore demonstrating some explicit knowledge of similarity or generalization of knowledge. Only five I-level children were classified as having an implicit justification type, thus meeting the prediction. The

majority of E-level children were allocated to either full or partial justification types as expected however nine were allocated to the implicit justification.

There appears to be no clear difference in justification type according to whether the representational level of spelling understanding was implicit or explicit. This is supported by a chi-squared Goodness of Fit test: χ^2 (6, N = 101) = 15.71 P = .02 as although the result demonstrated an association between representational level and justification type, that association was only found between the pre-implicit representational level and the implicit justification type on the pairs task [1](adjusted residual value of 2.8) and explicit representational level and the full justification type (2.7). However there are no associations between the implicit representational level (as based on the recognition task) and a specific justification type on the pairs test.

Task Three; Substitution Task

Having found no differences were between I-level and E-level children in terms of the ability, to generalize and communicate knowledge of similar words in the pairs task, the substitution task will be analyzed to see whether any difference is present here. It was predicted that I-level children (as classified on the recognition task) would be less able to verbally justify how they produced new words and less able to explain how the new word was still similar to the original word compared to E-level children

Materials

Children were given one magnetic board that contained all the letters of the alphabet (laid out in order) and one board for the words to be formed on. Four of the words were real and four were non-words, see Table 2.8 for the words originally presented to the children and the conversion words.

[1] Since the chi-squared test is an overall significance test, a significant p-value does not indicate which of the cells of the cross-tabulation differed "significantly" from their expected values. This can be examined using adjusted standardized residual scores. If the cell is above 1.5 there is a frequency significantly more than expected and if the cell is below -1.5 there is a frequency significantly less than expected.

Table 2.8: Real and Non-words presented in the substitution task

Word Type	Word Presented	Word Converted To
Real Words	cold	sold
	cook	book
	bat	fat
	day	may
Nonwords	lold	wold
	dook	pook
	dat	jat
	cay	tay

Procedure

The task was given one week after the recognition task. Children were presented with eight words (separately) spelled out on a magnetic board. The word was read out and they were then asked to explain what would have to be changed in that word in order for it to spell a different word eg. given *sold* and asked to explain how you would change it into *cold.* Participants then implemented the suggested change by using further magnetic letters. Participants were then asked to verbally justify their action. Responses the children made were recorded then classified as one of two response types: justification present or justification absent based on their predominant response type and this was compared with their representational level for spelling (based on the recognition task). Inter-rater reliability measures were not deemed necessary for any of the Task 3 coding as it was straight-forward and not subject to the complexities of the recognition task.

1. Children that made **justification present** responses were able to verbally explain their action regardless of whether the new word they had formed was correct or not. For example:

"I swapped the "s" for the "c" to make sold"

"I put in a "s" at the start of the word instead"

2. Children that made **justification absent** responses could not verbally explain the action they had made. Either they simply said

"I don't know"

"I changed it"

or they just physically reversed the letter changes they had made without being able to explain verbally. Again this response type could be assigned whether the word created was correct or not.

After this children were asked to explain how the new word was similar to the original one. Three response types were coded: justification correct, justification incorrect, implicit.

1. When a child had created the new word and it was spelled correctly and they could justify the similarity the response type was called **justification correct**. For example:

"Sold is still like cold because they both have "old" in" or

"Sold is still like cold because they both have l-d at the end."

2. When a child had created the new word but it was *not* spelled correctly e.g. *colds* instead of *sold* and could not justify the similarity between the two words the response type was called **justification incorrect**. For example:

"I put a "s" in"

3. When a child had created the new word and it was spelled correctly but they could not identify the similarity between the two words the response type was called **implicit**. For example, simply spelling out the new word: "s-o-l-d" or referring to either the letter they had removed or added: "Its got "s" in", "needs "c" in" or simply replying: "I don't know".

Children were assigned to one of the three response types based on their predominant response type and this was examined in terms of allocated representational levels of spelling understanding (based on the recognition task).

Results

The first analysis concerns the ability to explain the production aspect of the task**.**

Table 2.9: Number (%) of children at each justification response type (present, absent) for production on the substitution task and spelling representational level

Representational level	Justification Present	Justification Absent
Pre-Implicit	4 (3.96)	3 (2.97)
Implicit	13 (12.87)	10 (9.9)
Explicit	60 (59.41)	11 (10.89)

A Chi-squared Goodness of Fit test on representational levels of spelling understanding and justification type for production was found to be significant: χ^2 (2, N = 101) = 9.02 P = .01 (adjusted residual values in brackets). Most children at the E-level consistently made justifications to explain how they formed new words (3.0). Table 2.9 also indicated that E-level children were very rarely allocated to the justification absent type. This finding supports expectations that E-level children would be able to verbally justify their actions on the substitution task. However the results for the I-level children are less conclusive as there was a fairly even allocation to both the "justification present" and "justification absent" (2.5) types.

The main prediction for the substitution task was that I-level children would be less able to justify how the new word was similar to the original word due to an inability to recognize and explain similar word components.

Table 2.10: Number (%) of children at each justification response type for identification of word similarity in the substitution task and spelling representational level

Representational Level	Justification Correct	Justification Incorrect	Implicit
Pre-Implicit	0 (0)	6 (5.94)	1 (0.99)
Implicit	5 (4.95)	5 (4.95)	13 (12.87)
Explicit	30 (29.7)	24 (23.76)	17 (16.83)

A Chi-squared Goodness of Fit test (χ^2 (4, N = 101) = 17.77 P = .001) found a significant relationship between the representational level of spelling understanding and the type of justification provided as to the similarity of words on the substitution task. Support has therefore been found for the prediction. Out of the three response types examined, most I-level children (recognition task) despite their successful task performance could only provide implicit justifications (3.1) that did not communicate any explicit generalized knowledge about word pattern similarity. In contrast many E-level children (recognition task) could provide a complete justification for word similarity (2.5) and communicated generalized knowledge, for example: "Sold is like cold because they both have "old" in". However there is variability present within the I-level and E-level groups as indicated in Table 2.10.

Discussion

The present study had two main aims. First, to consolidate research by Critten, et al. (2007) providing empirical evidence for implicit spelling representations but using a younger sample. Secondly, should children be found to have I-level understanding of spelling, can the predicted inability to consciously access and verbalise component parts of a representation at this level (Karmiloff-Smith, 1992) distinguish them from children with some level of explicit understanding on two further spelling tasks?

Following on from previous research (Critten et al.), the majority of children were found to be at one of the explicit representational levels of spelling understanding (E1A, E1B, E2), frequently making errors in recognition but being able to justify them accordingly either through phonological (E1A) or morphological (E1B) knowledge, for example, "it has to have –ed".

However 20% of this younger sample was found to have implicit spelling representations. This is a higher incidence than Critten et al. (2007) found and meets the first aim of the study. It is apparent that using a younger sample of children has captured more instances of this early form of representation used in spelling. It can be suggested therefore that children unconsciously access representations comprising implicit procedures that cannot be verbalized. As expected, children at this level correctly recognized words but could not justify their choice or why alternatives were incorrect: "I don't know", or if they did try to make a justification it showed a lack of conscious access to knowledge: "filld is wrong as it has i". However, judging by the number already displaying some level of explicit understanding (even at this early age), children may not only utilize implicit representations for very long. This rapidity of development is not unexpected given the earlier instruction of literacy in the UK from the foundation stage (3 years +) onwards as referred to earlier.

The discovery of children who appear to access implicit spelling representations further validates the use of the RR model in conceptualizing the representations that underlie spelling. Previously only varying levels of explicit knowledge had been demonstrated questioning whether implicit knowledge plays a role in the development of spelling. This finding builds upon and integrates the descriptions of early spelling in the accounts of Frith (1985) and Ehri (1998, 1999, 2002) that could be construed as implicit and the review of implicit spelling by Steffler (2001) by applying a framework of spelling development that not only incorporates implicit representations but describes how they develop beyond this. Indeed it can now be suggested that implicit procedures underlie early visual or logographic spelling while explicit representations underlie the acquisition of phonological and morphological knowledge of spelling (E1A, E1B, E2, E3).

Furthermore the novel use of verbal explanations alongside performance on spelling tasks is a rich source of data and is invaluable when distinguishing between implicit and fully explicit knowledge.

Having found children at the implicit level for spelling it was possible to see if they differed from children at explicit levels in the ability to make links between and verbally explain similarities in word patterns. This ability should not be present if there is no access to component parts of implicit representations, despite task success.

However in the pairs task no differences between levels were found in the type of word pairings or in the ability to break-up words into their component parts or explain pattern similarities. Most E-level children (85%) followed the predicted pattern and could identify word similarity in a full and explicit manner:
"Sold and cold both have "old" in"
However despite a tendency for some I-level children to make more implicit justifications and less full (explicit-type) justifications compared to E-level children:
"I don't know"
"Sold and cold are both the same"
many (70%) were able to provide fully explicit answers.

The contrast in behaviour displayed by some of the I-level children on the recognition and pairs tasks is intriguing. How is it that a child who is clearly implicit on one spelling task then displays some form of explicit understanding on another spelling task? This matter of inconsistency will be discussed later but for now attention will be turned to the substitution task.

Some differences in the ability to explain production of a new word did emerge as 50% of I-level children exactly matched the prediction by achieving task success, e.g., changing cold into sold, but were unable to explain their procedure:
"I just changed it".

Interestingly when asked how they did it some of these children physically reversed the letter changes they had made without attempting to explain. This would match the procedural nature of the implicit level (as described by Karmiloff-Smith, 1992) accompanied by the inability to verbalise. As expected and in contrast the majority of E-level children could competently justify how they produced the new word, e.g.:
"I swapped the "s" for the "c" to make sold".
E-level children therefore could access the knowledge they were applying and explicitly express it.

However, the results were not clear-cut as the remaining I-level children did provide some explicit explanations; either producing the correct spelling and fully explaining how the change was made or failing to produce the correct spelling (no task success) but still explaining their procedure. Therefore although compared to the pairs task, a greater contrast between I-level and E-level children was found some consistency was lacking. Again the variability was greater within the I-level group as the majority of E-level children acted in an expected manner compared to only half of the I-level children.

More comprehensive support was found for differences according to level in the ability to explain word pattern similarity on the substitution task. Two thirds of I-level children could not do this even though they had successfully changed the original word into the new word. For example:
"I don't know"
"It's s-o-l-d"
In contrast many E-level children (75%) could provide explicit explanations as to word similarity:
"Sold is still like cold because they both have "old" in".
Therefore many E-level children could access knowledge and communicate it where most I-level children could not.

However even though there were differences according to the levels, the performance of some children was inconsistent with their representational level, e.g., the five I-level

children who could perform the task and provide explicit justification as to word similarity and the 17 E-level children who only provided implicit justifications when asked about word similarity.

Overall the present study has found empirical evidence for implicit spelling representations following on from the research of Critten et al. However attempts to differentiate between I-level and E-level children on further spelling tasks has not produced definite results. What does this mean in terms of representational development? It does appear from the substitution task certainly, that many I-level and E-level children (over 50%) behaved as predicted. This lends credence to Karmiloff-Smith's notion that implicit representations prevent conscious access to knowledge or verbalization of component parts. This may prove a useful tool in shedding light upon the nature of implicit spelling. However while children deemed I-level or E-level on the recognition task could often be differentiated on the substitution task this was not true of the pairs task and reasons for this will now be discussed.

Methodologically speaking the tasks appear similar. Both use word groups containing common patterns and success on these tasks in terms of the production of verbal justifications requires communication of this word pattern knowledge, e.g., recognition that "old" is present in sold and cold. However the two tasks may have been tapping into different spelling skills and requirements of understanding. The level of skill required does seem better matched for the recognition and substitution tasks rather than the recognition and pairs tasks; perhaps the pairs task was fundamentally "easier". The recognition and substitution tasks could be "purer" spelling tasks as to be successful *and* verbally justify answers, the child requires phonological knowledge, e.g., letter names and phonemic blending, morphological knowledge, e.g., use of –ed on regular past tense verbs but most importantly an understanding of the shared pattern conventions that can be generalized appropriately across similar words, for example, -ed on the recognition task and "old" on the substitution task.

In contrast, the pairs task is more of a visual task. If a child can scan across all four words and see the similarities between the pairs, the task can be performed. To provide a verbal justification all the child has to know are letter names, for example: "they both have o-l-d in". The relative ease of this means that even those children who were implicit on the recognition and substitution tasks were able to provide explicit explanations on the pairs task. However it should be acknowledged that out of the 17 I-level children (out of 23) who produced explicit responses, 11 of them only managed *partially* explicit responses. The difference from the recognition task is not therefore that extreme.

Irrespective of task differences it may simply not be logical to expect children to be at one representational level for all spelling tasks and the results of the present study would confirm this. Some children do display consistent spelling representational understanding particularly across the recognition and substitution tasks, conforming to predominantly implicit or explicit behaviour. However other children vary across tasks suggesting the existence of multiple spelling representations. Karmiloff-Smith does account for multi-representations in the RR model and the representation that is accessed may depend upon the nature and context of the task. Therefore a child may not be implicit or explicit across all tasks no matter how similar those tasks may seem.

Furthermore Critten et al. reported children that were more difficult to assign to one representational level as the understanding displayed seemed to vary across the different words of the recognition task. Interestingly they also reported that the younger children studied in their second experiment, would show their predominant representation-type less, than the slightly older children from their first experiment. The present study included younger children still, who are unlikely to be at one representational level for all spelling tasks as they are learning so much so quickly and will have greater understanding in some areas than others. This also echoes reports made by Dietrich & Brady (2001) of the unstable representations of poor adult readers and it may be that developing representations are akin to these. According to Karmiloff-Smith initial implicit representations are never lost and even adults can still access them for the

purposes of automaticity. Although children develop beyond them, clearly this transition takes time and does not occur across a whole domain at once.

Indeed the models of Ehri (1998, 1999, 2002) and Share (1995) would also not predict a pervasive spelling ability across all words and spelling tasks. Ehri argues that her model describes phases of spelling development and that according to a child's experience they may be at a higher phase for some words than others. Similarly Share suggests that word-specific knowledge is the key to understanding development, as we could never be equally proficient with all words on all tasks even as adults. The results of the present study therefore seems to reflect predictions that descriptive models have made therefore supporting the RR model as a suitable framework for shedding light on the underlying representations as it advocates a multi-representational structure.

Therefore much can be learnt from this study. Using the RR model as an investigative tool has highlighted the complexities underlying spelling representations in a manner not attempted before. Evidence has been found to support an implicit level of spelling. Furthermore allocation to either the I-level or E-level on the recognition task can, to some extent, be used to make predictions about behaviour on other spelling tasks. It seems clear that these predictions are more successful on production-based tasks like the substitution task where the level of difficulty was more equivalent. Even though children may not have been implicit across all tasks, the fact that implicit procedures were displayed on all three tasks supports the notion of an implicit level in spelling development and it was here that verbal explanations proved vital in distinguishing between implicit and explicit task success. Variability is obviously an important factor but the levels provide a framework for conceptualizing the underlying representations in novel ways, e.g. whether task success is due to implicit or explicit representations and whether children can consciously access and communicate their knowledge and understanding of spelling.

In terms of the assessment of spelling ability and understanding in young children, this study argues for a pluralistic approach to assessment and the use of more than one tool.

A variety of tasks that address slightly different aspects help to identify where any weaknesses lie, for example: in letter naming, phonics, phonemic blending, pattern similarities and morphological rules. Verbal justifications indicate whether ability is due to explicit knowledge and exposes any errors that can be addressed. This study also indicates the importance of being able to recognize and generalize spelling knowledge across similar words such as common word patterns, e.g. "old". Not only does this improve recognition and production ability but increases the level of explicit understanding so that a child can begin to acquire a coherent overview of the regularities inherent in spelling and express this understanding verbally. Finally this study indicates the importance of asking children to explain themselves. Clearly task success is not the only issue if it is achieved without understanding.

Chapter Three

Longitudinal Study Part One: Can representational levels be identified for reading as a basis for studying representational change longitudinally?

Based on previous research (Critten et al. 2007) and the findings described in Chapter 2, the RR model (Karmiloff-Smith, 1992) offers a useful framework for understanding representations underlying children's spelling development. It is an effective investigative tool for integrating previous research that suggests initial spelling is implicit (e.g., Steffler, 2001) as there is a continuum for development where initial implicit spelling representations are redescribed to become increasingly explicit (Implicit, E1A, E1B, E2 and E3). If RR levels can be identified in reading development akin to those for spelling then a more cohesive understanding of a reading and spelling representational system could be articulated. To achieve this, a longitudinal study was conducted which is described in this chapter and the next.

The first aim of the present study is to see whether representational levels can also be applied to reading, identifying both implicit and explicit levels of understanding. As indicated in the discussion of literature in Chapter 1 there is support for the importance of implicit processes in learning to read as explained by Ellis (1997). Indeed an essential part of the Knowledge Sources Account of reading (Thompson et al, 1996) is the emphasis upon implicit phonemic awareness as shown by studies of an advanced reader, (Fletcher-Finn & Thompson, 2000, 2004). Similarly in joint models of spelling and reading development (e.g. Frith, 1985, Ehri, 1998, 1999, 2002) early reading in particular is referred to as visually based or logographic and can be construed as implicit as it comprises automatic recognition and acquirement of a sight word vocabulary. However the implicit to explicit mechanism advocated by the RR model has not been used before to account for how children's reading representations develop. Now that the implicit level has been empirically established for spelling, if reading levels can also be identified in a similar manner this will conceptualise the underlying representations in a novel way and shed light on the co-development of the two abilities.

If reading levels can be identified the second aim of the study will be to follow children's development longitudinally over the course of a year. Although it has been possible to characterise children understanding of spelling as implicit or at one of the explicit levels (Chapter 2), these studies were cross-sectional and therefore do not describe a developmental trajectory. If the process of explicitation can be shown not only in spelling but in reading, this will show how underlying representations may develop using the new RR framework to build upon and extend existing models of spelling and reading development (e.g., Frith, 1985, Ehri, 1998, 1999, 2002)

This last point leads directly into the third aim of the study: to compare how spelling and reading develop in relation to each other. Frith (1985) in her classic stage model drew attention to the overlapping and mutually dependent course of the developmental paths of spelling and reading. Although Ellis's (1997) review of this model and many recent studies, (e.g., Lehtonen & Bryant, 2005, Bernstein & Trieman, 2004, Ferguson & Besner, 2006) indicated that alphabetic and orthographic information form representations interactively rather than develop in a serial fashion, the message is clear: there is a relationship in the development of representations used for spelling and reading as children learn. Support for Frith's "pace maker" predictions, i.e. that alphabetic spelling may lead alphabetic reading; have already been found by Caravolas et al. (2001).

Thus, a longitudinal study will make a contribution to our understanding of literacy on a number of levels. It will investigate the use of the RR model to conceptualise reading in a similar way to spelling, e.g. implicit and explicit representations, whether knowledge is consciously accessible and verbalisable and the nature of errors. Then it will be possible to see whether children's reading and spelling representations involve a process of explicitation proposed in the developmental sequence, i.e. is this the way children learn? Finally it will involve the collection of data not only about children's spelling and reading accuracy but also about their understanding over the course of a year to see whether the development of these two abilities is overlapping or one acts as a pace maker for the other.

The longitudinal study will be conducted over one year with four testing points beginning in the third term of Reception Year and completing in the third term of Year 1. This length of time was chosen as the development of spelling and reading knowledge is a complex process that takes years so if the study were any shorter it may not capture definitive change in children's understanding. At each testing point a series of spelling and reading tasks will be given: simple one-word spelling and reading tests to obtain measurements for accuracy and spelling and reading recognition tasks to identify spelling and reading representational levels: Pre-implicit, implicit, E1A, E1B, E2, E3). The former will use the same method and coding scheme as Critten et al., also employed in Chapter 2. The reading recognition task is new to this study. Furthermore, additional performance measures will be taken using four tasks from the Phonological Assessment Battery (PhAB) (Frederickson, Frith & Reason).

The reading recognition task and the coding of children's performance and verbal explanations derived from this task is the key issue as it will be used to develop a methodology for coding reading in terms of RR levels. The materials for the task are designed to match those used for the spelling recognition task to make the tasks as equivalent as possible so that children's understanding and performance across the spelling and reading tasks can be directly compared. This method proved successful in the RR application to spelling. There will be one fundamental difference. When children are presented with a flash card containing the spelling alternatives they will not be told the target word to find instead they will be told there is one real word and two pretend words. They will be asked to identify and try to read the word they believe real and the words they believe pretend and explain how they read the words. This will provide an insight into whether are using implicit recognition without conscious access to their reading process or whether they can access explicit representations and communicate *how* they read words both familiar and unfamiliar to them.

Behaviour at each level (Pre-implicit, implicit, E1A, E1B, E2, E3) is predicted to be akin to that in spelling. It is expected that children using implicit representations will be able to achieve task success, as they will be able to identify and correctly read the real words.

However because they cannot consciously access knowledge they will be unable to explain how they read words or decode any of the error alternatives. Children at the E1 level may have abstracted theories of phonology and or morphology akin to that in the spelling E1A and E1B levels that will provide them with some insight into how they read words and thus make knowledge communicable in a basic form. However errors may also start to occur as a result. It is expected that children at the later E2 and E3 levels will be able to identify and read both real words and error alternatives. Furthermore they will be able to provide explicit explanations as to how they read words demonstrating blending and segmentation. Again children will be allocated to the level they display the majority of the time (at least 50%). This criteria, was also used by Critten et al (2007) and in Pine & Messer's (1998, 1999) balance studies.

This chapter will outline the methods used in the longitudinal study and present the findings of the establishment of a coding scheme for reading levels. There are three main predictions in this study but only the first will be focussed on in the present chapter. If RR levels can be identified for reading then it is predicted that children will be allocated to separate reading and spelling levels at each testing point of the study. The results for predictions two and three will be analyzed in Chapter Four.

Method

Design

This longitudinal study took place over the course of 12 months and involved tests being given at four points. The second testing point took place four months after the first, the third testing point took place eight months after the first whilst the fourth and final testing point took place exactly a year from the start. There were five measures at each phase of the study: the performance measures of spelling production, reading production and spelling recognition (number of words correct out of 9 in each case) and allocation to one spelling and one reading representational level (out of pre-implicit, implicit, E1A, E1B, E2 and E3) based on the spelling and reading recognition tasks respectively. The order of the spelling and reading tasks was counterbalanced at each phase: where half the sample did spelling tasks first and half the sample did reading tasks first. In addition four

dependent variables were derived from the PhAb tasks: score out of 10 for Alliteration, score out of 10 for Alliteration with picture, score out of 21 for Rhyme and score out of 20 for non-word reading.

Participants

Seventy-three children took part in each of the four testing points of the longitudinal study (36 males and 37 females). They were recruited from two Mixed Primary State schools situated in Hertfordshire and received spelling and reading instruction in accordance with the UK National Literacy Strategy (DfES, 2001). When first tested the children were in the third term of their Reception year and the mean age was 5 years, 3 months (with a range of 11 months) and the next three testing points took place once a term in the following three terms until the children were in the third term of Year 1.

Materials

1. Single-word spelling and reading tasks

Children were presented with the same 9 words for the single-word spelling and reading tasks. They consisted of 3 words from each of 3 categories: regular past tense verbs, irregular past tense verbs and non-verbs ending in /d/ and /t/ and were taken from Nunes, et al. (1997), see Table 3.1. It was decided in discussion with class teachers to use this number of items as when the study commenced some children were only 4.5 years old and none of the sample had experienced any spelling and reading testing. It was also a consideration that the number of items would influence the number of sets in the recognition tasks and again the nature of the questioning in these tasks is quite taxing for such young children.

Table 3.1: Words used in the single-word spelling and reading tasks

Regular verbs	Irregular verbs	Non-verbs
filled	sold	soft
kissed	lost	ground
opened	slept	cold

2. Spelling and reading recognition tasks

In both the recognition tasks children were presented with same 9 sets of alternative spellings. Each set contained three spelling alternatives of a word only one of which was correct and were presented separately on individual flash cards. The 9 target words were those included in the single-word spelling and reading tasks. The position of the correct word on the card was randomly allocated in order to prevent a biased response set. The alternative sets are shown in Table 3.2 and the order of presentation was randomised.

Table 3.2: Alternative word sets used in the spelling and reading recognition tasks

filled	fild	filld
kissed	kised	kissd
opened	openned	opend
sold	soled	solded
lost	losed	losted
slept	sleped	slepted
soft	sofed	softed
ground	grownd	grouned
cold	coled	colded

3. PhAB Tasks (Frederickson et al.)

The following tasks were taken from the Phonological Assessment Battery

1. Alliteration task: Comprised 10 sets containing three words where two of the words started with the same sound, e.g. ship, fat, fox. Each correct answer received a score of one.
2. Alliteration test with pictures: Same as above but with accompanying pictures.
3. Rhyme test: Comprised 21 sets of three words where two of the words contained the same end pattern, e.g., made, hide, fade.
4. Non-word reading test: Consisted of 20 non-words ranging in length from 3-9 letters, e.g., pim, plutskirl.

Procedure

Phase one consisted of the spelling tasks while Phase two that took place approximately two weeks later, involved the reading tasks. This order was counterbalanced for half of the sample.

Phase one: Spelling

1. Single-word Spelling Test

Children were taken individually to a quiet room and presented with two magnetic boards. One board was empty and the other had magnetic letters (all the letters of the alphabet) laid out in order. They were informed that they would be told some words (one at a time) that they should try to spell on the empty board using the letters from the other board. The words were then presented in isolation with each word spoken twice by the experimenter at a suitable time pace.

2. Spelling Recognition Test

After the spelling test was completed, children were presented with 9 sets of spelling alternatives, one at a time. They were told the target word and were asked which spelling out of three alternatives they thought was correct and why. After this the experimenter pointed to the other two alternatives in turn and asked children to explain why they thought those spellings were wrong. All responses were recorded using a tape recorder.

Phase Two: Reading

The single-word test was given to all children first and then three days later the recognition test was given so as to prevent any task influence. Again all responses were recorded

Single-word Reading Test

Again, children were taken to a quiet room. They were presented with 9 flashcards, one at a time. Each card had one word written on it and they were all previously presented in the spelling test. They were asked to look closely at the word and try to read it.

Reading Recognition Test

Children were presented with the same 9 sets of spelling alternatives (one at a time) that were used in the recognition test. However this time they were not told the target word. Instead they were told that only one of the three alternatives was actually a real word, the other two were nonwords or pretend words. Children were then asked to carefully look at the alternatives and identify which they thought was the real word. They were then asked to read their chosen alternative and to explain how they did that:
"How did you work out how to read it?"
The experimenter then pointed to the other two alternatives in turn and asked children to read them and again to explain how they read them.

PhAB (procedures from the test manual were followed)

1. Alliteration: Children were told to listen as the three words in each set were read in serial fashion (they were not shown the words). They were then asked to repeat the two words that started with same sound. If less than three sets were answered incorrectly out of the first five then the task was discontinued.
2. Alliteration with pictures: Children were told the three words in each set whilst simultaneously being shown a corresponding picture. Children were asked to indicate by pointing to the pictures the two words that began with the same sound. If less than three sets were answered incorrectly out of the first five then the task was discontinued.

3. Rhyme: Children were told the three words per set in serial fashion and were asked to repeat the two words they believed to rhyme/sound the same. If less than nine sets were answered incorrectly out of the first twelve then the task was discontinued.
4. Non-word reading: Children were asked to read each word in turn. If three consecutive words were read incorrectly then the task was discontinued.

Coding Scheme: Reading representational levels

The performance and verbal explanations on the spelling and reading recognition tasks were used to allocate children to two representational levels of understanding; one for spelling and one for reading at each testing point of the study. The coding scheme used for spelling representational levels is derived from Critten et al. (2007) and can also be seen in Table 2.3 from Chapter 2. However the coding scheme used for identification and allocation to reading representational levels is new to the present study and is outlined briefly in Table 3.3. The characteristics of each level had been predicted before the study commenced and derived from the equivalent spelling levels. The first 30 children tested (out of the overall 73) in the first testing point of the longitudinal study acted as a pilot study for the coding scheme in case modifications did prove necessary. Once the coding scheme had been validated the remainder of the sample was tested.

Table 3.3: Reading Representational Levels

Level	Performance	Characteristics and typical verbal responses
Pre-Implicit	Very poor, alternatives picked at random so accuracy in identifying the real word is below chance level. Inability to read the word chosen as real or the other alternatives	Complete lack of or only a rudimentary knowledge of letter names and phonics. Due to the inability to read any of the words no attempt at explaining the word was read. If guesses are made when reading they commonly share the first letter of the word, e.g. read sold as said or see. The errors are not phonologically plausible error versions.
Implicit	Accuracy in identifying and correctly reading the target words is high, >70% so improvement from the PI level but without understanding. Inability to read any of the error alternatives	Inability to explain how the target words were read. Common explanations indicate this lack of explicit knowledge as they involve reciting letters/sounds of a word in parrot fashion rather than identification of component parts; "it says sold, I read it s-o-l-d"
E1A	Correct choices in identifying and reading the target word are made but also phonetic errors, e.g. choosing filld but reading it as filled so performance may drop from the I-level. Correct attempts are now made to read some error alternatives	There is now an ability to make some explanations as to how a word is read focussing on aspects of phonology, –ed is hardly recognized as a unit. "How did you read filld?"(exp), "because it has f at the start and d at the end" (child). Or "because f and i make a fi sound so I thought it was filled" (child). Children can be kept at this level even if they correctly identify and read target and error words if their explanations remain akin to the parroting shown at the implicit level.

E1B	Again correct choices can be made but performance may stay lower than the I-level as error versions may be chosen and identified as the real word e.g. solded read as sold.	Verbal explanations at this level must refer to an abstracted morphological rule, in this case -ed "What does this word (solded) say?" (exp), "it says sold" (child), "How did you read it?" (exp), "it has sol and ed and that makes sold" (child). Children can be kept at this level if they can explain how they read real words but are still unable to read some of the error versions or explain how they read them.
E2	Performance improves again in identification of the target words as the real words. Most error alternatives can now be read.	Component parts of words are now identified. "How did you read that word (filled)?" (exp), "Well it has f and i which make fi and i, l and l that makes ill so that makes fill. Then add –ed to make filled" (child). The explanations must be this detailed for how all the words (real and errors) are read for a child to progress to E3.
E3	Accuracy returns to that of the I-level. All target words are chosen as real and read correctly. Error versions are also read correctly.	Full understanding of how to segment words into component parts in order to read them correctly: real and the unfamiliar error versions. Children can apply knowledge of how they read real words to decode the error versions. "How did you read that word (solded)?" (exp) "Well it is the word sold and -ed, s and o and l make sol and d and–ed make ded so, sol-ded, solded" (child)

Note: exp = experimenter, reps = representations

The coding process followed a similar pattern when establishing both spelling and reading representational levels for each child. Explanations derived from the spelling

and reading recognition tests were transcribed for each child. Each test consisted of 9 sets of alternative spellings and each set was then separately analyzed and allocated to one of the representational levels (Pre-implicit, Implicit, E1A, E1B, E2, E3) for either spelling or reading according to the criteria described above. The level that was allocated most frequently out of the 9 sets on the spelling recognition task then became the child's overall representational level for spelling and the level that was allocated most frequently out of the 9 sets of the reading recognition task became their overall reading representational level. For example, a child's verbalizations for 2 out of the 9 sets may have been allocated to E1A but because the other 7 sets were coded as E1B, the participant would be coded as E1B overall. Every child had a predominant level that accounted for their knowledge and understanding in more than 50% of the 9 spelling and reading alternative sets. The majority displayed their predominant level more than 75% of the time.

The first aim of the longitudinal study has therefore been met as a methodology has been established using the RR levels to characterise children's implicit and explicit knowledge and understanding of reading.

Results: Can children be allocated to one representational level for spelling and one for reading at each of the four time points?

The identification of the new reading representational levels meant that children's spelling and reading could be assessed at each of the four time points of the longitudinal 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 transcriptions of the children's explanations and performance accuracy for 20% of the sample (chosen at random) across the four time points and asked to allocate each child to a representational level. Following Critten et al.'s (2007) rating of 73%, concordance was achieved on spelling levels in 100% of cases. The new reading levels proved similarly reliable with an agreement of 93%.

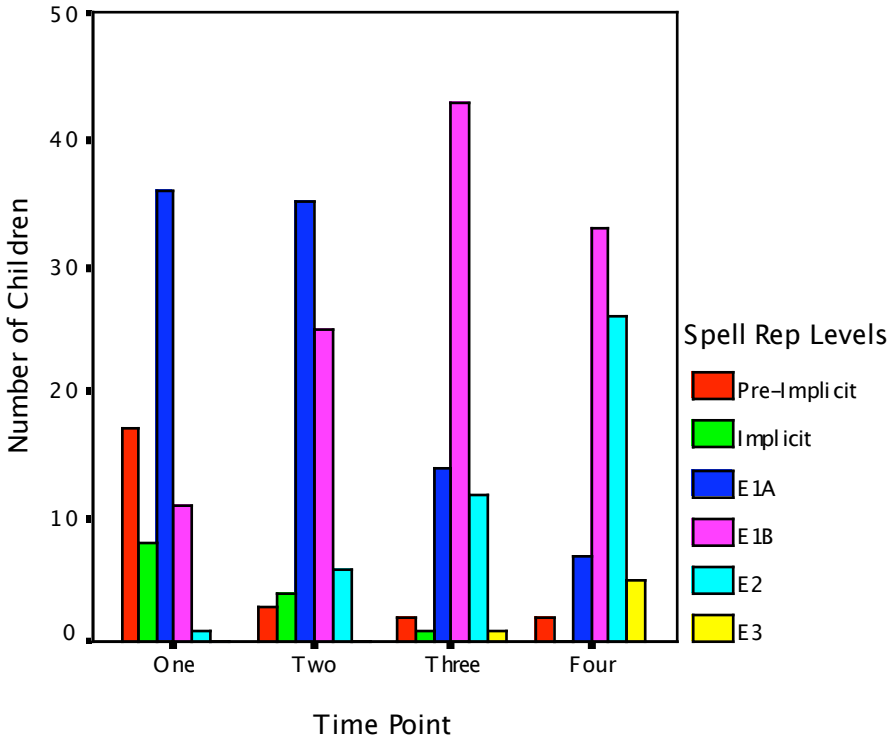

Figure 3.1: Number of children at each spelling representational level (Pre-Implicit, Implicit, E1A, E1B, E2, E3) at each of the four time points.

As shown in Figure 3.1 all children were allocated to a spelling level at each time point. The simplest way to approach this is to look at each level separately across each of the time points. The number of children at the pre-implicit level decreased at each time point from 17 children at time one to only 2 children at times three and four. The Implicit level also shows a similar pattern with a reduction between time one with 8 children and times three and four where no child demonstrated implicit spelling representations. Allocation to this level was generally low in comparison with the other levels but examples of children at the first three time points support the finding of Chapter 2 that children do pass through this level.

Levels E1A and E1B appear to show a shift in prevalence as the study progressed. At times one and two the modal level across the sample was E1A (N = 36). However there

were drops in allocation at times three and four by which time only 7 children were displaying these characteristics. Conversely, the number of children at level E1B was moderate at time one before rising at time three with 43 children. At time four it remained the modal allocation across the sample. The later explicit levels of E2 and E3 also reflect changing paths across the time points. At time one only one child was allocated to E2 which is not surprising given the age of the sample at the time (MEAN = 5.3) but rose to 6 at time two and 26 at time four making it the second most common level at the end of the end of the study. Level E3 unsurprisingly was not represented in the sample until time three and at the end of the study 5 children were judged as showing fully explicit knowledge in their understanding of spelling.

The changing patterns, of the number of children at each spelling level, suggests there was representational development, but this will be further analysed in the next chapter. What does the same examination of reading representational levels show?

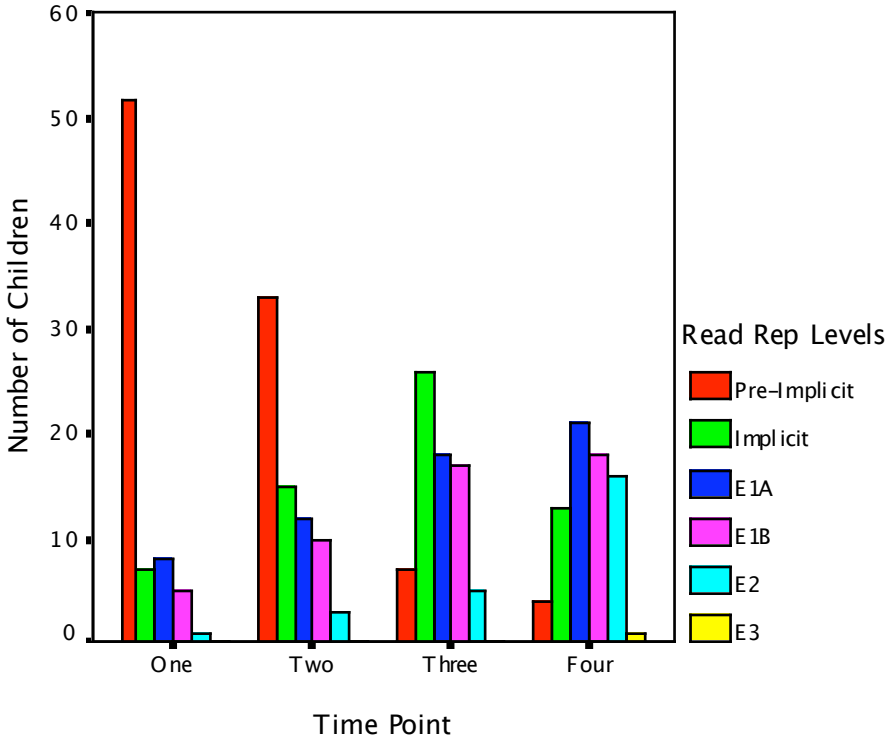

Figure 3.2: Number of children at each reading representational level (Pre-Implicit, Implicit, E1A, E1B, E2, E3) at each of the four time points

Again each level will now be explored separately across the time points (see Figure 3.2). The pre-implicit level clearly dominated at time one with 52 children at this level however by the end of the study only four children were still unable to read many of the words after a year of literacy teaching. The number of children at the implicit level of reading increased at each of the first three time points and was the modal level at time three with 26 children.

Allocation to levels E1A and E1B were initially low at time one with eight children and five children respectively. However numbers rose steadily until time four when they were the most represented levels. The later levels of E2 and E3 were also found although unsurprisingly were not that prevalent at the first three time points. However at the climax of the study, 16 were allocated to E2; nearly 25% of the sample. Only one child was at E3 for their understanding of reading at the final time point as the consistency and

explicitness of explanation required to attain this level was clearly difficult for children of this age.

Discussion

The first aim of this longitudinal study was to see whether the coding scheme developed for the levels of representations in relation to spelling could also be identified for reading. The spelling levels developed by Critten et al. (2007) were used as a basis to develop representational levels for reading spanning pre-implicit, implicit and varying levels of explicit knowledge. The pilot study conducted on the first 30 children in the first testing point confirmed that modification of those original predictions was not required and an inter-rater concordance rating of 93% supports the reliability of this new methodology.

This made it possible to allocate children to spelling and reading representational levels at each of the four time points of the study meeting the first requirement of the longitudinal study. Indeed this was vital if children's representational development was to be tracked and the development of spelling and reading understanding was to be compared.

Reading representations can now be conceptualised using the levels of the RR model. In terms of spelling, representational levels offered a new way to view spelling development as not only did it build upon descriptive models (e.g., Nunes et al. 1997), it introduced a framework encompassing implicit to explicit knowledge and attempted to account for the cognitive mechanisms underlying this development within the concept of representational-redescription. Using the RR model as a tool to investigate reading builds upon descriptive models/studies such as Frith (1985), Ehri (1998, 1999, 2002) and Caravolas et al (2001) by suggesting a framework that explains how and why reading knowledge develops over time. Furthermore it incorporates the idea of implicit knowledge of reading already documented by Ellis (1997) and Thompson et al. (1996) and inferred in the initial stages/phases of traditional models (Frith, Ehri) as a starting point in the mechanism for change. As with spelling, this new perspective comprises

what children can understand and communicate about their reading knowledge, not just what they can and cannot do. This allows insight into how development goes beyond implicit recognition to form explicit representations incorporating phonological and morphological knowledge. Children abstract, interpret and apply this knowledge leading to the errors and creativity seen at level E1 in this study.

Now that children's reading understanding can also be characterised within the implicit-explicit continuum it should be considered whether the separate but equivalent spelling and reading levels do complement each other, otherwise, comparisons at each testing point of the study would have no purpose. Alternatively it could be argued that comparisons of equivalence should not really be attempted as the study by Caravolas et al. (2001) suggests that although spelling and reading do interact in the course of development to a certain extent they depend on different cognitive skills. However classic models by Frith and Ehri do examine development of the two skills together and Ehri particularly has always highlighted their similarities and co-dependence: "two sides of the same coin" (Ehri 2000). Furthermore Holmes & Davis (2002) among others stress that representations are shared for the two skills. To address these issues it is therefore important to explore the nature of each reading representational level and how it compares to its spelling equivalent.

The pre-implicit level for reading is very similar to its spelling equivalent. Knowledge is being collated from the environment but implicit representations have yet to be formed, therefore any knowledge of letter names and phonics is rudimentary and incomplete. Children are unable to read any of the words yet and therefore ability to identify the target word as the real word is below chance and knowledge cannot be verbalised. This is akin to the random choices and absence of verbal explanations children make on the spelling task even though they have been told the target word to find. Typically on the reading task children will try and guess what the word says by using the first letter as a reference point, for example, if the target word is *lost*, they may read it as *let* or *look* (akin to errors reported by Caravolas et al. 2001).

It is however the contrast that can be made between the pre-implicit and implicit level for reading that is most informative.

At the implicit level for reading, children will commonly identify the target word as being the real word out of the three alternatives (remember in the reading recognition task they are not told the target word). Most crucially the child can *correctly read* the target word they have chosen which distinguishes this from behaviour at the pre-implicit level. However children at this level are still unable to read the errors or justify how they read target words. Commonly explanations devoid of conscious access to knowledge involve reciting the word again or the letter/sounds ad verbatim. For example:
"How did you read that word (lost)" (experimenter)
"It's (sounds out) l-o-s-t" (child)
Children can therefore successfully read words they have encountered before but lack conscious access to their knowledge. They cannot break up unfamiliar words into component parts in order to decipher them. This explains why they cannot read the error alternatives; they have to be read via decoding and accessing knowledge from target words, e.g. using the word *sold* to help you read *solded*. If children at this level try to read errors common mistakes include *seld* or *soldy* for *solded*.

Level E1 for reading like its spelling equivalent is characterised by abstraction and over-application of theories that can lead to a decrement in performance. Again two types of theory can be characterised, predominantly phonological (E1A) and predominantly morphological (E1B). When identifying the word believed to be real children at these levels may choose an error alternative but read it as the target word. At E1A it may be a phonological error, e.g., choosing filld but reading it as filled while at E1B it may be a morphological error relating to -ed, e.g., choosing solded but reading it as sold.
It seems apparent that an error representation of the word has been accessed in accordance with overriding theory as a child would never have seen these spellings in the environment; written in books, displayed in class rooms or on the television. Children at the E1 level may also identify and read the target words correctly but the nature of their

verbal explanations and their ability to read error alternatives may prevent allocation to the higher E2 level.

As well as attempting to read errors another difference to children at the implicit level is the ability to make simple explanations for how words were read. At E1A children may use simple phonology to explain their processes:
"How did you read that word (opend)?" (experimenter)
"It has o at the start and d at the end" (child)
Or slightly more advanced…
"It has o and p and e which makes an ope sound" (child).
While children at E1B will incorporate the rule of –ed into their justifications:
"How did you read that word (sleped)?" (experimenter)
"It's got slep and ed so that makes slept" (child at reading E1B).

As children progress to more explicit levels of E2 and E3, comparisons can again be made across the spelling and reading representational levels. A balance is forming between information gleaned from the environment (implicit knowledge) and the explicit knowledge that has been abstracted in the form of phonological and morphological theories (E1A/E1B). As the error representations of the E1 level are no longer dominant, performance starts to improve again as children apply their phonological and morphological knowledge appropriately, e.g. correctly identifying and reading lost and filled but equally realising that information should not be over-applied and some words simply do not occur in the environment, e.g., *losted* and *filld*. Children at the these levels for spelling and reading can also correctly identify and read the errors equipped with insight into why words are correct/incorrect and how they read real words and non-words. Children's explanations convey this increased awareness and often involve the very ability that is impossible at the implicit level; transfer of knowledge from words to non words and the breaking down of words into component parts to describe how a word is read. For example:
"How did you read that word (filled)?" (experimenter)

"Well, f and i make fi and i, l and l make ill so together that makes fill. Then add –ed to make filled." (child at E2 for reading)
And:
"How did you read that word (solded) (experimenter)
"Well it has the word sold in it which is right but then it has –ed as well that isn't. If you add them together that makes solded." (child at E2 for reading).

Similar to the spelling equivalent, children at level E2 for reading can often produce very explicit answers for how they read words just as children at level E2 for spelling can often do the same for why words are spelled correctly or incorrectly. However due to the fact that the balance between environmental information and internal theories is still forming, inconsistency is present and until children produce consistently explicit explanations for how they read words/non-words or why words are incorrect/correct they remain at E2.

This examination of the reading and more established spelling representational levels has proved encouraging, as the nature of children's knowledge, errors and explanations seems comparable across the levels. Although it cannot be said for definite that the spelling and reading levels are equivalent, they have been based on a similar conception of the underlying cognitive processes. Reading representational levels have been identified in a similar vein to spelling, essential not only for the success of the longitudinal study but for using the RR model to conceptualise representations underlying reading development. Thus the first aim of the longitudinal study was achieved and children could be allocated to reading and spelling levels at each of the four time points meeting the first prediction of the study.

When examining the number of children at each spelling representational level, results have consolidated and built upon Critten et al. (2007) and the investigation of implicit understanding of spelling (Chapter 2). Over the course of the year the number of children with pre-implicit and implicit understanding of spelling decreased whereas E1A, initially the dominant level at time one was gradually replaced by E1B and E2 understanding at

time four. At the onset of the study it seemed that while most children had already abstracted a phonological theory of spelling reflected in their recognition choices and verbal justifications (E1A), by the close, knowledge had grown ever more explicit incorporating theories of the morphological rule of –ed (E1B) forming a balance between information in the environment and internalised theories (E2) as reflected in verbal explanations.

Following the findings of Chapter 2 further support has been found for the implicit level in this new domain as children were allocated to implicit levels for understanding of spelling and reading. Therefore it does seem clear that whilst implicit understanding might only occur fleetingly in very young children and may not occur across all tasks within a domain, (spelling or reading), it is a level, children pass through in their development and marks a difference between conceptual and procedural knowledge. Further support of Chapter 2 is the number of children allocated to a pre-implicit level for their understanding of spelling and particularly of reading which is not surprising given the age of children. Knowledge of letter names, sounds, phonemic blending, etc., is rudimentary and therefore choosing correct word alternatives is not informed by any knowledge, implicit or otherwise. If correct alternatives are picked it is by chance and in the case of the reading recognition task, hardly any words can actually be successfully read at all.

The nature of reading representational levels has already been examined in detail but it is worth examining the patterns of allocation throughout the study and how they may differ to spelling: a point that will be further explored in Chapter 4. At the first time point the prevalence of pre-implicit understanding of reading was striking, at the commencement of the study most children were unable to read any of the stimuli. This is where a longitudinal study was crucial as a cross-sectional study would have provided scant evidence for an implicit-explicit continuum in reading. The number of pre-implicit children significantly dropped over the course of the study allowing more explicit representations to emerge.

The other notable finding was the robustness of the implicit level for reading compared to spelling, in fact it was the predominant form of reading representation at time three. It does seem to suggest that the majority of early reading is indeed implicit supporting Ellis's (1997) claim that this aspect in the reading literature is under-researched. This finding seems compatible with the Knowledge Sources Account of reading (Thompson et al, 1996) and Fletcher-Finn & Thompson's (2000, 2004) suggestion that their precocious reader did not have explicit awareness of phoneme-grapheme relations.

It is possible to view implicit representations of words used in reading by children as akin to photographs or snap shots taken from their environment: books they have read, TV programmes or information on classroom walls. As they read, they simply access these snap shots but cannot explain how they read the words and cannot use this information to generalise to other similar words or the errors used in the recognition task, e.g. solded instead of sold. It could be argued that this is akin to Frith's logographic stage and Ehri's pre-alphabetic phase. However these models did not employ an overall framework of explicitation provided by a more general model of cognitive development and this is the contribution made by this study.

Returning to the patterns of reading representational change we can also see that, despite the robustness of the implicit level, at the end of the study 50% of the sample was allocated to the E1A and E1B levels. This demonstrates the existence of error representations formed on the basis of internalised theories that were leading to overgeneralisations. Some children went further progressing into the later level of E2 where more explicit explanations are being given as to how to read real words and errors signifying the increasing balance between these internalised theories and information in the environment.

At the end of the study the majority of children were at one of the E1 levels for their understanding of spelling and reading. This provides insight into the nature of developing representations of children at this age. They are ambiguous in the sense that they may contain errors based on overriding theory-driven understanding that is not yet

flexible or explicit enough to recognize exceptions. This is consistent with descriptions of underspecified representations of poor adult readers and spellers described by Katz & Frost (2001) and Dietrich & Brady (2001). An alternative explanation for believing that all poor reading and spelling in adulthood is due to flawed routes that are somehow separate from the usual pattern of development (i.e. specific phonological or semantic impairments in dyslexias) it could simply be that some adult representations have never developed past those that most children have; for some reason the knowledge has not become more explicit, exceptions have not been recognized and errors are still being made. Admittedly the reason for this is undoubtedly fundamental problems in phoneme-grapheme relations.

To conclude, this chapter has identified representational levels for reading and describes the characteristics of each level compared to its spelling equivalent. Furthermore children were allocated to separate spelling and reading levels at each of the four time points of the longitudinal study and the changing patterns of allocation have been described. In the next chapter attention will be focussed on the issues particular to the longitudinal nature of the study, whether children developed and how spelling and reading understanding developed in relation to each other.

Chapter Four

Longitudinal Study Part Two: The process of explicitation and how spelling and reading develop in relation to each other

Chapter 3 described the development of a new methodology for assessing children's representational level of reading akin to spelling levels developed by Critten et al. (2007) that were used in Chapter 2. In meeting the first aim of the longitudinal study it was possible to compare the number of children at each of the spelling and reading levels over the course of the year. This chapter will contain analyses made possible by the longitudinal nature of the study to see whether children did develop through the representational levels and how the understanding of spelling and reading developed in relation to each other.

Changing patterns of allocation to spelling and reading levels highlighted in Chapter 3 would suggest a process of explicitation in children's knowledge and understanding of spelling and reading as predicted by the RR model and this possibility will be analysed in this chapter. A non-interventionist study of development through RR levels has not been attempted before in any domain although Pine & Messer (1998, 1999, 2003.) were able to facilitate children's explicit understanding of the balance beam task following intervention over the course of a week. Identifying levels in cross-sectional studies does not establish that children will develop through these levels as they learn and this is why a longitudinal study was required. It will also be possible to examine rates of learning, e.g., it may not be reasonable to expect a child who is pre-implicit for reading and spelling at the start of the study to show fully explicit (E3) knowledge one year later, a more gradual improvement may be achieved. Furthermore analysis will also identify if there was a particular time when children improved or whether progress was steady throughout the year. The second prediction of the longitudinal study is that children will develop by at least one representational level for their understanding of reading and spelling across the four time points supporting the developmental aspect of the RR model.

If the process of explicitation can be shown then it will increase confidence that using the RR model can provide a new perspective for understanding how spelling and reading develop in relation to each other. By comparing children's reading and spelling representational levels at each time point it can be seen whether they will overlap and show mutual co-dependence or not. Previous research (Frith, 1985, Ehri, 1998, 1999, 2002, Caravolas et al. 2001) suggests sometimes one skill leads another, so it is possible that mismatches will occur. This is why a comparative study of understanding should be conducted, not least because of the issue of knowledge transfer between representations within or between domains. It is because of this last point that the recognition tasks and representational levels for spelling and reading were made as equivalent as possible. Therefore the possibility that any differences found, e.g., one skill apparently leading the other, are due to artefacts of the methodology, will have been minimised.

Support for the pace maker predictions of Frith's (1985) model were provided by the 3-year longitudinal study conducted by Caravolas et al (2001) who describe how at different times both spelling and reading take the lead. They wanted to look at predictors of spelling skill relative to reading over the first three years of schooling and address the relationship between the two skills; is it reciprocal or does reading provide the foundation for spelling? A comprehensive range of tests were employed over the time period to track the children including letter names and sounds tests, phonemic knowledge tasks and single-word spelling and reading tests.

Results indicated that the development of phonological spelling (phoneme to grapheme mapping) is necessary for the later development of spelling and reading skill. However predictors of spelling skill and reading skill differed. In the first 1-1.5 years of schooling, conventional spelling skill was predicted by letter-sound knowledge and phoneme isolation skill, but by the third year of schooling only reading skill and conventional spelling predicted spelling performance. In contrast phoneme isolation skill and letter-sound knowledge did not have the same predictive relationship for reading, as there was a more important bi-directional relationship between letter-name knowledge and reading. In fact, towards the end of the testing period this difference became increasingly

apparent. Therefore to a certain extent early reading and spelling depend on different cognitive skills although an interactive process is also evident. In the first two years of schooling phonological spelling ability appears to drive the development of reading but during the third year of schooling, and beyond this, influence is no longer exerted and reading becomes the "pace maker". Such findings provide some support for Frith's (1985) model.

This pattern of pace maker development is also supported by the nature of the errors that the children made in the first two years of the study. In spelling, children tended to employ knowledge that was largely phonological in nature and they commonly formed words via "sounding-out" the phoneme to grapheme correspondences. Therefore errors were often phonologically plausible. However, whilst reading, children at the earliest ages rarely used a similar method of "sounding-out" grapheme to phoneme correspondences. If children did not know a word they either would not make a response at all or commonly they would produce an incorrect word that had the same initial letter but was not phonologically plausible, e.g., *so* or *sand* when the target word was *sun.* This supports early phonological spelling as a pace maker for reading. After this, reading skill caught up and assumed prominence as a predictor of spelling ability. This pattern is supported by Ehri's (1998, 1999, 2002) phase model that also suggests that alphabetic information is used in spelling before reading.

Relating to this is research examining the nature of spelling and reading representations in adults suggesting that representations are shared for the two skills (e.g., Holmes & Davis, 2002 Holmes & Carruthers, 1998, Burt & Tate, 2002). Despite this it may not be plausible to expect matches in children's spelling and reading performance and understanding as single spelling and reading representations may, as Holmes & Davis suggest, contain multiple alternatives of a word. Furthermore unstable or impoverished representations containing more than one alternative version of a word have been reported in adult poor readers by Katz & Frost (2001) and Dietrich & Brady (2001). Clearly how complete children's developing representations are will certainly play a major role in levels of accuracy and understanding and may go some way in explaining

any mismatches: the differing nature of spelling and reading tasks however equivalent may not produce the same response. Therefore the third prediction of the study is that children's spelling and reading levels will not match as early phonological knowledge will benefit spelling understanding before reading (Frith, 1985). It may be that more than one pattern may emerge within the sample and it will then be possible to use allocation to spelling and reading representational levels as well as the performance measures (e.g. spelling, reading, recognition, PhAB scores) to elucidate any differences present.

An advantage to the RR approach is that assessment of development in many studies, including Caravolas et al. (2001) have looked at spelling and reading ability in terms of accuracy on a series of standardised tests. This study will focus on children's underlying representations as reflected in their verbal explanations to provide a valuable new source of data that will enable comparisons between performance and understanding in spelling and reading development.

The first set of results with accompanying discussion will consider whether children developed through the representational levels in the course of the study. The second set of results and accompanying discussion will consider how spelling and reading developed in relation to each other. At the end of the chapter a general discussion will summarise the overall findings from the longitudinal study (Chapters 3 and 4)

Method

See Chapter 3

Results: Do children develop by at least one representational level in their understanding of reading and spelling across the four time points supporting the developmental aspect of the RR model?

This results section will show whether children developed through at least one level for reading and spelling throughout the year. Analysis will also examine the rate of

development and the number of children that stayed the same or improved or regressed at each time point.

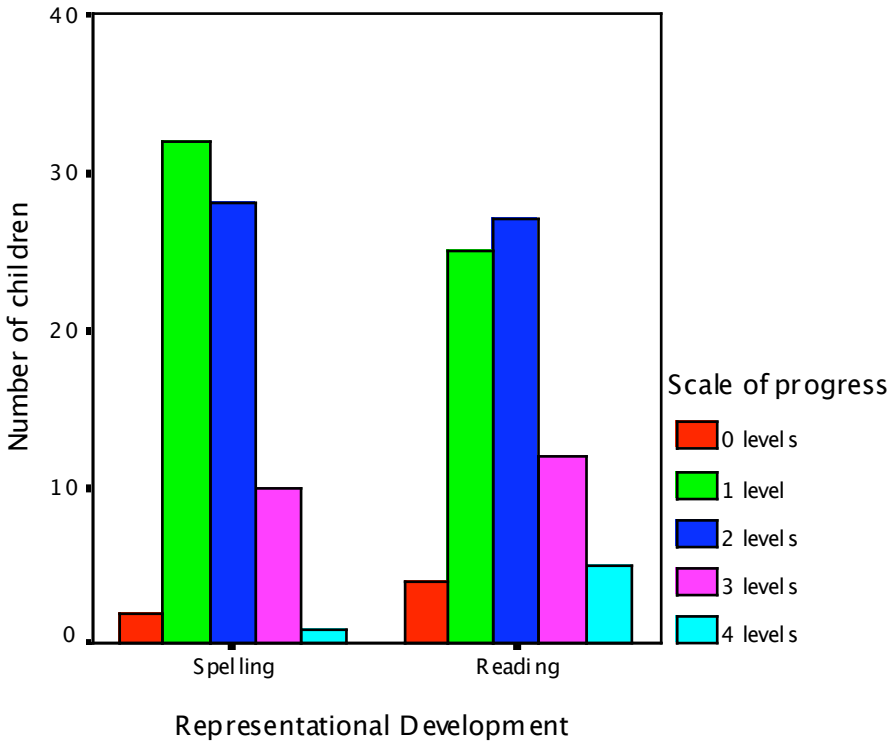

Figure 4.1: Number of children that had progressed through zero, one, two, three, or four levels for spelling and reading at the end of the study

Figure 4.1 shows that with the exception of two children for spelling and four children for reading, every child developed through at least one representational level for spelling and reading over the course of the year thus supporting the developmental application of the RR model to the domain(s) of spelling and reading. Chi-Squared Goodness of Fit tests were conducted separately for spelling (χ^2 (4, N=73) = 58.03, P = .001) and reading development (χ^2 (4, N=73) = 32.41, P = .001) respectively and both were significant (adjusted residual scores are shown in brackets). In both cases the majority of children progressed by either one or two levels for spelling (17.4 for one level and 13.4 for two levels) and reading (10.4 for one level and 12.4 for two levels) throughout the course of the study regardless of starting point. However about 15% of the sample improved by three levels and there were even a few children that progressed by four levels practically

spanning the entire implicit to explicit continuum. Clearly the scope for development in the explicitation of spelling and reading knowledge was quite broad although 75% followed a more expected progression of one or two levels

With the exception of a few children, the vast majority showed progression in their understanding of and ability to verbalise, their spelling and reading knowledge across the course of a year. What happened at each time point though and were there any differences? Did all children remain at the same level at one time point and progress at the next or was there a continual pattern of improvement? Figures 4.2 and 4.3 show the number of children that stayed the same or progressed to a higher level at time points two, three and four for spelling and reading.

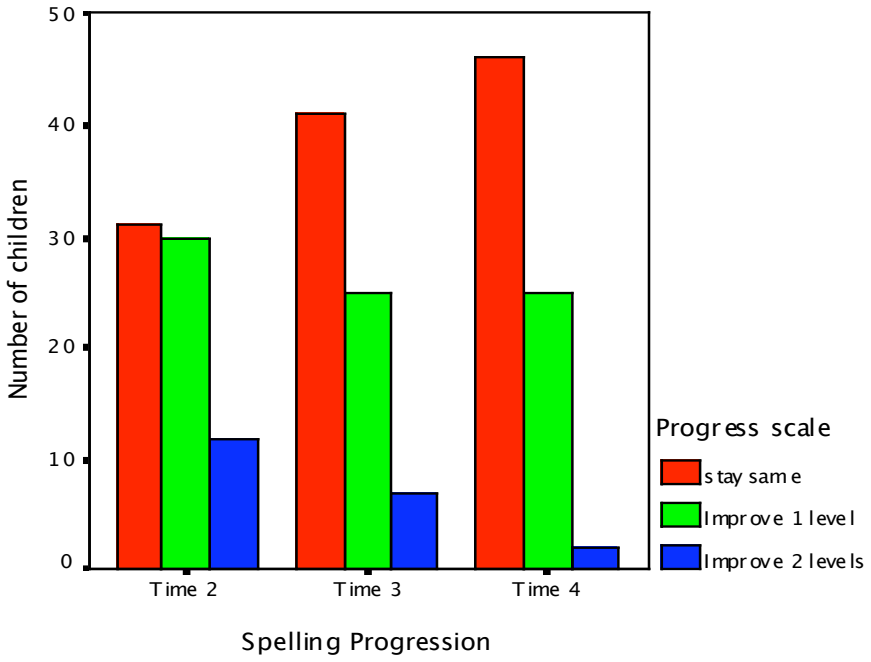

Figure 4.2: Number of children who stayed the same or progressed by one or two levels at each time point in their understanding of spelling.

A Chi-Squared Goodness of Fit test was conducted upon time point and whether children progressed or stayed at the same level for spelling and proved to be significant: χ^2 (4, N=73) = 10.74, P = .03 (adjusted residual scores are shown in brackets). Figure 4.2 does

not indicate uniform leaps at specific time points. There is a more continual development, while some children stayed the same, some children developed. The rate of children that improved by one level remained steady throughout the study at about 35% whilst the number that improved by two levels sharply dropped from 12 children at time two to 2 children at time four (-2.4) indicating that these more noticeable increases happened earlier in the study. So whilst Figure 4.1 demonstrated that all but a few children improved by at least one representational level for spelling, this improvement was relatively steady across the time points rather than occurring at just one time point for example.

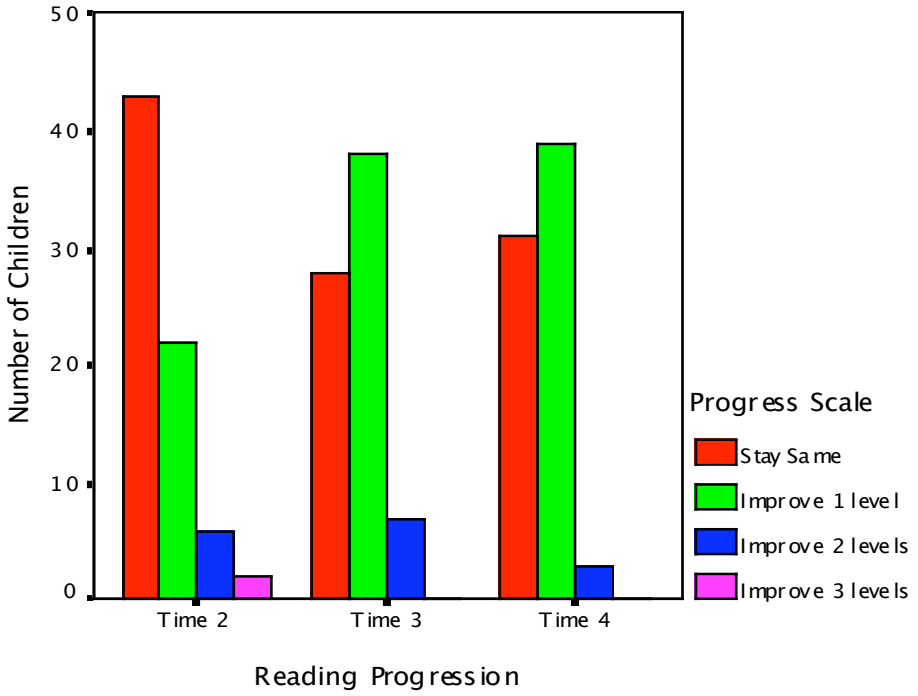

Figure 4.3: Number of children who stayed the same or progressed by one, two or three levels at each time point in their understanding of reading.

Again a Chi-Squared Goodness Fit test was conducted upon time point and whether children progressed or stayed at the same level for reading and proved to be significant: (χ^2 (6, N=73) = 14.85, P = .02 (adjusted residual scores are shown in brackets). Similar

to the spelling progression, Figure 4.3 shows a steady development across the time points. At time two over 50% of children had made no change in their understanding of reading from the commencement of the study. In contrast the number of children that improved by one level increased from time two to time four (2.0). The number of children improving by two levels remained relatively steady across the study at about 7% and surprisingly 2 children managed to improve by three levels from time one to time two (1.7). This is a notable increase in the explicitation of reading knowledge that was not displayed elsewhere in the sample within such a short space of time: the gap between each time point was only four months. Therefore while steady improvement can be seen in understanding of spelling, improvement in the understanding of reading seemed to occur in most children after time two.

Discussion

The findings suggest that representational development in spelling and reading occurred across the time points. Almost all children, (with the exception of two for spelling and four for reading), showed explicitation in their spelling and reading knowledge by passing through at least one representational level. The children that failed to make any progress remained in the pre-implicit level indicating that they may have had learning difficulties. This is not unexpected in a sample of 73, as approximately 5% of children in mainstream education will have some form of learning problem. The two children that remained pre-implicit for spelling were also children that were pre-implicit for reading. The remaining two children that were pre-implicit for reading were at the E1B level for spelling so clearly there is mismatch here.

Not only did over 95% of children progress, the improvement made by some was far better than expected: two, three and sometimes even four levels. However these results may not be considered surprising when viewed within the context of the Year One literacy curriculum. A great deal of phonological and morphological work is covered in the course of this year and it would appear that as children incorporated and endogenously processed this knowledge, they were able to progress from early pre-

implicit and implicit representations to gain much more explicit and verbalisable knowledge.

Whilst it would be expected for children to show progress throughout a school year, what is innovative about this study is using the framework of the RR model to track children's spelling and reading representational development has not been done before in this or any other domain. The fact that children have demonstrated an explicitation of knowledge both in the performance and explanations given on the recognition tasks supports the developmental application of the RR model to this domain far more than the cross-sectional studies of Critten et al. (2007) and in Chapter 2, especially as there were no regressions to lower levels.

Simultaneous studies of spelling and reading development to date, of which Caravolas et al. (2001) is a good example, have employed many standardised measures of accuracy but do not look further beyond what children can and cannot do. This study focused on when children can achieve even without understanding (implicit level) or when they make errors but are gaining explicit insight into a particular aspect of spelling or reading (E1 levels). This is why verbal explanations could prove a valuable assessment tool alongside traditional measures.

The rates of development, i.e. when children stayed at the same level or when they progressed, did not seem to vary greatly at different time points. This suggests that rather than all children progressing in a uniform fashion at specific time points, the process is continual. Therefore while children pass through the same levels at similar rates, each child's development is particular to them. There is some indication that the rates may have been slightly different for reading compared to spelling but this will explored in the next results section.

It is however noteworthy that the stimuli used in this study were derived from Nunes et al. (1997) and Critten et al. (2007) to use as a research tool. The morphological rule focussed on in this instance has been the development and overgeneralisation (at E1B) of

the past tense rule of –ed. This was chosen, as it is a typical example of a complex rule in the English orthography as the irregular exceptions to it produce errors in children's reading and spelling, e.g. solded. Furthermore past tense verbs also provide a good way of documenting phonological errors as children will invariably spell filled as filld before applying –ed correctly (as seen at E1A). These phonological and morphological errors, had already been documented by Nunes et al. and therefore provided a strong foundation for exploring representations that may underlie this development of knowledge and understanding and this is what Critten et al. sought to achieve. Chapter 3 demonstrated how reading representational levels were identified and the same stimuli and a similar recognition task were used to make them akin to spelling levels so that the co-development of the skills could be followed. However despite the fact that the focus has been specified this does not mean that the principles of development (the process of explicitation) shown in this study should not be extrapolated to other spelling rules, e.g. "silent e". The scope to which the representational levels could be adapted is very broad and would definitely worth be exploring in future study. For the purposes of this study, the stimuli have satisfied the objective of conveying longitudinal change.

In conclusion, the second prediction of this longitudinal study has been supported. Children showed representational development in their understanding of spelling and reading throughout the four time points. The number of children at pre-implicit and implicit levels decreased while the number at later explicit levels increased and each child progressed by at least one level for spelling and reading although within the sample some progressed up to four levels. These findings support the use of the RR model for conceptualising representations and their development within an implicit to explicit framework.

Results: Will children mismatch across their spelling and reading levels due to early phonological knowledge benefiting spelling understanding before reading (Frith, 1985)?

The first two results sections for this longitudinal study have established that reading representational levels can be allocated to each child in a similar way to that of spelling

and that 95% of children have developed through at least one level (for spelling and reading) over the course of a year. So what is the relationship between spelling and reading representational development? Does spelling act as a pacemaker for reading as Frith (1985) would suggest as phonological knowledge can be utilised first in spelling or will children match across their understanding of spelling and reading?

Cluster Analysis is an appropriate statistical method to apply here as it identifies homogenous groups within samples. If there is more than one pattern of spelling and reading development then it could be used to identify these groups and structure analysis in a more informative manner. Cluster Analysis was conducted using children's allocation to spelling and reading representational levels at each of the four time points, totalling eight variables in all. The analysis identified two distinct clusters within the sample. Group 1, labelled High Achievers (HA) contained 26 children and Group 2, labelled Low Achievers (LA) contained 47 children.

1. Are these clusters reliably different?
2. In what way do these clusters differ?

The first question was addressed by undertaking a Multiple Discriminant Analysis (MDA). The overall Wilk's Lamda proved significant $\Lambda = .22$, $\chi^2 = (8, N=73) = 100.26$, $P = .002$ indicating that the two clustered groups differentiated in allocations to spelling and reading representational levels at each time point. Furthermore classification analysis indicated that 97.3% of children were assigned to the correct group in the original cluster analysis. Now it can be assumed that the groups reliably differ on all the variables used, what can the difference between these groups tell us about the developmental relationship between spelling and reading understanding?

As has already been outlined, the two groups differed significantly at each measure of spelling and reading at each time point but in what way? Table 4.1 shows the number of children from each of the two groups allocated to each spelling representational level at each of the four time points.

Table 4.1: Number (%) of children from the two groups (HA, LA) at each of the spelling representational levels (Pre-Implicit, Implicit, E1A, E1B, E2, E3) at the four time points

Spell Rep Level	HA/LA	Time One	Time Two	Time Three	Time Four
Pre-Implicit:	HA	0 (0)	0 (0)	0 (0)	0 (0)
	LA	17 (36.17)	3 (6.38)	2 (4.26)	2 (4.26)
Implicit	HA	1 (3.85)	0 (0)	0 (0)	0 (0)
	LA	7 (14.89)	4 (8.5)	1 (2.13)	0 (0)
E1A	HA	13 (50)	6 (23.07)	1 (3.85)	0 (0)
	LA	23 (22.7)	29 (61.7)	13 (27.66)	7 (14.89)
E1B	HA	11 (42.3)	14 (53.84)	13 (50)	2 (7.69)
	LA	0 (0)	11 (23.4)	30 (63.82)	31 (65.96)
E2	HA	1 (3.85)	6 (23.08)	11 (42.31)	19 (73.08)
	LA	0 (0)	0 (0)	1 (2.13)	7 (14.89)
E3	HA	0 (0)	0 (0)	1 (3.85)	5 (19.23)
	LA	0 (0)	0 (0)	0 (0)	0 (0)

Note: High Achievers N = 26, Low Achievers N = 47

To analyse Table 4.1 separate Chi-Squared Goodness of Fit tests (adjusted residual scores are shown in brackets) were conducted for each time point as groups 1 and 2 consistently differed on their patterns of allocation to spelling representational levels. At time point one (χ^2 = (4, N=73) = 32.97, P = .001) over 90 % of High Achievers were at levels E1A or E1B (4.8) for spelling displaying the dominance of internalised theory. In contrast there were no Low Achievers beyond the first explicit level with the majority in E1A (3.9) and Pre-implicit levels (3.5). At time point two (χ^2 = (4, N=73) = 24.46, P = .001) most High Achievers were at an E1 level (3.2) but now some were at E2 (3.4). For Low Achievers the number at pre-implicit and implicit levels dropped while the number for E1B (2.6) increased.

At time point three (χ^2 = (4, N=73) = 25.4, P = .001), the number of children at E1B and E2 (4.4) was fairly equivalent and there was even one child judged as possessing fully explicit understanding of spelling. There were only three Low Achievers at the pre-implicit and implicit levels with the majority at E1B. At the fourth and final time point (χ^2 = (4, N=73) = 42.49, P = .001) most High Achievers were judged to have reached E2 (5.0) for spelling whilst five children reached level E3 (3.1) indicating explicit knowledge in relation to phonological and morphological aspects of spelling. 65% of Low Achievers were displaying E1B (4.8) theory driven understanding although seven children reached level E2. Overall the two groups differed at each time point as most High Achievers displayed more explicit understanding of spelling compared to most Low Achievers.

Table 4.2: Number (%) of children from the two groups (HA, LA) at each of the reading representational levels (Pre-Implicit, Implicit, E1A, E1B, E2, E3) at the four time points

Read Rep Level	HA/LA	Time One	Time Two	Time Three	Time Four
Pre-Implicit:	HA	9 (34.61)	0 (0)	0 (0)	0 (0)
	LA	43 (91.49)	33 (70.21)	7 (14.89)	4 (8.51)
Implicit	HA	3 (11.54)	2 (7.69)	0 (0)	0 (0)
	LA	4 (8.52)	13 (27.66)	26 (55.32)	13 (27.66)
E1A	HA	8 (30.77)	11 (42.31)	4 (15.38)	0 (0)
	LA	0 (0)	1 (2.13)	14 (29.79)	21 (44.68)
E1B	HA	5 (19.23)	10 (38.46)	17 (65.38)	9 (34.62)
	LA	0 (0)	0 (0)	0 (0)	9 (19.15)
E2	HA	1 (3.85)	3 (11.54)	5 (19.23)	16 (61.54)
	LA	0 (0)	0 (0)	0 (0)	0 (0)
E3	HA	0 (0)	0 (0)	0 (0)	1 (3.85)
	LA	0 (0)	0 (0)	0 (0)	0 (0)

Note: High Achievers N = 26, Low Achievers N = 47

Table 4.2 shows the number of children from the two groups at each reading representational level at each of the four time points. Again as the time points differed significantly from each other they were analysed separately using Chi-Squared Goodness of Fit tests (adjusted residual scores are shown in brackets). At time point one (χ^2 = (4, N=73) = 33.07, P = .002) there was a notable contrast between the two groups. The number of High Achievers at pre-implicit, E1A and E1B levels is spread relatively evenly while the majority of Low Achievers (over 90%) are at the pre-implicit level (5.1) and unable to read the majority of words. At time two (χ^2 = (4, N=73) = 61.44, P = .002) most High Achievers, displayed E1A (4.4) or E1B (4.6) reading levels. In contrast most Low Achievers were still pre-implicit (5.8) although 13 children now displayed implicit representations (2.6). At time three (χ^2 = (4, N=73) = 59.43, P = .002) most High Achievers were identified as E1B (6.3) whilst over 50% of Low Achievers were at the implicit level (4.7). The number of children at the pre-implicit level considerably dropped and early explicit understanding was occurring. At the final time point (χ^2 = (4, N=73) = 53.38, P = .002) most High Achievers reached the E2 level (6.1), one child was even judged fully explicit. In contrast the highest reading level reached by Low Achievers was the nine children at E1B. Over 70% of children were still implicit (3.0) or at the earliest explicit level (4.0). In summary it would appear again that the groups differ significantly at every measure of reading at every time point because High Achievers had more explicit understanding.

Cluster analysis, MDA and subsequent exploration revealed that two different groups of children could be identified on the basis of their representational levels for spelling and reading understanding at the four time points. The presence of variability within a sample of 73 children is not surprising. However now the reliability and nature of these differences have been confirmed, the groups can used to address the issue of the way spelling and reading develop in relation to each other. If these analyses had been conducted on the sample as a whole any subtleties may have been lost. There are two main aspects to consider; firstly, whether there was a quicker rate of development within the High Achievers group and secondly was there a difference between the two groups in terms of whether children had the same or different levels for spelling and reading?

1. Rate of development

The rate of development in spelling across the time points will be addressed first. Table 4.3 shows the number of children in each of the two groups who stayed the same or progressed in their understanding of spelling at time two, time three and time four.

Table 4.3: Number (%) of children from the two groups (HA, LA) who stayed the same or progressed by one or two levels for spelling at the last three time points

Spelling progress	HA/LA	Time Two	Time Three	Time Four
Stay same	HA	13 (50)	16 (61.54)	0 (0)
	LA	18 (38.29)	25 953.19)	7 (14.89)
Progress one	HA	12 (46.15)	7 (26.92)	3 (11.53)
	LA	18 (38.3)	18 (38.3)	4 (8.51)
Progress two	HA	1 (3.85)	3 (11.54)	4 (15.38)
	LA	11 (23.4)	4 (8.51)	14 (29.79)

Note: High Achievers N = 26, Low Achievers N = 47

Table 4.3 indicates that High Achievers and Low Achievers did not differ in their rate of progress in spelling understanding at any of the three assessments; time two (χ^2 = (2, N=73) = 4.69, P = .09), time three (χ^2 = (2, N=73) = 1.0, P = .61) and time four (χ^2 = (2, N=73) = 5.47, P = .07. This result is also true for the number of levels progressed overall: (χ^2 = (4, N=73) = 4.17, P = .38). It can therefore be concluded that the rate of progress established for the whole sample in results section two equally applies to both groups. High Achievers may have had more explicit understanding of spelling but they did not develop any faster, they simply started from a higher level.

The same result would be expected for reading development, however there was a difference between the groups (χ^2 = (4, N=73) = 12.55, P = .01) as shown in Table 4.4.

However the data in Table 4.4 suggests that the difference was due to the five High Achievers that developed by four levels for their understanding of reading whilst no Low Achievers showed this amount of progress. This difference is further specified in Table 4.5 as, there was only a difference in the rate of development at time two (χ^2 = (3, N=73) = 20.02, P = .01) as, more High Achievers progressed, (adjusted residual value of 3.1), while nearly 50% of Low Achievers did not. At the other time points there was no difference in the rate of progress between the two groups.

Table 4.4: Number (%) of children in the two groups (HA, LA) that progressed by zero, one, two, three or four levels in their understanding of reading across all four time points.

Number of levels progressed	**HA**	**LA**
0	0 (0)	4 (8.51)
1	9 (34.62)	16 (34.04)
2	7 (26.92)	20 (42.55)
3	5 (19.23)	7 (14.89)
4	5 (19.23)	0 (0)

Note: High Achievers N = 26, Low Achievers N = 47

Table 4.5: Number (%) of children from the two groups (HA, LA) who stayed the same or progressed by one, two or three levels for reading at the last three time points

Reading progress	HA/LA	Time Two	Time Three	Time Four
Stay same	HA	7 (26.92)	14 (53.84)	10 (38.46)
	LA	36 (76.6)	14 (29.79)	21 (44.69)
Progress one	HA	12 (46.15)	11 (42.31)	15 (57.69)
	LA	10 (21.28)	27 (57.45)	24 (51.06)
Progress two	HA	5 (19.23)	1 (3.85)	1 (3.85)
	LA	1 (2.13)	6 (12.77)	2 (4.26)
Progress three	HA	2 (7.69)	0 (0)	0 (0)
	LA	0 (0)	0 (0)	0 (0)

Note: High Achievers N = 26, Low Achievers N = 47

2. Match or mismatch?

Thus far results have shown that although High Achievers had a more explicit understanding of spelling and reading compared to Low Achievers, the groups did not differ in rate of spelling development. However High Achievers did differ from Low Achievers for rate of development in reading as some children made exceptional progress overall and the rate of development was faster at time two. Despite these exceptions most children irrespective of group showed a similar rate of development for reading. Therefore the final issue to address is whether the groups showed any differences in how spelling and reading developed in relation to each other.

Table 4.6: Number (%) of children from the two groups (HA, LA) who had the same spelling and reading levels, were higher for spelling or higher for reading at each of the four time points.

Spelling/Reading Relationship	HA/LA	Time One	Time Two	Time Three	Time Four
Same levels	HA	8 (30.77)	9 (34.62)	12 (46.15)	15 (57.69)
	LA	17 (36.17)	4 (8.51)	6 (12.77)	10 (21.28)
Higher spelling	HA	16 (61.54)	13 (50)	12 (46.15)	10 (38.46)
	LA	30 (63.83)	43 (91.49)	41 (87.23)	37 (78.72)
Higher reading	HA	2 (7.69)	4 (8.51)	2 (7.69)	1 (3.85)
	LA	0 (0)	0 (0)	0 (0)	0 (0)

Note: High Achievers N = 26, Low Achievers N = 47

Separate Chi-Squared Goodness of Fit tests were conducted for the number of children from each group who had the same level or were higher for spelling or reading at each time point and some intriguing results emerge (adjusted residual scores are shown in brackets). At time point one there was no relationship between the two groups and how the spelling and reading levels related. Table 4.6 shows that about 60% of each group had a higher representational level for their understanding of spelling compared to reading while about 1/3 of each group had the same level. However from time two differences between the two groups start to emerge. At time two (χ^2 = (2, N=73) = 17.39, P = .001) both groups still show more children with higher understanding of spelling but the frequencies are very different. About 50% of High Achievers show higher levels for spelling (-4.0) compared to 90% of Low Achievers (4.0). Furthermore, while about 35% of High Achievers have the same levels for spelling and reading (2.8), only 4 Low Achievers (15%) now match. Low Achievers have yet to find a child with a higher level of reading compared to four High Achievers. At time three (χ^2 = (4, N=73) = 15.07, P = .001) the relative differences remain similar to time two as High Achievers shows more of an even split between children who have the same level (3.2) and children who have a

higher level for spelling while the majority of Low Achievers have a higher level for spelling (3.8).

The final time point is the most striking though in terms of the differing patterns (χ^2 = (2, N=73) = 12.5, P = .002) as nearly 60% of High Achievers had the same levels (3.1) for spelling and reading compared to the rate of higher spellers at 38%. In contrast the majority of Low Achievers (80%) were still higher spellers (3.4), a greater number than the 60% at time one. Only one child displayed a higher level for reading at the end of the study and overall this pattern did not occur very often. In summary it would seem that while comparable in relative patterns of spelling and reading understanding at time one; as the study progressed High Achievers began to show more children at the same levels for spelling and reading, while Low Achievers remained populated by children whose understanding of spelling was higher compared to reading.

3. Performance Measures

Analyses thus far have shown that High Achievers displayed a more explicit understanding of spelling and reading at each time point compared to Low Achievers. More importantly as the study progressed High Achievers were more likely to have an understanding of spelling and reading at the same level compared to Low Achievers where the majority of children had higher understanding of spelling. The differences in the developmental relationship between the two groups merit further investigation: for example do the groups differ in terms of the performance measures? First we will examine scores obtained from the four PhAB tests (Alliteration, Alliteration with pictures, Rhyme, Non-word reading) at each time point for both groups shown in Table 4.7.

Table 4.7: Means (and standard deviations) for Alliteration (/10), Alliteration with pictures (/10), Rhyme (/21) and non-word reading (/20) for each group (HA and LA) at each time point

PhAB	HA/LA	Time One	Time Two	Time Three	Time Four
Alliteration	HA	7.76 (1.8)	8.42 (1.14)	9.23 (1.12)	9.73 (.6)
	LA	4.02 (2.71)	5.61 (2.47)	7.17 (2.76)	8.12 (2.16)
Allit	HA	8.46 (1.65)	9.11 (.91)	9.88 (.43)	9.96 (.2)
Pictures	LA	5.87 (2.93)	6.78 (2.39)	8.25 (2.25)	9.00 (1.63)
Rhyme	HA	9.92 (4.85)	11.23 (4.18)	15.11 (3.89)	17.07 (3.27)
	LA	5.63 (4.00)	6.97 (4.32)	9.51 (5.52)	11.55 (5.62)
N/W	HA	7.03 (3.91)	9.15 (2.92)	12.08 (3.37)	15.62 (2.84)
Reading	LA	2.19 (2.31)	4.40 (2.76)	7.51 (3.49)	9.12 (3.95)

The mean scores shown in Table 4.7 indicate that High Achievers were better than Low Achievers on each of the tasks from the PhAB at each of the four points and that performance on each task improved across the four time points. A Multivariate ANOVA was carried out on the data and showed there to be a significant Main Effect of Time in terms of Alliteration ($F(3, 291) = 25.13$, $P = .001$), Alliteration with pictures ($F(3, 291) = 19.12$, $P = .001$), Rhyme ($F(3, 291) = 27.53$, $P = .001$) and Non-word reading ($F(3, 291) = 74.34$, $P = .001$). There was also a significant Main Effect of Group on Alliteration ($F(1, 291) = 92.14$, $P = .001$), Alliteration with pictures ($F(1, 291) = 60.53$, $P = .001$), Rhyme ($F(1, 291) = 75.01$, $P = .001$) and Non-word reading ($F(1, 291) = 171.47$, $P = .001$). However there were no significant interactions.

Tukey Post Hoc tests were carried out upon data for time point to discover where the significance lay. For Alliteration and Alliteration with pictures, time points one, two and three all differed showing improved performance at each point. However there were no significant improvements from times three to four, this could be explained by the ceiling effects. In contrast improvement occurred at each time point for Rhyme and Non-word reading and there was still scope for further progression at the end of the study.

High Achievers consistently showed higher performance than Low Achievers for each task, although the ceiling effects at time four for both groups indicate that Low Achievers caught up. However clear differences still remain for Rhyme where High Achievers were averaging 80% correct versus Low Achievers at 55%. The difference is even more pronounced for non-word reading as Low Achievers were still struggling to read 50% of the 20 words while High Achievers were nearing an 80% success rate.

Can a similar performance pattern be uncovered for one-word spelling, recognition and reading tests at each time point?

Table 4.8: Means (and standard deviations) for spelling production, spelling recognition and reading production scores (out of 9) for each group (HA and LA) at each time point

Measures	HA/LA	Time One	Time Two	Time Three	Time Four
Spelling	HA	.96 (1.31)	2.12 (1.70)	3.81 (1.91)	4.81 (1.33)
	LA	.34 (1.01)	.50 (.89)	2.19 (1.48)	3.02 (1.42)
Reading	HA	5.03 (2.41)	7.77 (1.53)	8.42 (1.07)	8.65 (.98)
	LA	.81 (1.54)	3.14 (2.87)	6.49 (2.5)	7.64 (2.21)
Recognition	HA	4.69 (1.76)	5.65 (1.09)	6.35 (1.23)	6.39 (1.24)
	LA	3.96 (1.77)	4.29 (2.01)	5.34 (1.43)	5.64 (1.33)

The mean scores (Table 4.8) suggest that High Achievers were better than Low Achievers on each of the performance measures at each of the four time points and that each performance measure improved across the four time points. A Multivariate ANOVA was carried out upon the data and showed there to be a significant Main Effect of Time in terms of spelling ($F(3, 291) = 80.95$, $P = .003$), reading ($F(3, 291) = 83.4$, $P = .003$) and recognition ($F(3, 291) = 17.01$, $P = .003$). There was also a significant Main Effect of Group on spelling ($F(1,291) = 71.19$, $P = .003$) reading ($F(1,291) = 130.61$, $P = .003$) and recognition ($F(1,291) = 25.27$, $P = .003$). However there were no significant interactions between time point and group for spelling, reading or recognition.

Tukey Post Hoc tests were carried out upon data for time point to discover where the significance lay. Results indicated that for spelling and reading every time differed from the others so there was a consistent significant improvement in spelling and reading production at every testing point of the study. For recognition the significant differences lay between the first time point and times three and four and the second time point and times three and four. Therefore improvement did not occur after the third time point.

High Achievers consistently gained higher performance scores compared to Low Achievers at all four time points. In terms of spelling production even High Achievers only managed to reach a mean score of 4.81 out of 9 at time four indicating that accurate spelling although showing improvement over time was still difficult for these children despite the increase in understanding as shown by allocation to representational levels. In terms of spelling recognition the differences appear smaller although significant when looking the mean scores as they all seem to hover around chance level (4/5 correct). In reading production the superiority of High Achievers certainly seems more obvious at time one with a mean of around five words correct while the mean of Low Achievers has yet to reach one word read correctly and similarly at time two. However at time three and time four while High Achievers appear to have hit ceiling, Low Achievers are not far behind.

These overall findings from the PhAB, spelling, reading and recognition tasks complement the differences in representational understanding between the two groups as more explicit knowledge is leading to better performance. However it is worth noting that the reading scores were approaching ceiling by the end for both groups. This could be interpreted in two ways as correct reading could be a sign of implicit understanding or explicit understanding. From examining the standard deviations there is a certain amount of variance within each group for each measure which would be expected as while implicit and fully explicit knowledge would support good performance particularly on the recognition and reading measurements, early explicit knowledge of E1A and E1B does produce errors. In every group despite particular and obvious trends of understanding

there was some variation in allocation to the levels so some variance in performance would be expected as well. To gain a more comprehensive view of development (both in terms of performance and understanding) in High Achievers and Low Achievers see the case studies of a typical child from each group in Appendix 1.

Further analysis related to the performance measures will help to clarify the issue of how spelling and reading understanding developed in relation to one another. Table 4.9 indicates that reading production is always better than spelling independent of time point. A series of Paired Sample t-tests confirms this at times one ($t(72) = -5.72$, $P = .001$), two ($t(72) = -11.17$, $P = .001$), three ($t(72) = -17.45$, $P = .001$) and four ($t(72) = -22.24$, $P = .001$).

Table 4.9: Means and standard deviations for spelling and reading production for the entire sample (N =73) at each time point.

Time	Spelling	Reading
One	.56 (1.15)	2.32 (2.77)
Two	1.08 (1.46)	4.86 (3.29)
Three	2.77 (1.81)	7.18 (2.29)
Four	3.66 (1.62)	8.0 (1.92)

4. Results Summary

These performance measures have therefore proved useful in understanding the nature of how spelling and reading developed in relation to one another. It has already been established that High Achievers displayed more explicit understanding of spelling and reading at each time point. This has been supported by the fact that PhAB, spelling and reading production and recognition scores were also higher for High Achievers at each time point. Earlier it was discovered that by the end of the study over 50% of High Achievers were at the same level for spelling and reading compared to Low Achievers where most children were displaying higher levels for spelling compared to reading.

However in terms of performance, Table 4.9 demonstrates that at each time point reading production was always better than spelling.

Discussion

Thus far it has been established that children's reading development can be understood in a similar way to that of spelling within the implicit to explicit framework provided by the RR model (Karmiloff-Smith, 1992). It has also been shown that the vast majority of children within the sample (over 95%) showed development through at least one representational level for their understanding of spelling and their understanding of reading over the course of a year. As this is the first longitudinal study to document the development of both spelling and reading understanding using the RR model the third main issue to address was how understanding of spelling and reading compared as the children progressed. Was there an overlap in their levels of understanding throughout the year or did children show different levels for understanding of spelling and reading? If the latter was the case then in what direction was the mismatch? Frith (1985) would suggest that in the youngest children phonological knowledge is utilised in spelling before reading hence the third prediction of this study, that children would be higher in their understanding of spelling compared to reading.

The two different groups formed from Cluster Analysis allowed examination of this complex issue and produced three main findings. First it seems clear that High Achievers generally had more explicit understanding of spelling and reading compared to Low Achievers. This was apparent from the outset of the study and prevailed across all four, time points. This superiority of understanding, was supported by their significantly higher scores on the performance measures (PhAB tasks, spelling and reading production, spelling recognition). One aspect of the clustering that could be considered surprising is the presence of two not three distinct groups. Taking into consideration classic differentiation techniques within classrooms of top, middle and bottom groups one might have expected a small number of children to be have been singled out for a third or

"bottom" group. This phenomenon might be expected to emerge, as the children get older if some were to lag significantly behind their peers.

When considering the rates of development there are a number of points of interest. It might be sensible to predict that although High Achievers began the study at higher representational levels compared to Low Achievers that the rates of progress within the two groups would still be the same: the development would be uniform independent of the starting place. This proved true for spelling, as within each group there were similar rates of progress at each time point and across the whole study. However there was a higher rate of development in reading for High Achievers at time two and therefore overall. So is this result due to a few exceptional High Achievers who skewed the results? Or, is it that High Achievers generally were showing a faster rate of development in their understanding of reading that was catching up with their understanding of spelling?

To address that final point attention will now turn to the third main finding from the group analysis regarding matching and mismatching across spelling and reading levels. The High Achievers (as highlighted by case study one in Appendix 1) were beginning to show a tendency toward having the same levels of understanding for spelling and reading at the end of the study. It could indeed be suggested that for High Achievers, children's understanding of reading was catching up with their understanding of spelling certainly compared to Low Achievers. The majority of Low Achievers (80%) remained at higher levels for understanding of spelling at time four (as shown in case study two, Appendix 1). High Achievers were attaining the later levels of E1B and E2 with frequency by the end of this study suggesting that once representations have redescribed to level E1B or beyond, the knowledge is being applied with a similar level of understanding in both spelling and reading tasks. Thus supports the notion of knowledge transfer and generalisation across the spelling and reading tasks and suggests that the same knowledge is being drawn upon whether the task is primarily focussing on spelling or reading.

It is more straightforward to find an explanation for why children would be at the same levels of understanding rather than not. However the findings show a clear tendency for both groups at the start and Low Achievers throughout, to be at higher representational levels for their understanding of spelling. Does this imply that these children are better at spelling compared to reading? The performance results of spelling and reading production would refute this as reading was clearly more successful than spelling at each time point. How can this be accounted for?

First it could be argued that although the methodology tries to match spelling and reading skills across each representational level, this is not possible as, in essence, they are testing different skills and therefore cannot be said to be equivalent. This is a difficult issue to tackle as although past research does point to slightly different pathways of development (Frith, 1985, Caravolas et al. 2001), these researchers and others (e.g. Ellis, 1997, Ehri, 2000) further maintain that the two skills are mutually dependent and do interact over time. Therefore to argue that the two skills should be judged independently and that the child's spelling representational level will have no bearing upon their reading representational level is illogical. Indeed all results do indicate an affiliation so the challenge is to try and understand the nature of the relationship rather than conceptualise spelling and reading as two independent skills. Also, as discussed after the first results section in Chapter 3, when comparing spelling and reading representational levels, children's explanations, errors and performance all seem as equivalent as can be expected.

A further potentially fruitful way of interpreting this result is to return to the issue debated by Holmes & Davis (2002) and the notion that the spelling and reading knowledge of a word stems from a shared representation or from separate representations. As discussed in a review of the literature, the notion of separate representations stems from research with brain-damaged individuals that show dissociated spelling and reading abilities, e.g., Weekes & Coltheart (1996). So could it be that children with higher spelling representational levels have separate and superior representations for spelling? This account seems unlikely not least because these

neuropsychological theories would suggest superior representations for reading not spelling, furthermore, research with adults (e.g. Holmes & Davis, 2002, Burt & Tate, 2002) shows common errors across spelling and reading indicating shared knowledge. Finally, the present study showed that children gained lower spelling performance scores compared to reading. However if adopting a shared representations view then it would be sensible to predict that children would be allocated to the same representational levels for their understanding of reading and spelling. The material point from this last statement when considering this issue is that these are the *developing* representations of children and therefore to expect uniformity would be unwise.

A more plausible perspective stems from the past research of Frith (1985), endorsed by Ehri (1998, 1999, 2002) and supported by Caravolas et al. (2001) suggesting that when learning to read and spell, initially alphabetic spelling acts as a pacemaker for reading. This does not mean that spelling production is superior to reading, it simply suggests that the early phonetic knowledge that children acquire in terms of phonemic awareness (implicit and explicit), letter sounds and early blending, is more successfully applied in early spelling than it is in early reading. This can be inferred from characteristics displayed at time one when there were a high proportion of children (esp. Low Achievers) with E1A level knowledge of spelling and pre-implicit knowledge of reading. The characteristics of these children will now be examined in more depth.

To reach level E1A for spelling children have to show early phonological analysis of words when told the target word they have to find. As Caravolas et al. (2001) indicate, they can apply some basic phoneme to grapheme relations in order to choose the word they believe is the target word. As outlined earlier, the alternative spelling that children often choose at E1A is a phonologically plausible error of the target word, e.g., *filld* instead of *filled*. When asked to justify why they believe words to be correct/incorrect children at this level can make simple phonological observations, for example:
"Why is that word correct (filld)?" (experimenter)
"It has two l's in it." (child at E1A)

These explanations display early explicit knowledge that shows basic phonology and makes no mention of morphology. However this basic explanatory ability coupled with the presence of phonological recognition errors would suggest level E1A rather than the implicit level. However a very different pattern emerges when examining performance on the reading recognition task at time one.

Although these children (E1A for spelling, pre-implicit for reading) could apply a phonological theory and some basic phoneme to grapheme relations when the experimenter informs them as to the target word, in the reading recognition task they are not told the target word. The children would then have to apply either implicit knowledge or early grapheme to phoneme conversion skills in order to decipher the alternative words and to identify and successfully read the target words. This is where the contrast lies between spelling and reading understanding. According to the theory of early alphabetic spelling (as a pacemaker) children cannot apply their early phonemic knowledge to read words, only to spell them. Therefore children failed to read most of the words and were allocated to the pre-implicit level for reading. Thus the initial mismatches in understanding occurred.

This is supported by the nature of children's reading errors at the PI level. As outlined before when told a target word (in the spelling recognition task), children would often make phonological recognition errors: the phonological theory was dominating and therefore –ed was not recognised as –ed cannot be heard at the end of a word, just d, and so errors such as *filld* or *opend* were common. However whilst doing the reading recognition task, many children would not try to sound-out the words and if they did, lacked the blending skills required to form words: simply saying each sound of the word s-o-l-d does not help you to read sold, it's more effective to try s-ol-d or sol-d in order to successfully identify the word. Most children therefore commonly used the first letter of a word as a clue and simply guessed what the word said as shown earlier, e.g., *sun* or *sand* instead of *sold* (Caravolas et al. 2001).

This mismatch of phoneme to grapheme conversion skills versus grapheme to phoneme conversion skills does seem a plausible explanation for the E1A spelling and pre-implicit reading mismatches and was characteristic of many children (esp. Low Achievers) at the start of the study. At these early levels alphabetic spelling could be acting as a pace maker certainly in terms of understanding rather than performance. These differences in understanding continued for Low Achievers at each time point even though reading understanding was also developing. However the High Achievers were beginning to show a different pattern and Frith (1985) and Caravolas et al. (2001) can also account for this differing relationship. The original Frith model suggests that although phonological knowledge is first utilised in spelling acting as a pace maker for reading, reading does catch up and in turn drives the whole process. Is that what was happening with High Achievers? It cannot be said for definite for two reasons: first the study has been completed so it cannot be determined whether the children would have continued to match across understanding or whether reading would have taken over. Furthermore and perhaps more importantly, the stimuli used had been rather exhausted by many of the High Achievers as they were beginning to reach ceiling. To follow their progress further would have required a slightly harder stimuli set that explored other morphological rules. It may be that Low Achievers would also have started to show the same pattern using the existing stimuli if the study had continued for longer.

So if children are mismatching but still drawing upon knowledge from the same representations (e.g., Holmes & Davis, 2002) then what is the nature of these representations? It could be argued that although the spelling and reading knowledge of words are contained within a shared representation, they will be accessed differently according to the nature of the task and therefore will lead to greater success in some tasks compared to others. Support for this comes from the adult literature. Both Katz & Frost (2001) and Dietrich & Brady (2001) refer to the notion of unstable or impoverished representations when studying adult poor readers. They found inconsistency within and between different tasks thus pointing to incomplete representations. It is not implausible to assume that early E1 representations (that were dominant in reading and spelling at the end of the study) and developing representations in general will be rather incomplete and

often contain errors. As the representations become more complete children can progress from simple phoneme to grapheme correspondence skills to grapheme to phoneme correspondence skills and can gain more of an explicit understanding as to how they read words.

This also relates to the notion of multiple representations in the RR model whereby different representations may be accessed according to the demands of the task. It has already been documented by Critten et al. (2007) and Chapter 2 that some children are a little harder to allocate to one representational level for their understanding as they seem to show multiple levels or are in transition between two according to the word given. The RR model explains that even when representations are redescribed, previous incarnations remain intact so that implicit representations can be accessed for speed. Later explicit representations may only then be accessed if explanations are required. According to this model children are able to use their developing explicit representations to explain matters related to spelling but fall-back on implicit representations when reading as there is a paucity of information in the later representations to allow generalisation of knowledge for reading similar errors or explaining their reading process.

In conclusion the complexity of the issue relating to mismatches in understanding and the nature of shared representations must still be acknowledged. However it should be emphasised that the use of representational levels for spelling and reading within a new theoretical framework (RR) has supported findings from existing literature (Frith, 1985, Ehri, 1998, 1999, 2002, Caravolas et al, 2001) and built upon them with this new theoretical perspective and method focussing upon children's understanding within an implicit to explicit framework. Against predictions 60% of High Achievers were at the same levels of understanding for spelling and reading at the end of the study. This suggests stable and explicit representations where knowledge can be generalised for spelling and reading tasks leading to equivalent understanding. However and as predicted, 80% of Low Achievers still displayed higher representational levels for their understanding of spelling at the end of the study and (sometimes) implicit level reading. This suggests they are operating with early representations that are incomplete and

unstable. According to the task given and how that representation is accessed, different levels of understanding/communication and performance on spelling and reading tasks may be observed. Evidence is also provided for access to multiple representations as implicit representations may be used if explicit representations are incomplete. Therefore developing representations appear to resemble those of adult poor readers as described by Katz & Frost (2001) and Dietrich & Brady (2001) rather than the consistent representations of the Holmes & Davis (2002) adults.

General Discussion: Longitudinal Study

Many implications arise from these longitudinal findings. The RR model has received further validation as a tool for conceptualising underlying spelling and reading representations, as the levels have been identified in the new domain of reading in a similar manner to spelling (Critten et al. 2007). Not only does this aid our understanding of the representations children use as they spell and read it shows that development of these skills can be understood within a more generalised model of cognitive development. Furthermore the process of explicitation demonstrated by children's progress in their understanding and communicable ability provides support for the RR model as a model of development. A longitudinal study using the framework of this model to track spelling and reading has not been done before and suggests that children's implicit/explicit understanding is a valid assessment tool and could be used in conjunction with standardised measures of accuracy (e.g. Caravolas et al. 2001). By applying this theoretical basis and new method we can go beyond descriptions of what children can do and start to understand the possible mechanisms underlying development as suggested by the process of explicitation.

As the findings of Critten et al. (2007) built upon the stage model of spelling development suggested by Nunes et al. (1997) the present longitudinal study has done the same for the stages/phases and pacemaker notions of spelling and reading development originating from classic models (Frith, 1985, Ehri, 1998, 1999, 2002). Findings support joint models of spelling and reading development in order to fully understand this

interactive relationship. Furthermore the present study suggests that these joint models should incorporate an implicit to explicit continuum where orthographic information is represented from the outset (Ellis, 1997). Thompson et al. (1996) do consider implicit reading abilities but theirs is not a dual model.

Finally the present study has shed light upon the nature of developing spelling and reading representations. Despite the mismatches in spelling and reading understanding there is little evidence to suggest that representations are not shared for the reading and spelling of words (Holmes & Davis, 2002). It may be that early explicit representations (E1A) are accessed first for spelling, while implicit representations are relied upon for longer when reading, thus producing the mismatches. What is apparent is that children's representations can be incomplete and unstable as seen in adult poor readers (Katz & Frost, 2001, Dietrich & Brady, 2001). This combined with the multiple representational nature of the system as well as different characteristics of the spelling and reading tasks (however equivalent you endeavour to make them) accounts for any variability present.

Chapter Five

What is the role of contextual facilitation in accuracy and understanding in spelling and reading?

The longitudinal study (Chapters 3 and 4) demonstrated how levels derived from the Representational-Redescription model shed light upon the development of spelling and reading representations in young children. Children's real-life literacy experiences, however, are rarely context-free. Therefore, to truly understand the development of children's spelling and reading knowledge, further empirical and theoretical consideration of context is imperative. Frith, (1985) and Ehri (1998, 1999, 2002) acknowledge its role but primarily as an implicit facilitator for early reading. The recognition tasks given to children so far have tested orthographic and, to a lesser extent, phonological knowledge. While this captures fundamental spelling and reading processes it does not consider the role of semantic knowledge. The present chapter addresses how context facilitates spelling and reading accuracy and understanding, as characterized by the representational levels. Previous studies focus upon how semantic information aids accuracy (predominantly in reading) but have not tested its effect on understanding. This study will provide insight into *when* context facilitates and the nature of the relationship between orthographic and contextual information.

The influence of semantic information has typically been modelled using connectionist systems, for example the PDP word recognition model of Plaut et al (1996) and the more fully realized "triangle" model comprising phonological, orthographic and semantic information (Harm & Seidenberg, 2004). Studies comparing the reading skills of atypically developing children who have limited access to semantic information: poor comprehenders (Nation & Snowling, 1998) and children with William's Syndrome (Laing et al. 2001) to typical controls provide support for the inclusion of semantic information in models of word recognition. It was assumed that younger readers primarily use phonology as a mediator between orthographic and semantic information due to more systematic mappings between orthography and phonology. However recent work by Nation (2007) has suggested that children as young as 7 years, may be able to

activate word meanings directly from orthography without the need for phonological recoding. The relationship between orthographic and semantic information in young children certainly merits further research and that is what this study aims to achieve.

Connectionist modelling is not however without criticisms (see Chapter 1) and is only one of a range of models and theories that have acknowledged the importance of context for word recognition. This includes models of reading development, for example: the Knowledge Sources Account (Thompson et al. 1996) and the self-teaching hypothesis (Share, 1995). Both refer to the context of the printed word and the former expands the definition beyond semantic information to include syntactic qualities as well. However recent attempts to test the contextual aspect of the self-teaching hypothesis have not proved fruitful. (Nation, Angell & Castles, 2007). They explored orthographic learning of non-words within a meaningful context and without and discovered no differences in learning success or retention of information. However the authors suggest that the use of non-words may have prevented the use of context to complement decoding as they were not present in the child's vocabularies.

This "triangular" notion still remains a strong force in the reading literature as evidenced by the Lexical Quality Hypothesis (LQH) (Perfetti & Hart, 2002). However in contrast to those models mentioned above, the LQH can be more readily applied to spelling as well, providing a more coherent explanation not only for how the three components interact but how they develop in relation to each other over time. It can therefore support the notion of shared representations for reading and spelling as discussed by Holmes & Davis (2002) and throughout this thesis. This application to spelling is an advantage over the connectionist models where this has not been formally tested. Indeed thus far it has only been in the neuropsychological literature that studies exploring both reading and spelling in relation to semantic information have been conducted, e.g. Ward et al. (2000), Cortese et al. (2003)

Perfetti & Hart (2002) suggest that if one or more of the constituents of orthography, phonology and semantics (meaning and syntax) is lacking, then the quality of the

representation is reduced and errors in reading and spelling may occur. This notion of underspecified or unstable representations has been discussed before in relation to Katz & Frost (2001) and Dietrich & Brady (2001) among others and indeed my findings in the longitudinal study (Chapters 3 and 4) have supported this notion in the developing representations of children. The fundamental difference with the LQH is that semantic information has been directly integrated into these representations: not just orthographic and phonological. Indeed Perfetti & Hart suggest that semantic information can compensate for underspecified phonological and orthographic information.

This is supported by studies employing semantic priming paradigms (e.g. Farrar et al, 2001, Reimer, 2006) and from a recent reading fluency training study by Berends & Reitsma (2006). Farrer et al. (2001) demonstrated that semantic information primes phonological information, for example the word *night* will activate a semantically related word *day* which in turn will prime a phonologically related word, *dare.* Furthermore, Reimer (2006) also demonstrated that children prime orthographic as well as phonological information from semantics echoing Nation (2007). He used an orthographically incompatible priming condition, for example the word *table* will activate the semantically related word *chair*, which would be expected to prime the phonologically related word *rare* as it shares a pronunciation rime. However it does not share the same spelling body, thus creating conflict at the orthographic level and findings showed that this interfered with the priming effect. Reimar (2006) therefore suggests that semantic information can strengthen both phonological and orthographic connections in developing representations.

Berends & Reitsma (2006) trained children to repeatedly read words either focussing on orthographic properties (whether clusters such as *tr* are present in the target words) or semantic properties (whether words are semantically associated such as spoon and fork). Their findings suggest that although semantic information does prove beneficial to younger children's reading (aged 6 years) they may still require more orthographic processing before they show the larger gains made from it by older children (aged 8 years +) and adults. This again supports the notion of a relationship between orthography and

semantics in early development of reading and in contrast to Nation et al. (2007) has found a facilitative effect of semantics arguably because real words were used.

Studies that explore spelling and semantic information in children are starting to emerge reflecting the need for this research with the emphasis so long confined to reading. Lewis et al. (2000) in their longitudinal study of children with speech-sound difficulties discovered that semantic information plays a more vital role in early reading compared to early spelling. They suggest that the influence of semantic information upon spelling may become more apparent as children grow older (6 years +). This is supported by Berends & Reitsma (2006) who also suggested in reading that semantic information may play a greater role once sufficient orthographic knowledge has been established.

More direct findings of the facilitative effect of semantic information upon spelling has been provided by Hilte & Reitsma (2007) again using the LQH as their basis to conduct a training study similar in principle to Berends & Reitsma (2006). They found that both descriptive and depictive semantic tasks were equally effective in improving spelling performance however this facilitation did drop off over the following three weeks. Hilte & Reitsma suggest that semantic connections if not reinforced, particularly in such poor spellers may easily become unstable again over time reducing their positive influence.

The first aim of the present study in exploring the facilitative effect of context upon spelling and reading is to also look at semantic facilitation of reading and spelling performance following studies by Berends & Reitsma (2006) and Hilte & Reitsma (2007) but not using a semantic cueing technique. Instead a more real-life literacy situation will be established using a sentence context in order to look at contextual facilitation. This allows for a wider study of the influence of the context that will include both aspects of semantic information as described by Perfetti & Hart (2002), Share (1995) and Thompson et al. (1996): meaning and syntactic information, e.g. word order. The Lexical Quality Hypothesis suggests that semantic information can strengthen or compensate for any phonological and orthographic information that is lacking and it is predicted that

spelling and reading accuracy will be higher in the context of a sentence compared to the single word test.

Spelling has not previously been looked at in relation to context so whilst a facilitative effect akin to that in reading is predicted it is not a certainty. It is possible that an implicit cueing process from the context may aid reading a word but not be sufficient for spelling a word where precision is required to put the correct letters in the correct order. Therefore context may compensate for orthographic and phonological weaknesses for reading in incomplete representations (Dietrich & Brady, 2001, Katz & Frost, 2001) but not enough for a correct spelling. If spelling is also facilitated by context it will provide more support for the notion of shared representations (Holmes & Davis, 2002), as the same cognitive processes will be seen as occurring in spelling and reading.

A fundamental part of the present thesis is children's understanding of spelling and reading, as evidenced by the representational levels that primarily tap into orthographic knowledge and to a lesser extent phonological knowledge. The second aim of the present study is to take the LQH further and also test whether *understanding* is facilitated by the presence of context. It is predicted that children will show higher levels of explicit understanding in the context of a sentence compared to the standard 3-word recognition tests. However one cannot rule out the possibility that context only facilitates implicit knowledge, leading to an improvement in performance but not in explicit understanding. Explicit knowledge, i.e., verbal explanations is a more sophisticated type of information and if phonological and orthographic knowledge is lacking in children's explanations then context may be unable to compensate. If however it can, more support will be provided for the notion that development does follow a process of explicitation and that context can aid this process in orthographic and phonological knowledge. Furthermore it may suggest that children develop an integrated understanding of spelling and reading that draws upon semantic information

Thirdly if context helps some children but not others it will also be possible to explore why this is the case. Perfetti & Hart (2002) propose that the key to representations that

support successful reading and spelling is a continued integration between the phonological, orthographic and semantic constituents over time. They argue that low skill readers do not show a proper integration and efficient use of orthographic knowledge so accuracy in identifying word form depends heavily on just phonological knowledge while fluency depends on just phonological and semantic connections. They believe the mechanism driving this integrative process developmentally is primarily experience with words: the more skilled the reader the more information can be added to representations, e.g. spelling, pronunciation, meaning etc.

However while not denying that experience plays a vital role in reading and spelling development it is not by itself a satisfactory explanation of how representations grow in quality over time: external information has to be internalized and interpreted as shown by the new representational levels for spelling and reading. This underlines the importance of applying the RR model to the issue of semantic information and how it interacts with orthographic information. Does the process of explicitation advocated by the RR model account for how the different constituents are able to form coherent high quality representations over time? To shed light on this further exploring the process of explicitation tracked in the longitudinal study one aims to see *when* representational understanding is facilitated by context. This will aid understanding of the relationship between orthographic and semantic knowledge in young children.

A series of spelling and reading tasks were given to children aged 5-7 years in Experiment 1. To address the first aim of the study children's spelling and reading accuracy was compared using spelling and reading tests of words presented without any context or in the context of the sentence. To address the second aim of the study baseline representational levels for spelling and reading were established for each child using the standard recognition tasks (without context). Secondly spelling and reading levels were established using sentence tasks (with context) to see whether understanding was facilitated. In Experiment 2 a possible flaw in the order of task presentation was addressed and this discussion will be fully presented following analysis of Experiment 1.

Experiment 1

Method

Design

This study employed a within subjects design with two independent variables: The presentation of the words to be read or spelt (two levels: presentation alone and presentation within the context of a sentence.), the establishment of spelling and reading representational levels (two levels: within the context of the standard recognition tests and within the sentence contexts.) There were eight dependent variables:

1) Number of words correct on the single word spelling test (/15)
2) Number of words correct on the single word reading test (/15)
3) Baseline representational level of spelling understanding using standard recognition task: Pre-Implicit, Implicit, E1A, E1B, E2, E3
4) Baseline representational level of reading understanding using standard recognition task: Pre-Implicit, Implicit E1A, E1B, E2, E3
5) Number of spellings correct within the sentence context (/15)
6) Number of target words correctly read within the reading context (/15)
7) Representational level of spelling understanding within a sentence context: Pre-Implicit, Implicit, E1A, E1B, E2, E3
8) Representational level of reading understanding within the sentence context: Pre-Implicit, Implicit E1A, E1B, E2, E3

Participants

Sixty children (31 males and 29 females) took part in the study, 31 were in Year 1 and 29 in Year 2 of their schooling. There was an age range of 5 years 7 months to 7 years 6 months with a Mean age of 6 years 6 months (SD= 1.01). All children attended a state-run Mixed Infant school in Hertfordshire and were taught in accordance with the National Literacy Strategy (DfES, 2001).

Materials

The same 15 words taken from Nunes, Bindman & Bryant (1997) were used throughout the tasks and consisted of five regular past verbs, five irregular past tense verbs and five non verbs, (see Table 5.1).

Table 5.1: Words used in the single word and sentence based reading and spelling tasks.

Regular past tense verbs	Irregular past tense verbs	Non verbs
Called	Found	Cold
Filled	Heard	Ground
Opened	Sold	Gold
Laughed	Lost	Bird
Stopped	Slept	Soft

1. Standard spelling and reading recognition tasks

Spelling and reading recognition measures were obtained to establish baseline spelling and reading representational levels (derived from the RR model) for each child. Standard coding schemes for spelling (from Critten et al. 2007) and reading (from longitudinal study, Chapters 3 and 4) were used. In each of these recognition tasks the same flash cards (15 in total) were presented to the children, one at a time. Each flash card contained three alternative spellings of the target word (only one of which was correct) spread out evenly across the card, see Table 5.2. The position of the correct word was randomised on each card, as was the order in which cards were presented.

Table 5.2: Alternative word sets used in the spelling and reading recognition tasks

Word sets		
Called	Caled	Calld
Filled	Fild	Filld
Opened	Openned	Opend
Laughed	Larfed	Laughd
Stopped	Stoped	Stoppd
Found	Fownd	Fownded
Heard	Hird	Hearded
Sold	Soled	Solded
Lost	Losed	Losted
Slept	Sleped	Slepted
Cold	Coled	Colded
Ground	Grownd	Grownded
Gold	Goled	Golded
Bird	Burd	Birded
Soft	Sofed	Softed

As the same words were being used across all tasks it was necessary to introduce distracter items that were similarly presented with error alternatives. Five were developed for the spelling recognition task and five for the reading recognition. Again, they consisted of regular past tense verbs, irregular past tense verbs and nonverbs (see Table 5.3). They were excluded from later data analysis.

Table 5.3: Distracter word sets used in the spelling and reading recognition tasks

Spelling task	walked	walkked	walkd
	sent	sentd	sented
	left	leftd	lefted
	paint	paintd	paintted
	felt	feltd	felted
Reading task	covered	coverred	coverd
	kissed	kised	kissd
	drank	drankd	dranked
	belt	bellt	beltd
	next	nexed	nexted

2. Reading and spelling sentence tasks

In the spelling task children were given sentences that had a slot where the target word was to be entered, e.g., for the word filled, the sentence was presented as:
"The cup was _____ with milk"
There were 15 sentences used, one for each of the words used in the single word tests and they were presented in a randomised order. See Table 5.4 for the sentences used:

Table 5.4: Sentences used in the reading and spelling context tasks (target words in italics)

Sentences
The boy *called* to his dog
The cup was *filled* with milk
I *opened* the door
She *laughed* at the joke
He *stopped* the car
The girl *found* her keys
I *heard* some music
The house was *sold*
He got *lost* on the way home
She *slept* in a bed
The ice was *cold*
He fell onto the *ground*
The ring was made of *gold*
A *bird* was in the garden
The rug was *soft*

In the reading sentence task the layout of the sentences was slightly different. The target word was presented with the same two error alternatives as shown in the standard reading recognition test. For example for the word filled:
"The cup was **filled / filed / filld** with milk"

As before, distracter sentences were developed for both the spelling and reading context tasks: five for each task (see Table 5.5).

Table 5.5: Distracter sentences used in the spelling and reading context tasks (target words in italics).

Spelling context	The hat *covered* her head.
	The man *kissed* the woman.
	I *drank* some milk.
	He wore a *belt* with his trousers
	They went shopping the *next* day.
Reading context	She *walked* down the road.
	I *sent* the letter.
	I *left* school early.
	She bought some new *paint* for the room.
	The cooker *felt* hot

Procedure

Standard Tasks (no context)

1. Single word spelling test

The 15 words of the spelling test were presented to the children in their classes as a whole. The class teachers remained in the room whilst the experimenter conducted the test. Recording sheets numbered 1-15 were given to the children that had a line by each number (for the spelling to be written on) to reduce any confusion. They were informed there would be 15 spellings but were told not to worry if they did not know an answer as a guess would be fine. Each word was repeated two or three times as necessary.

The other tasks were conducted with the children one-to-one outside the classroom. There were a few days between the presentations of each of the standard tasks to prevent inter-task influences.

2. Single word reading test

Children were presented with 15 flash cards one at a time. Each card had one word on it and the children were simply asked to try and read the word

3. Standard spelling recognition task

Procedure was as before (Critten et al. 2007, Chapters 2, 3 and 4). Children were given 20 sets (presented on flash cards, including five distracters) of 3 alternative spellings of a target word only one of which was correct. They were told the target word and asked to identify the alternative they believed to be correct and then to explain their choice. Each of the other alternatives was pointed to in turn by the experimenter and the children were asked to explain why they believed them to be wrong. Performance and the verbal explanations were used to allocate the children to a baseline representational level for spelling understanding. Coding scheme was as used by Critten et al, (2007) and in Chapters 2, 3 and 4.

4. Standard reading recognition task

Procedure was as used in the longitudinal study detailed in Chapters 3 and 4. Children were given the same flash cards (but with five different distracters) containing the alternative spellings as used in the spelling recognition task. This time however children were not informed of the target word. Instead children were told that out of the three words only one was a real word, the other two words were pretend or nonsense words. The children were asked to identify the word they believed to be real and then asked to read it and explain how they read it. The experimenter then pointed to the other two alternatives in turn and asked the children to try and read each of them and justify how they read each word. Performance and verbal explanations were used to allocate children to a baseline representational level for reading understanding. Coding scheme was as used in Chapter 3 and 4.

Sentence tasks (with context)

The sentence tasks were presented two weeks after the last standard task and again each sentence task was separated by a few days.

1. Spelling sentence context task

Children were presented with a sheet containing the list of sentences (including five distracters). Each sentence had a slot for the target word to be inserted. The children were encouraged to try and read the words that were there and to insert the word "space" where the slot was, for example:

"The cup was (space) with milk"

The experimenter helped the child if they had any problems identifying the words. The child was then told the target word and asked to write the word in the appropriate slot on the sheet using a pencil. After each spelling was completed the sentence was re-read and a series of questions were put to the child to establish their understanding:

"How did you spell that word?"

"What sounds can you hear in the word?"

"How can you split the word up into different parts to make spelling it easier?"

Also if the word contained the morpheme –ed (whether it was supposed to be there or not!) the children were asked:

"Why do we use –ed at the end of a word, what does it mean?

Performance and verbal explanations were then used to allocate children for a second time to a representational level of spelling understanding, see adapted spelling coding scheme in the Results.

2. Reading sentence context task

Children were presented with a sheet containing the list of sentences (with five different distracters). In each sentence the target word was presented with two error alternatives. The children were encouraged to read the rest of the sentence as before:

"The cup was (space) with milk"

The child was then encouraged to re-read the sentence and choose the alternative of the target word they believed to be correct. In the course of reading the sentence the experimenter would help the child with any problem words except the target word, the children had to try and work this out by themselves. When the child had identified the target word the procedure was exactly the same as used in the standard reading recognition task. The children were asked to read each alternative and explain how they read them. Performance and verbal explanations were used to establish a second reading representational level. Coding scheme was as used in the reading recognition task and from Chapter Three.

Results

Three main issues will be considered in this results section. First whether performance in spelling, reading and reading recognition was more accurate in the context of a sentence compared to no context. Secondly whether children's understanding of spelling and reading was more explicit in the context of sentence. Thirdly, how children who showed more explicit knowledge in the context of a sentence differed from those that displayed the same level of understanding in the presence and absence of context. Why do some children respond to the presence of the context and some do not?

1.Performance

Spelling performance was examined for the same 15 words in the single word spelling test and the spelling sentence context task. A Paired Samples t-test found that the children displayed greater accuracy within the context of the sentence (MEAN=4.92, SD=4.1) compared to the absence of context (MEAN=3.57, SD=3.59), t (59) = -6.89, P = .01). Although the scores do seem quite low there was a full range of ability from 0-15 words correct; most children seemed to benefit from the presence of the sentence.

Reading performance was similarly explored with the same 15 words in a single word reading task and then in the reading sentence context task. In the latter task children were initially judged to see if they could identify the word that should be in the sentence

regardless of whether they picked the correct alternative spelling of that word. A Paired Samples t-test found that children were able to read more words correctly within the context of the sentence (MEAN=13, SD=3.23) compared to the absence of context (MEAN=8.77, SD=5.24), t (59) = -8.73, P = .01. Again the sentence context helped the children and notably there was a more pronounced difference than with the spelling performance. It is also worth acknowledging that reading performance overall was better compared to spelling and this was true without context: reading MEAN= 8.77 (SD=5.24) versus spelling MEAN=3.56 (SD=3.59), t(59)= -10.7, P = .01) and with, reading MEAN= 13.0 (SD=3.23) versus spelling MEAN=4.92 (SD=4.91), t(59)= -16.53, P = .01).

The final performance measure was also derived from the reading tasks. The standard reading recognition task (without context) and the reading sentence context task have two different measures attached to them. Firstly whether children could identify the word and secondly whether they chose the correct alternative as the spelling of that word. The reading measures above are simply concerned with identifying the word; this measure is whether having identified the word, children made the correct recognition choice, for e.g. looking at:
"The house was sold/soled/solded" a child may correctly say that the word is sold but may incorrectly identify solded as the spelling of the word. A Paired Samples t-test found that correct reading recognition occurred more often within the context of a sentence (MEAN= 9.28, SD=3.39) compared to the standard reading recognition task (MEAN=7.17, SD=4.51), t (59) = -5.27, P = .00.

2. Understanding

In terms of performance, the presence of context does seem to improve children's spelling and reading production abilities. The next section will explore understanding and whether the sentence context will increase the level of explicit knowledge children can communicate through their verbal explanations.

2.1 Spelling

Coding children's understanding of spelling

Spelling understanding was established for children in the absence of context using the standard spelling recognition task and coding scheme originating from Critten et al. and also employed in Chapters 2-4. Establishing spelling understanding within the sentence context employed a slightly different coding scheme as it stemmed from the spellings the children produced and how they could explain their spelling process. Again spelling representational levels of PI, Implicit, E1A, E1B, E2 and E3 are used and are equivalent in knowledge and performance to those produced from the spelling recognition task, see Table 5.6.

Table 5.6: Coding scheme for representational levels derived from the spelling sentence context task.

Rep Level	Typical Spelling	Typical verbal explanations
Pre-Implicit	Very basic bearing little resemblance to the actual word and cannot be called phonologically plausible, e.g fd for filled, sd for sold	No attempt to explain beyond repetition of the sounds used often identifying incorrect sounds in the process
Implicit	Spelling produced is correct	Inability to verbalise the process beyond repeating in parrot fashion the sounds used, for example "I spelled it s-o-l-d"
E1A	Spelling is a phonologically plausible error version of the word, for e.g. fild for filled, solld for sold, calld for called. The –ed rule is not used	Attempt to demonstrate how to break a word into smaller components and identification of phonemic blends, for example: 'The word calld has all in it." "In the word filled f and i make fi." The –ed rule is never referred to.
E1B	Phonological errors will still	Same as E1A but the –ed rule will also

	be made but the –ed rule is also being made use of, sometimes correctly in this error version of opened: opened but sometimes incorrectly when applied to irregular verbs and nonverbs e.g. solded for sold	be referenced to again not always correctly, for e.g. 'All words that have a "d" sound at the end must have –ed.
E2/E3	Correct word is produced	Ability to break words down into components parts and include –ed in the explanation when appropriate. "The word sold can be broken into the sound s followed by old". The word call is c-a-l-l and to make it into called add –ed." To reach E3 child has to be able to explain why we use –ed on some words; "It is something that has already happened" or "It is in the past tense".

As Table 5.6 shows each of these representational levels map directly onto those derived from the standard spelling recognition task as Pre-Implicit shows an almost complete lack of ability, the Implicit level displays accurate performance but an inability to consciously access knowledge and explain the spelling process by breaking words into component parts. E1A and E1B demonstrate the adoption of dominant phonological and morphological theories allowing verbalisation of knowledge but leading to spelling errors as the theories are over applied. The latter explicit levels show improving performance again, the ability to apply phonology and morphology appropriately and to communicate the spelling process by breaking words into component parts.

Children's representational levels of spelling in the presence and absence of context were compared as shown in Table 5.7 and a Chi-Squared Goodness of Fit test proved to be significant: χ^2 (9, N=60) = 62.74, P = .02 (adjusted residual values shown in brackets).

Table 5.7: Number (%) of children allocated to spelling representational levels in the standard spelling recognition task and the spelling sentence context task

Spelling Recognition Task	Spelling sentence context task			
	Pre-Implicit	E1A	E1B	E2
Pre-Implicit	4 (6.67)	0 (0)	0 (0)	0 (0)
E1A	6 (10)	22 (36.67)	4 (6.67)	0 (0)
E1B	0 (0)	1 (1.67)	7 (11.67)	14 (23.34)
E2	0 (0)	0 (0)	0 (0)	2 (3.3)

As Table 5.7 indicates no child was found to have a predominant level of spelling understanding deemed Implicit or E3 in either of the spelling tasks. The majority of children were displaying E1A understanding (4.9) adopting a phonological theory although there was also the presence of E1B (1.7) and E2 (2.4) understanding showing some children were quite advanced in their ability to explain their spelling processes. So did some children show greater explicit spelling understanding in the sentence context? This can be more easily established when viewing Figure 5.1.

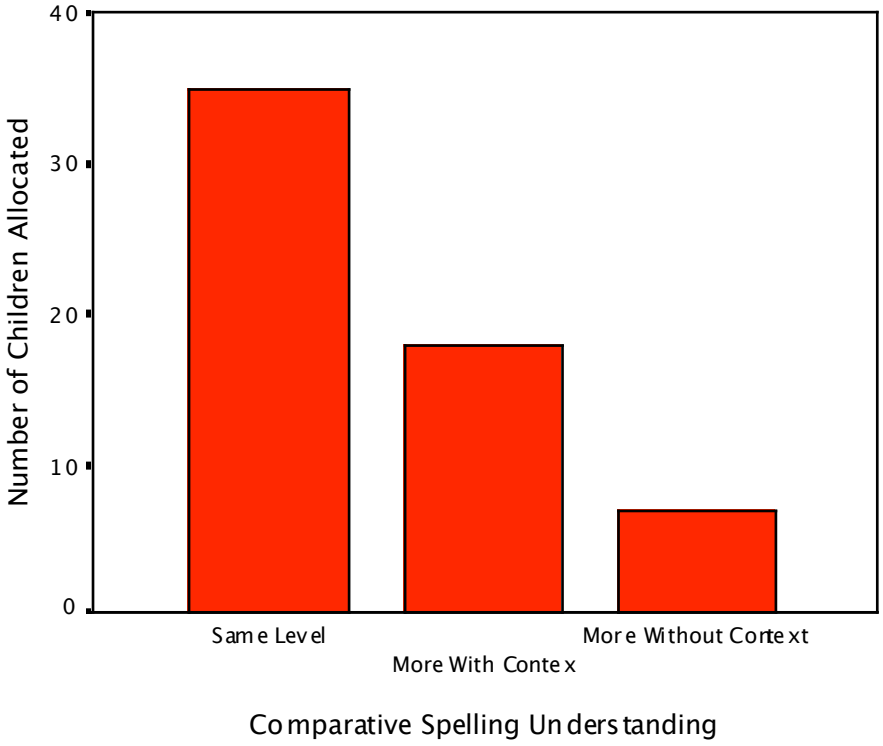

Figure 5.1: Comparison of representational spelling understanding: same level in both tasks, more explicit understanding with context, more explicit understanding without context.

Figure 5.1 demonstrates (χ^2 (2, N=60) = 19.9, P = .03) that most children in the sample (58%) displayed the same level (15.0) for their representational understanding of spelling in the presence and absence of context. However 18 (30%) children displayed more explicit understanding (-2.0) in the presence of a context. As Table 5.7 indicates most children's improvement was by one representational level and occurred at two main points of the continuum. Four children improved from E1A to E1B but a much more noticeable 14 children improved from E1B to E2. Interestingly and more unexpectedly a small minority of children (11%) showed a more explicit level of understanding without context achieving E1A in the standard spelling recognition task but only showing pre-implicit understanding on the sentence context task. Context therefore has facilitated understanding but only in the predicted direction for 1/3 of the sample.

2.2 Reading

The comparison of understanding of reading: will the use of context result in more children displaying more explicit knowledge of reading compared to spelling?

Coding children's understanding of reading

The coding scheme for the reading sentence context task replicates the standard reading recognition task established in the longitudinal study (see Chapter 3) as the same three alternative spellings of word were used in each case. The only difference was that in the recognition task they were presented alone on a flash card whereas in the context task they were presented within a sentence. The same levels of Pre-Implicit, Implicit, E1A, E1B, E2, E3 were used.

Children's representational levels of reading in the presence and absence of context were compared as shown in Table 5.8 and a Chi-Squared Goodness of Fit test proved to be significant: χ^2 (16, N=60) = 59.16, P = .02 (adjusted residual values shown in brackets).

Table 5.8: Number (%) of children allocated to reading representational levels in the standard reading recognition task and the reading sentence context task

Reading Recognition Task	Reading sentence context task				
	Pre-Imp	Implicit	E1A	E1B	E2
Pre-Implicit	3 (5)	12 (20)	6 (10)	1 (1.67)	0 (0)
Implicit	0 (0)	2 (3.33)	3 (5)	2 (3.33)	0 (0)
E1A	0 (0)	0 (0)	9 (15)	8 (13.33)	1 (1.67)
E1B	0 (0)	0 (0)	0 (0)	6 (10)	6 (10)
E2	0 (0)	0 (0)	0 (0)	0 (0)	1 (1.67)

Table 5.8 shows that none of the children displayed predominant E3 level understanding. However there is a greater distribution across the other levels with children showing Implicit, E1A (2.2) and E1B (1.9) the most often. Moreover the more extreme ends of the continuum are also represented with allocations to pre-implicit (2.3) and E2 (2.6) levels of understanding. This presents quite a different pattern compared to spelling with greater variability of reading understanding within the sample. The exact comparison of reading understanding across the reading tasks as shown in Figure 5.2 also demonstrates a contrasting relationship (χ^2 (1, N=60) = 5.4, P = .02) as 65% of the sample showed an improvement in their understanding of reading with context (9.0) compared to 35% that showed no change in their understanding.. Again Table 5.8 shows that this improvement can be seen in all aspects of the continuum and the improvement seems only to be by one level. Similarly those children that show no improvement can also be found at all representational levels. Therefore in the reading task 2/3 of the sample made the predicted improvement with context suggesting that it facilitated understanding of the reading process more emphatically than the spelling process.

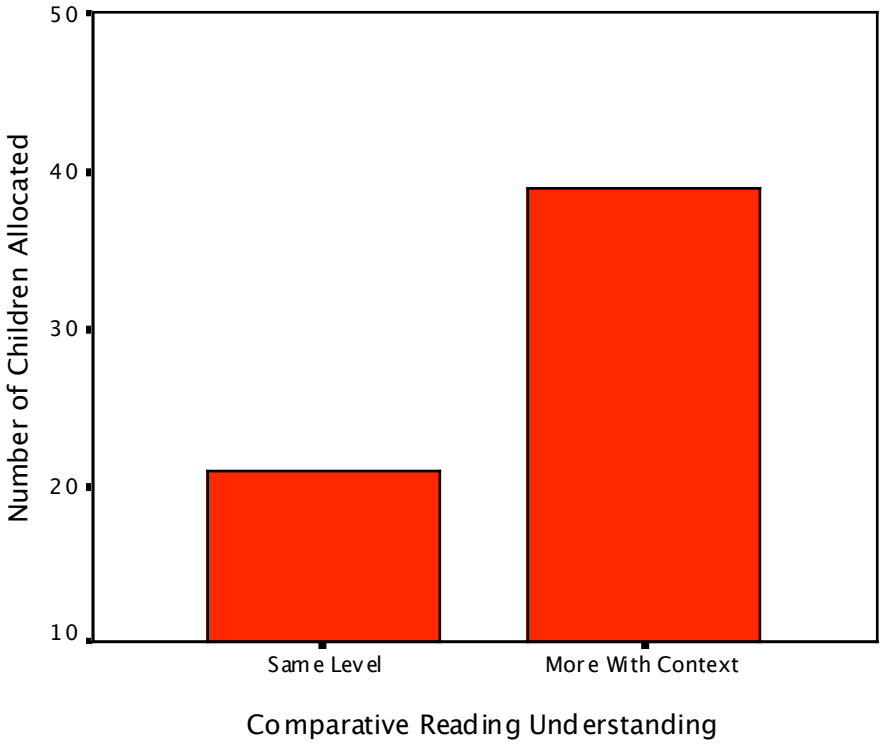

Figure 5.2: Comparison of representational reading understanding: same level in both tasks, more explicit understanding with context, more explicit understanding without context.

3. Why do some children show improvements in understanding with context and others not?

Results thus far have shown that 1/3 of the sample showed greater understanding of spelling with context compared to without and that 2/3 of the sample showed greater understanding of reading with context compared to without. Did the same children that improved for spelling also improve for reading? Figure 5.3 shows the number of children that improved in both understanding of reading and spelling with context, those that just improved for spelling, those that just improved for reading, those that showed no change in the presence or absence of context and those categorise as Other as they showed less understanding of spelling with context.

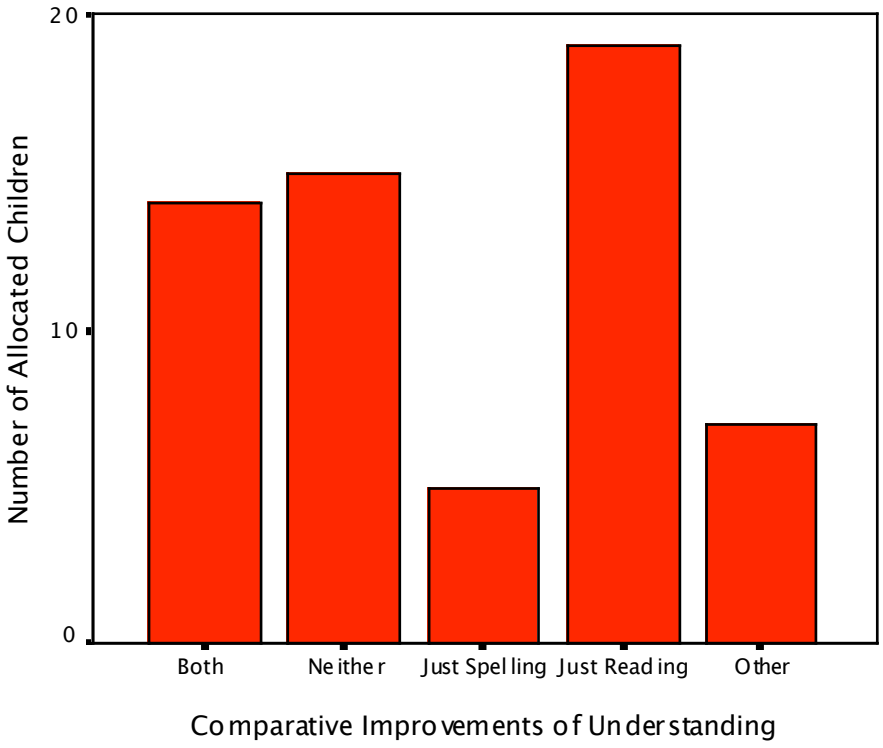

Figure 5.3: Comparative improvement in spelling and reading understanding in the presence and absence of context: improvement in both, improvement in neither, improvements in just spelling or just reading and other

Figure 5.3 shows that (χ^2 (4, N=60) = 12.33, P = .02) about 20% of the sample (N=13) made improvements in both spelling and reading understanding in the presence of context compared to the absence. Similarly 25% of the sample made no improvement in spelling and reading understanding in the presence of context. The remaining 50% of the sample show a more complex pattern as five children only showed improvement in the understanding of spelling in the presence of context but saw no change in their reading understanding whereas a predominant number of children: 20/60 which is 1/3 of the sample only showed improvement in understanding of reading. The remaining seven children were worse in their understanding of spelling with context.

Why do some children show improvement with context while others show no change? One possible explanation is that the children who showed no improvement in their understanding of either spelling or reading in the presence of context similarly made no improvement in their spelling and reading accuracy. Table 5.9 shows whether the spelling performance of children who improved in their understanding of spelling and reading, just spelling, just reading or improved for neither was facilitated by the context of a sentence.

Table 5.9: Spelling performance with context compared to without (same or better) according to whether children improved in both spelling and reading, showed no improvement, improved just in spelling or reading or were classed as other (%).

Spelling	Comparative Improvements in Understanding				
Performance	Both	Neither	Just Spelling	Just reading	Other
Same	4 (6.67)	4 (6.67)	1 (1.67)	9 (15)	3 (5)
Better	9 (15)	11 (18.33)	4 (6.67)	11 (18.33)	4 (6.67)

Table 5.9 indicates that out of the 15 children who showed no improvement in their understanding of spelling and reading in the sentence context, 11 children showed improved *performance* in spelling in the sentence context. So even though their level of understanding may not have changed their performance was still facilitated by the context. Only 4 children showed no facilitation of context either in performance or understanding. The complexity of this picture can be seen elsewhere in Table 5.9, some children who improved in their understanding of spelling and reading made no gain in their spelling performance. Also 11 children who made no change in their understanding of spelling (but gained in reading understanding) performed better in the sentence context. As expected nearly all the children who improved for their understanding of spelling also improved in spelling accuracy. Overall independent of understanding the majority of children (39/60) improved in spelling production within the sentence context.

Table 5.10 represents the same examination of understanding and performance but this time concerns reading accuracy.

Table 5.10: Reading performance with context compared to without (same or better) according to whether children improved in both spelling and reading, showed no improvement, improved just in spelling or reading or were classed as other (%).

Reading	Comparative Improvements in Understanding				
Performance	Both	Neither	Just Spelling	Just reading	Other
Same	5 (8.33)	6 (10)	4 (6.67)	0 (0)	0 (0)
Better	8 (13.33)	9 (15)	1 (1.67)	20 (33.33)	7 (11.67)

From examining the children's performance in reading Table 5.10 shows that the majority of children who showed no improvement in understanding still benefited from the presence of context for reading performance with the exception of 6 children. The similar patterns of complexity as shown in Table 5.9 are repeated here as there are children who improved in both spelling and reading understanding or just spelling understanding who did not improve in reading performance. However it is important to point out that many of these children were at ceiling for reading performance and therefore could improve no further. All the children who improved in their understanding of reading also improved in their reading performance in the presence of context and overall 75% of the sample (45/60) benefited from the context for their reading production.

It cannot be said therefore that children who did not become more explicit in their understanding were not facilitated by context at all as some still improved in their performance. Thus explaining when context was facilitative and when it was not requires further exploration.

This issue is addressed next by looking at the stability of spelling and reading representational levels derived from the standard spelling and reading recognition tests that have no semantic input. This takes account of how often the children displayed their predominant level of understanding across the alternative word sets. So, for example, when a child was classed as E1A did he show this level of representation for 14 or 15 of

word sets thus displaying near 100% consistency? Alternatively did he displayed E1A for eight out of the 15 sets but E1B for the remaining seven thus showing consistency just over 50% of the time? Of interest is whether there is a difference in consistency in the underlying level of representation between children that showed improvement in understanding and those that did not.

Table 5.11: Mean % consistency of the predominant level of spelling representational understanding derived from the spelling recognition test: children that improved in both spelling and reading, showed no improvement, improved just in spelling or reading or were classed as other.

Comparative Improvement	Mean % Consistency	SD
Both spelling and reading	71.29	16.64
Neither	75.11	19.43
Just Spelling	58.67	9.89
Just Reading	68.67	16.48
Other	66.67	20.36

Table 5.11 indicates that children that only improved in their understanding of spelling with context showed less consistency in their representational level on the standard spelling recognition displaying their predominant level just under 60% of the time. However children that showed no facilitative effect of context seem to show more consistency in their spelling understanding displaying their predominant level 75% of the time. Similarly children that improved in both spelling and reading and just reading, also display fairly consistent understanding of around 70%. However a One-Way ANOVA failed to prove significant: $F(4, 55) = .96$, $P = .44$.

Results suggest a trend for children who improved in their understanding of spelling (with context) to show less consistency in their predominant representational level in the spelling recognition test (without context).

Next consideration is given to reading and the question of whether children that improved in their understanding of reading (with context) show less consistency in their predominant level of reading understanding in the reading recognition test (without context).

Table 5.12: Mean % consistency of the predominant level of reading representational understanding derived from the reading recognition test: children that improved in both spelling and reading, showed no improvement, improved just in spelling or reading or were classed as other.

Comparative Improvement	Mean % Consistency	SD
Both spelling and reading	60.0	11.86
Neither	73.78	17.16
Just Spelling	69.34	12.11
Just Reading	55.0	10.35
Other	57.15	22.06

Table 5.12 shows that children that showed improvement in reading understanding (with context) only showed their predominant reading level on the recognition test 55% of the time. This is much less consistent than children that made no improvement in understanding for reading or spelling who showed their reading level of understanding in the reading recognition task nearly 75% of the time. A One-Way ANOVA ($F(4, 55) = 4.29$, $P = .004$) and accompanying Scheffe Post Hoc test supported this. Children that improved in both spelling and reading understanding also showed less consistency with a Mean of 60% compared with those who made no improvement. This suggests that stability of representations can account for some of the differences between children whose understanding is facilitated by context and those who are not.

Summary

Results showed that spelling, reading and reading recognition performance improved in the context of a sentence. In terms of understanding (as shown by their verbal

explanations) 1/3 of the sample improved in understanding of spelling and 2/3 of the sample improved in understanding of reading in the context of a sentence. A comparison of spelling and reading with and without context revealed that 25% improved in both spelling and reading with context, just over 30% improved just for reading with context, nearly 10% improved just for spelling with context and 25% showed no improvement in either with context. However some children who showed no facilitative effect of context in their understanding did show improvements in their spelling and reading performance. Children who improved just for spelling showed a tendency to have less consistent spelling understanding in the spelling recognition task without context. Children who improved for both spelling and reading and just for reading showed less consistent reading understanding in the reading recognition task without context.

Discussion

The present study had three main aims. First following studies using semantic cueing techniques (Berends & Reitsma, 2006, Hilte & Reitsma, 2007) whether spelling and reading performance is facilitated in a sentence context. Secondly to build on studies looking at performance to see whether *understanding* of spelling and reading is also facilitated by context. If so, the third aim addresses the issue of when context is most facilitative shedding further light on the process of explicitation in children's representations.

The results in respect of the first aim demonstrate that children showed greater accuracy in reading, spelling and reading recognition when the word was presented in context. It was expected that context would facilitate word recognition due to the predictions of connectionist models (Plaut et al. 1996 and Harm & Seidenberg, 2004) and provides support for the wealth of studies already conducted on this topic (e.g., Nation & Snowling, 1998, Laing et al. 2001, Farrer et al. 2001, Reimer, 2006, Berends & Reitsma, 2006). However only the recent work of Hilte & Reitsma (2007) has explored semantic facilitation of spelling. If there are shared representations for the spelling and reading knowledge of words (e.g. Holmes & Davis, 2002); a notion supported by the Lexical

Quality Hypothesis, then it would be predicted that the presence of context would also facilitate correct spelling. The fact that spelling improved as well is a notable finding for this study as it was conducted with a real-life literacy situation of a sentence context and employed typically developing children. This shows that context has an important role to play in strengthening/cueing orthographic and phonological information supporting the Lexical Quality Hypothesis even if there are no severe deficiencies.

It appears that spelling may be improving due to a similar implicit cueing process reported in reading by Ehri's model among others. However although context improves children's spelling accuracy it should be acknowledged that overall spelling performance was quite poor and the average improvement of one or two words with context was less dramatic than the reading gains. There are various explanations for this that will be explored later in the Discussion. The hypotheses regarding improved performance within the sentence context can therefore be accepted for spelling as well as reading

The second aim was to investigate whether context also facilitates children's ability to explain their reading and spelling. This is the first study to investigate understanding of spelling and reading in relation to context. Of the 60 children sampled about 1/3 showed increased understanding of spelling and 2/3 showed increased understanding of reading with context. Generally the improvement was by one representational level and the pattern of the results indicated that this improvement occurred at all points on the continuum. Therefore context may not only influence performance, it can also aid children's ability to verbally explain their knowledge and identify the component parts that form words. Existing models concerning semantic information and literacy, e.g. Perfetti & Hart, Seidenberg & Harm suggest a facilitative effect of context upon accuracy. By applying the RR model it is now possible to also look at the facilitative effect upon levels of explicit understanding

Not all children showed improvement within the context situation. If they had it could simply be argued that the sentence context task does not facilitate children's understanding rather it just shows a true picture of knowledge underestimated in the

standard recognition tasks. However if this was the case then all children may be expected to show the same improvement. This point leads directly to the third aim of the study: when is context most influential?

Some children showed improvement in their understanding (just spelling, just reading or both spelling and reading) within the presence of context and some showed no change at all. Although some children made no improvements in spelling and reading *understanding* this does not rule out any facilitative effect of context since most improved in spelling and reading *performance* within context. This lends further support to the notion of two influences of contextual information, implicit for performance and explicit for understanding.

The stability of the underlying representations could provide insight into *when* children are more susceptible to the influence of context in terms of understanding. If a child's spelling and reading knowledge is in transition between two or more levels (indicated by multiple levels of understanding in their verbal explanations) they are showing less consistency in their predominant level of understanding. This transitional state indicates readiness to progress to the next level of explicitness. The contextual information provided by the sentence could facilitate that improvement. Conversely when a child is firmly in one predominant level of representational understanding, the impact of context may be less likely to facilitate change: certainly in explicit understanding if not performance. Findings supported this theory but again the effect is greater for reading (although the same tendency was shown for spelling). Children who showed no improvement in their understanding were more consistent in their predominant reading level compared to children who did improve in their understanding for reading and spelling or just for reading.

This notable finding suggests that contextual information facilitates literacy more powerfully when knowledge is in transition. Existing models e.g., Perfetti & Hart, (2002) Seidenberg & Harm, (2004) and Plaut et al. (1996) describe interacting links between phonological, orthographic and semantic information and perhaps these links become

more pronounced if that knowledge is already in transition. The next question is how does the knowledge become transitional for the links to be strengthened? Perfetti & Hart have tried to account for this in their LQH by explaining that the three constituents integrate over time forming higher quality representations due to continued experience with written words. They add that semantic information plays its largest role when phonological and orthographic information is insufficient. This makes the semantic facilitation of accuracy quite simple to understand from this point of view: the implicit cueing process shown in the present study and many others described.

What Perfetti & Hart would find more difficult to explain is *when* context facilitates understanding as experience, although important for accounting for developmental change, is not entirely satisfactory. As Karmiloff-Smith (1992) argues, external information has to be internalised and interpreted before fully explicit knowledge is reached. The process of explicitation that occurs when knowledge is in transition, i.e., redescription may account for when context was most facilitative for children's understanding. Is it also possible that the RR process of explicitation may account for the long-term integration of phonological, orthographic and semantic constituents? It is beyond the scope of this study to say but we have seen that context can facilitate orthographic (and phonological) information for reading and spelling implicitly in terms of accuracy and explicitly in terms of understanding. However for the improvement to be permanent the exposure to context would have to be sustained as shown in the Hilte & Reitsma (2007) spelling training study.

One remaining question is why the facilitative effect of context for both accuracy and understanding was more pronounced for reading if we have shared representations as the LQH and Holmes & Davis (2002) suggest. There is no easy answer to this but several possibilities. Lewis et al. (2000) suggested that semantic information may play a more important role in slightly later spelling development and Berends & Reitsma (2006) found in reading-delayed children that semantic information was more beneficial when orthographic knowledge had already started to build up. Whether it is also true of spelling has not hitherto been empirically tested. If children have very incomplete

phonological and orthographic knowledge then contextual information may only have a limited impact upon performance and understanding in spelling. However as representations become more complete and spelling performance improves this gives more scope for contextual information to facilitate spelling understanding. Improvements in spelling performance would be the driving force for the extent of the contextual influence.

The reading sentence task showed why context may facilitate reading understanding more easily in these young children. The child's recognition of a word is helped by the contextual information provided by the sentence: the implicit influence or "guessing". Then when they are asked to explain how they read that word/ how that word can be broken up, the word is plainly there in front of them to be broken up. If a child's knowledge is in transition the context may provide the support required to start to analyse that word in terms of its component parts: the explicit influence. Contrast this to the spelling sentence task where the child has only their own spelling to refer back to: if it is very poor then the contextual information will be unable to make any difference to that child's understanding.

Need for a follow-up study

As encouraging as these results are there is a minor methodological limitation within the design of the present study that needs to be addressed in a second experiment if the results are to be validated. All children were given the tasks in the same order: first the standard spelling and reading recognition tasks were given followed two weeks later by the spelling and reading sentence context tasks. Despite the inclusion of distracter items and the length of time between tasks one cannot rule out the possibility that some children's improvements were due to order effects. In retrospect this should have been controlled for but there was concern that if children were exposed to the context first that semantic information would prime knowledge. Thus understanding may have already been made more explicit when the standard recognition tasks were given. Experiment 2 will test this possibility to see whether it is context improving understanding or just familiarity with the words from prior tasks.

Experiment 2

To address whether order effects were present in Experiment 1, a second study was carried out using an equivalent sample of children employing the same materials and tasks. The only difference was that this time all children were presented with the context tasks first (within a week of each other) and then after a period of two weeks with the standard recognition tasks. It can now be seen whether the same trends are observed as in Experiment 1: do some children improve in their understanding of reading/spelling or both within the context of a sentence compared to the absence of context? If children are found to improve in their understanding in the standard recognition tasks it can be assumed that it is not the semantic information or lack of affecting levels of understanding but a familiarity effect with the words that is increasing the explicitness of knowledge.

Method

Participants

An equivalent sample taken from a different school to Experiment 1 was used employing eighteen children (11 males, 7 females) from Year 1 (N=11) and Year 2 (N=9) of schooling. There was an age range of 5 years 8 months to 7 years 7 months (MEAN=6.8, SD=1.1). All children were drawn from a state-run Mixed Infant school in Hertfordshire and were taught in accordance with the National Literacy Strategy (DfES, 2001).

Design, Materials, Procedure

All as Experiment 1 except the task order has been reversed: spelling and reading context sentence tasks first and then the standard spelling and reading recognition tasks.

Results

The Results from Experiment 2 are to test for order effects and therefore will only compare children's accuracy and understanding in the presence and absence of context.

1. Performance

Exploration of the performance measures mimics that of first experiment as spelling in the context of a sentence (MEAN=7.05, SD=3.04) was better than without context (MEAN=5.39, SD=2.4): t(17) = -4.21, P = .001, reading in the context of a sentence (MEAN= 14.5, SD= 1.04) was better than without context (MEAN=12.95, SD=2.49): t (17) = -3.76, P =.002 and reading recognition was better in the context of a sentence (MEAN=11.28, SD=2.05) than without (MEAN=10.22, SD=2.37): t (17) =-2.59, P =.02.

2. Understanding

Children's understanding of spelling and reading will now be explored to see whether similar improvements in the sentence context can be found in this follow-up study.

As before children's spelling representational levels of understanding were compared with and without context and are shown in Table 5.13. A Chi-Squared test was non significant due to the small sample size for the number of categories. From Figure 5.4 it can be seen that again a majority of the sample (N=10) remained at the same representational level for their spelling understanding. However there were six children, about 1/3 of the sample that did benefit in their understanding from the presence of semantic information. Interestingly there were also two children who as before showed poorer understanding with the context.

Table 5.13: Number (%) of children allocated to spelling representational levels in the standard spelling recognition task and the spelling sentence context task

Spelling Recognition Task	Spelling sentence context task			
	Pre-Implicit	E1A	E1B	E2
Implicit	0 (0)	2 (11.11)	0 (0)	0 (0)
E1A	1 (5.56)	7 (38.89)	3 (16.67)	1 (5.56)
E1B	0 (0)	1 (5.56)	1 (5.56)	0 (0)
E2	0 (0)	0 (0)	0 (0)	2 (11.11)

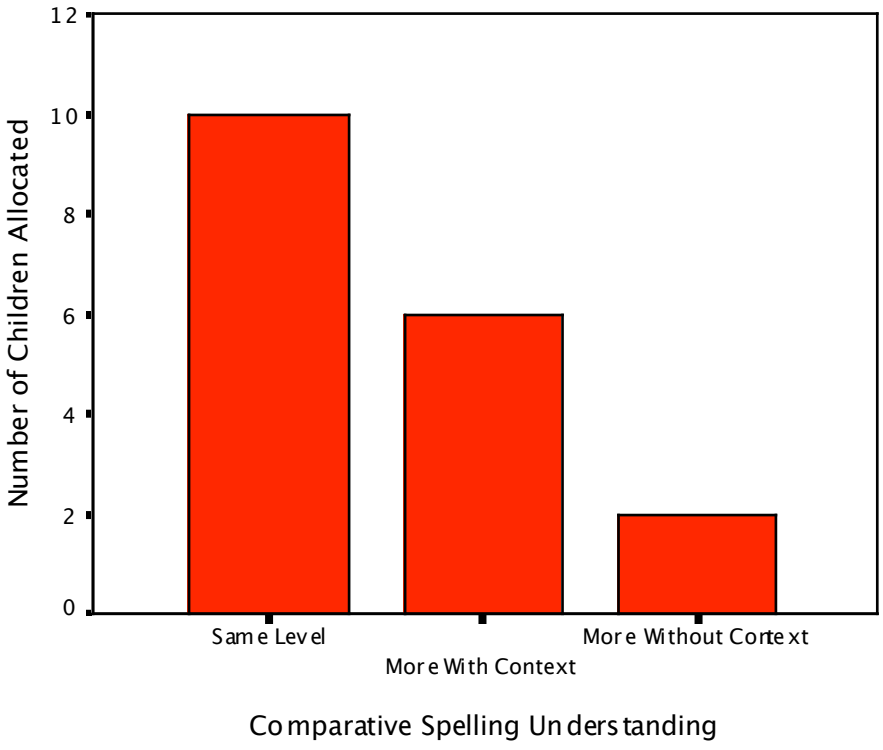

Figure 5.4: Comparison of representational spelling understanding: same level in both tasks, more explicit understanding with context, more explicit understanding without context.

A similar pattern has therefore been observed for spelling understanding in the presence and absence of context, so what about reading? A comparison has been made of children's representational levels of reading derived with and without context and is shown in Table 5.14. Again the sample was too small for A Chi-Squared analysis. From Figure 5.5 it can be seen that like Experiment 1, the majority of the sample: ten children improved in their understanding of reading in the presence of context.

Table 5.14: Number (%) of children allocated to reading representational levels in the standard reading recognition task and the reading sentence context task

Reading Recognition Task	Reading sentence context task			
	Implicit	E1A	E1B	E2
Pre-Implicit	1 (5.56)	0 (0)	0 (0)	0 (0)
Implicit	3 (16.67)	3 (16.67)	0 (0)	1 (5.56)
E1A	0 (0)	4 (22.22)	2 (11.11)	1 (5.56)
E1B	0 (0)	0 (0)	1 (5.56)	2 (11.11)

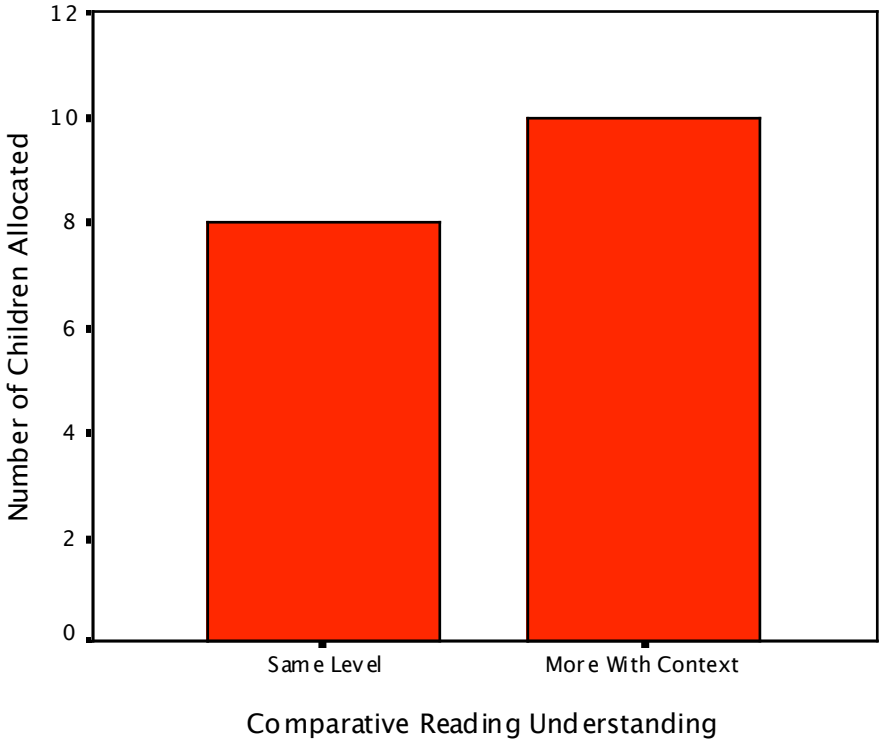

Figure 5.5: Comparison of representational reading understanding: same level in both tasks, more explicit understanding with context, more explicit understanding without context.

It has been established that as in Experiment 1 about 1/3 of the sample improved their understanding of spelling in the presence of context and about 2/3 improved their understanding of reading in the presence of context

Discussion

This follow-up study refutes the possibility that any improvements made in understanding were due to order effects rather than contextual facilitation. No children showed more explicit understanding in the standard spelling and reading recognition tasks despite the fact they had previously analysed the same words within the context

tasks. From this it can be concluded that the presence of contextual information, rather than a familiarity with the stimuli are attributable to the increases in spelling/reading understanding. This is also the case for the performance measures as children were still more likely to be accurate in spelling, reading and reading recognition in those first tasks with the sentence context again demonstrating both the implicit and explicit influence of semantic information on performance and understanding respectively.

This shows that the facilitative effects of context were only temporary to the task rather than causing permanent redescription of knowledge; unlikely given only one exposure. This echoes similar findings in Hilte & Reitsma's (2007) spelling training study. They discovered that the facilitative effects of the semantic training dropped off in the three weeks following the training and suggested that the semantic connections become unstable over time if not reinforced. This suggests that when children's knowledge is in transition it can be facilitated by context but that this experience will need to be repeated if knowledge is to permanently progress. This is akin to the "scaffolding effect" described by Messer et al. (in press) when exploring children's variable performance in similar balance tasks.

This follow-up study has also replicated the findings of the original study in terms of the proportions of the sample that made improvements in understanding in the presence of context. Again semantic information has had a greater facilitative effect upon the understanding of reading as 2/3 of the sample gained in explicit understanding compared to 1/3 of the sample for spelling. Similarly most improvements were made by one representational level and occurred along the implicit-explicit continuum. Children who showed no such gains in the presence of contextual information could also be found at any representational level so it is not the case that those who respond the presence of context are already more able.

Therefore this follow-up study not only confirmed the results from the first it refutes the possibility that order effects were responsible for the original findings

The present study has therefore shown that, regardless of task order, reading and spelling accuracy and level of explicit understanding can be facilitated by the presence of context. It can also be suggested that context has its greatest influence when the child's underlying spelling and reading knowledge is already in transition.

What are the implications of these findings? By demonstrating that spelling accuracy can also be facilitated by context in a similar manner to reading; this indicates an implicit cueing process where incomplete phonological and orthographic information can be strengthened by, or compensated for, by the context. This echoes the notion of the Lexical Quality Hypothesis (Perfetti & Hart, 2002). However the key finding here is the precision of information that can be activated for spelling purposes. Unlike reading where a word can be cued even if the underlying representation is incomplete, spelling requires the correct letters in the correct order. The fact that the LQH can be equally applied to spelling and reading has proved vital here as its assumption that the same underlying knowledge is applied to spelling and reading supports the shared representation view (Holmes & Davis, 2002) first explored in the longitudinal study (Chapters 3 & 4). The finding of comparable cognitive processes in the relationship between semantic and orthographic information in both spelling and reading is significant for both the LQH and the notion of shared representations.

This finding also provides further support for joint reading and spelling developmental models akin to those by Frith (1985) and Ehri (1998, 1999, 2002) as opposed to studying the skills separately. Indeed the "pace maker" notions originating from Frith have already found some support in the longitudinal study and the application of the RR model has been the first to track this development as a process of explicitation looking at children's understanding. However Frith's model lacks a clear semantic component while Ehri's looks at how the context cues reading but not spelling. This does not acknowledge the important role it seems to play in the development and facilitation of phonological and orthographic knowledge. Furthermore it is now apparent that this new

application of the RR model to reading and spelling while primarily a test of orthographic and to a lesser extent phonological knowledge thus far should incorporate contextual information to increase its validity from both theoretical and applied perspectives.

The present study also has implications for existing connectionist models (e.g. Plaut et al, 1996, Harm & Seidenberg, 2004) that do emphasize the importance of semantic information alongside phonological and orthographic and therefore have an advantage over stage models such as Frith (1985). However as they have been developed primarily to aid understanding of word recognition they do not provide a coherent picture of both spelling and reading development. Indeed many studies involving children looking at semantic information have been predominantly reading based, e.g. Nation & Snowling, 1998, Laing et al. 2001, Farrer et al. 2001, Reimer, 2006. Furthermore the contextual component of the self-teaching hypothesis (Share, 1995) remains unsupported (Nation et al. 2007) The present study would suggest that more research must be done to apply these models to spelling as well to gain a fuller understanding of underlying knowledge. The same would also be true of the Knowledge Sources account of reading (Thompson et al. 1996)

The Lexical Quality Hypothesis therefore receives support due not only to its inclusion of a semantic component but by retaining the coherence of a joint spelling and reading model. Importantly though the present study has gone beyond the LQH by showing for the first time that context can facilitate children's *understanding* of spelling and reading. This suggests that when semantic information influences orthographic and phonological information it does not just have an implicit effect by facilitating accuracy it also has an impact on explicit representations and can further children's understanding and ability to verbalize knowledge. This suggests that children develop an integrated understanding of spelling and reading, facilitated by context and becoming more sophisticated and explicit over time as suggested by the RR model and supported by the longitudinal study.

By applying the RR model we can also start to shed light upon how the three constituents (phonology, orthography, semantics) develop in relation to each other. The LQH

explains that children's continued experience with words is vital if their representations are to become complete. This is undoubtedly true but the RR model informs as to the process whereby this external information becomes internalized, interpreted and integrated: the process of explicitation or redescription. This is supported by the finding that context was more facilitative (and therefore became more integrated with orthographic and phonological information) when underlying knowledge was in transition and ready to become more explicit. This process may drive the integration of all spelling and reading knowledge, so that success and understanding can be achieved. Clearly some of this prediction is speculative and would require further study and although this improvement with context is somewhat temporary to the task it indicates that if the semantic connections keep being strengthened then understanding as well as accuracy may improve. Nevertheless it is encouraging that this application of the RR model has been able to pose these questions.

Finally another advantage to the study is the employment of typical children using a method that reflected a real-life literacy scenario. Previous studies have used special samples of children and semantic priming techniques and so it was important to form a study involving a more naturalistic setting to see if contextual facilitation could still be found.

To conclude, the studies of the thesis thus far have employed representational levels that test underlying orthographic and to a certain extent phonological knowledge to shed light upon the nature and development of spelling and reading representations. The present study has now incorporated the influence of semantic knowledge and explored how this may interact with orthographic knowledge to aid accuracy and understanding. The outcome is a much more coherent picture of underlying cognitive processes of spelling and reading where the process of explicitation may be the key to understanding how underlying knowledge interacts and develops.

Chapter 6: General Discussion

In the first part of this concluding chapter the four research questions posed in Chapter 1 will be reviewed and discussed in relation to the findings from the studies conducted. Following this, implications for existing models will be suggested that arise from the novel use of the RR model in conceptualising the representations that underlie spelling and reading. Finally a new model of spelling and reading development will be proposed that integrates these recommendations and forms predictions that can form the focus of future empirical research.

1. Research Questions

1.1: Can spelling and reading representations be conceptualised using the implicit-explicit continuum of the RR model?

The implicit-explicit framework provided by the RR model (Karmiloff-Smith, 1992) has been applied previously to children's learning of balance (e.g. Pine & Messer, 1998, 1999, 2003) and basic numerical principles (e.g., Chetland & Fluck, 2007, Butler et al. 2007). In its first application to the domain of literacy, Critten et al. (2007) were able to identify the explicit levels of the model (E1, E2, E3) in relation to children's understanding of spelling, accessed via verbal explanations. However three of the 90 children (aged 5-7 years) tested displayed an implicit level of knowledge involving task success without conscious access to, or the ability to verbalise, this knowledge. To validate the RR model as a tool to conceptualise underlying spelling and reading representations greater empirical support for the implicit spelling level was sought. Certainly previous studies have suggested the importance of implicit processes in spelling (see Steffler, 2001 for review). Furthermore the initial stages/phases of traditional models of spelling and reading development (e.g., Frith, 1985, Ehri, 1998, 1999, 2002) could be construed as a description of implicit processing with their focus on visual cueing, automatic recognition and the absence of phonemic awareness. This lends credence to the application of a general model of cognitive development that employs implicit-

explicit change as a mechanism for representational development. Indeed Sadoski & Paivio (2007) argued that application of such a generalised theory could provide a framework that would help to resolve some of the fragmented issues in current literacy research referring to a "lack of a viable overall architecture to unify them" (p.338, Sadoski & Paivio, 2007)

The first study of this thesis reported in Chapter 2 found empirical support for an implicit spelling level. Twenty per cent of a sample of younger children (N = 101, aged 4-6 years) displayed the characteristics of underlying implicit representations. They achieved task success due to consistent and correct recognition of target words (>70%). However they could not verbally explain why words were correct or error alternatives were incorrect; their knowledge appeared not to be consciously accessible. The remaining children in the sample were assigned to one of the explicit spelling levels thus providing further empirical support for the findings of Critten et al. (2007). Furthermore a new pre-implicit level was identified which appears to involve a process of information gathering before implicit representations are formed. Given this support for both the implicit and explicit spelling representational levels it was then possible to see if children's representations were consistently implicit or explicit on two further spelling tasks that used words containing common patterns, e.g. sold, cold. Results suggested that children could access either implicit or explicit representations depending on the equivalence of tasks used. For example there was some concordance on the recognition and substitution tasks as the majority of children were either consistently demonstrating access to implicit or explicit representations. However there was no relationship between the recognition and pairs tasks, possibly due to the latter essentially being an easier task. Therefore, although implicit representations are used in spelling, children's representations are not exclusively implicit or explicit on all spelling tasks.

Therefore the application of the RR model has enabled spelling representations to be viewed in a novel way. Not only has an implicit level been uncovered supporting the implicit-explicit continuum but also the multiple representational system described by the model can help explain the inherent variability in children's learning in this domain.

Furthermore the findings of variability are consistent with predictions made by Ehri's (1998, 1999, 2002) in her phase-like model. The model predicts that children may display differing spelling abilities across words and tasks depending on their familiarity with those words, e.g. they may be at the pre-alphabetic phase for certain word sets but at the partial alphabetic phase for others. The multi-representational RR framework also reflects this more flexible approach in contrast to global stage development again validating its use in conceptualising spelling and reading representational development.

Having established support for both implicit and explicit representations for spelling the focus of the thesis was extended to include reading. There are a number of arguments in favour of considering both spelling and reading in the same investigation and theoretical framework. Ehri (2000) argues that spelling and reading are highly connected and co-dependent in development so it is difficult to view them as entirely separate processes. This is demonstrated in the joint models of Frith (1985) and Ehri (1998, 1999, 2002). Furthermore work by Holmes & Carruthers (1998), Holmes & Davis (2002), and Burt & Tate (2002) suggest that representations are shared in reading and spelling. Therefore to form a cohesive understanding of the nature of children's underlying representations both skills should be considered. As with spelling, implicit processes in reading have been documented by Ellis (1997) and the knowledge sources account of reading (Thompson et al, 1996, Fletcher-Finn & Thompson, 2000, 2004). It was apparent therefore that the implicit-explicit mechanism of the RR model would also prove appropriate when assessing reading development allowing the simultaneous study of the two skills within the framework.

Chapter 3 introduced the longitudinal study that followed 73 children over the course of a year and involved developing a methodology for assessing children's representational level for reading. To directly compare children's understanding and ensure that reading and spelling levels were as equivalent as possible the newly formed reading recognition task used the same materials as Critten et al.'s (2007) spelling task (derived from Nunes et al, 1997). Children were not informed of target words to find instead they were asked to identify, read and try to explain *how* they read real and non-words. Predictions were

made based on the spelling coding scheme as to the likely characteristics of reading representational levels. The reading recognition task and reading coding scheme were tested on the first 30 children for validation before further testing of the remainder of the sample took place. Children's understanding of reading on the basis of performance and verbal explanations could now also be characterised as pre-implicit, implicit, E1A, E1B, E2 or E3.

The nature of performance and understanding at each of the reading levels resembles its spelling equivalent. Initial implicit representations lead to task success, i.e. the ability to identify and read target words but the inability to read error alternatives or explain the reading process. In the first explicit representations (E1A, E1B) theories have been abstracted, interpreted and applied when reading relating to principles of phonology and morphology. Children can now produce basic explanations of their reading process but are now prone to errors, e.g. choosing solded as the real word but reading it as sold. In the later explicit representations (E2, E3) the ability to identify and read both errors and target words is accompanied by insight into the reading process as children explain how they can segment words in order to identify them. The new coding scheme for reading achieved inter-rater reliability of 93% concordance and met the first aim of the longitudinal study as children could be allocated to spelling and reading levels at each of the four time points over the course of the year.

To summarise, the implicit-explicit continuum of the RR model allowed conceptualisation for the first time of children's underlying spelling and reading representations. Empirical evidence from Critten et al. (2007) and the studies documented in Chapters 2 and 3 suggested that underlying representations can be implicit and/or comprise varying levels of explicit knowledge. Novel methodology was employed and use of children's verbal explanations enabled analysis of their understanding of spelling and reading. Furthermore for the first time an implicit-explicit dynamic has been incorporated into a model of spelling and reading development coherently drawing together disparate strands of research. The implicit nature of spelling and reading appears to correspond to the automatic recognition of words described already in the

literature, (e.g. Frith, 1985, Thompson et al. 1996, Ellis, 1997, Ehri, 1998, 1999, 2002). However the gradual incorporation of phonological and morphological information (Frith and Ehri's latter stages/phases) can now be understood as the explicitation of underlying representations with accompanying errors and new abilities to verbally explain knowledge. What is significant here is the notion that children's underlying representations, certainly from E1 onwards are "active" children abstract, interpret and apply information. Learning is not a passive process where children just imitate or match patterns they have seen or been taught, the RR model demonstrates the creative and applied use of information which can lead to the type of errors children produce at E1, e.g. you would not see the word solded in the environment. However this interpretive quality facilitates the development of fully explicit representations as children learn and understand when it is appropriate to apply certain rules.

1.2: Does children's reading and spelling development follow the process of explicitation described in the RR model?

Having provided empirical support for implicit spelling representations and identified new representational levels for reading it became possible to track children's representational development longitudinally as reported in Chapter 4. The aim was to see whether over the course of a year children would progress through at least one representational level for spelling and one representational level for reading. If so, this would support the process of explicitation in children's learning advocated in the RR model. A long-term naturalistic study using the RR levels has not been conducted in any domain before, although Pine & Messer (1998, 1999, 2003) did demonstrate explicitation in children's understanding of balance using week-long intervention and microgenetic studies.

Results from the longitudinal study showed that 95% of the sample did progress. The very small number that did not improve (two children for spelling and reading and a further two children for reading) may have been showing early signs of learning difficulty. The rate of progress was steady across the four testing points and generally

improvement was by one or two levels rather than spanning the entire implicit-explicit continuum, although a few children did show exceptional advancements by the end of the study. The use of verbal explanations allowed children's representational development in reading and spelling to be followed for the first time, concentrating not just on children's performance but what they could understand and communicate. This builds upon studies that have used tests of accuracy to document progression, e.g., Caravolas et al. (2001). By studying the underlying representations in terms of whether knowledge is consciously accessible and verbalisable it can be seen whether task success is due to implicit or explicit representations, what children understand about spelling and reading rules/processes and what the nature of their errors are.

Viewing development as a process of explicitation of the underlying representations is a new perspective for considering how children learn to spell and read. Descriptive models (Frith, 1985, Ehri, 1998, 1999, 2002) provide exact details of what children learn and show that while initial spelling and reading ability relies heavily upon automatic recognition processes, these processes are later enriched via the accumulation of phonological and morphological knowledge. This leads to progress in both skills. The process of explicitation postulated by the RR model indicates possible mechanisms underlying this change. It seems clear that early spelling and reading is indeed implicit; children cannot consciously access their knowledge or verbalise it despite achieving success on tasks.

However, why is it that children go beyond this? Why is it that they can attempt to read and spell unfamiliar words, make overgeneralisation and recognition errors and develop the ability to communicate their spelling and reading knowledge? It is not enough to say simply they are taught to do so by teachers, we have to try and understand what is occurring at the representational level. By using the RR model and demonstrating the process of explicitation it became apparent that the reason why spelling and reading progresses beyond implicit recognition is because they become *active*. Children abstract, interpret and apply theories (phonological and morphological) and although information obviously comes from the environmental input, how this information is then organised

and analysed is governed by endogenous processes, e.g. self-organisation. It has therefore been possible to build upon traditional models of spelling and reading using the RR framework to understand the change described in the stages/phases as a process of explicitation.

1.3: How can using RR levels aid our understanding of the way spelling and reading develop in relation to each other?

Having demonstrated in Chapter 4 that children show representational development in spelling and reading when followed longitudinally, the next aim of the study was to see how spelling and reading developed in relation to each other. There is some debate regarding this issue in the spelling and reading literature and the RR levels were used to provide a new developmental perspective on the subject. In the literature which adopts a neuropsychological approach to investigations (e.g. Weekes & Coltheart, 1996) there is the suggestion that because reading ability is often superior to spelling ability there are separate representations for the two skills. However many studies using typical adults (e.g. Holmes & Carruthers, 1998, Holmes & Davis, 2002, Burt & Tate, 2002) have produced evidence of shared representations for the reading and spelling knowledge of a word as there is generally consistency in the errors that are made.

However, entrenched adult representations may lead to far more consistency than would be expected in children's performance and verbal explanations across spelling and reading tasks. Developing representations are likely to be incomplete and contain errors so even if there are shared representations for reading and spelling this may not translate to consistency across reading and spelling tasks. This becomes less likely when Frith's (1985) pace maker predictions are considered as although the skills are highly inter-dependent (a view echoed by Ehri, 2000) she suggests that sometimes one skill is leading another, e.g. phonological information is used first in spelling and so spelling may act as a pace maker for reading at that time. Indeed this pattern of development was given credence by Caravolas et al. (2001). In light of this it was expected that children would

not match across spelling and reading levels over the course of a year but that children may have higher spelling representational levels as suggested by Frith.

Findings from the longitudinal study (Chapter 4) proved insightful and raised issues not anticipated by the clear-cut prediction. By using Cluster Analysis two groups that appeared to be showing slightly different patterns in development were identified. High Achievers (N=26) were more advanced than Low Achievers (N=47) at each testing point of the study in terms of spelling and reading representational levels and scores on the performance measures. Differing abilities within a sample is unsurprising but when the spelling and reading developmental relationship was examined a more interesting finding emerged. When the study commenced, even though High Achievers were more advanced than Low Achievers the relationship between spelling and reading was the same; about 60% of children in each group had a higher representational level for spelling compared to reading while only about 30% were showing a co-development. However by the end of the study patterns had changed. While Low Achievers had made progress in reading, for 80% spelling representational levels were still higher. However the majority of High Achievers (60%) now matched across spelling and reading levels. This result combined with the finding that High Achievers showed a faster rate of reading development seems to suggest that reading had "caught up" with spelling.

It is apparent that Frith's predictions were supported as children's ability to abstract and use phonological information in spelling allowed them a higher level of representation (E1) than in reading where implicit representations were more frequent and accessed for longer. This finding validates use of the RR framework by consolidating the findings of Caravolas et al (2001) using this new method and form of data. Furthermore this new perspective can aid understanding of how reading starts to catch up with spelling. Analysis of High Achievers showed that once children's spelling representations had progressed to E1B/E2 reading abilities started to match. It appears that once representations reach this E1B/E2 threshold, this knowledge can then be accessed and generalised across other tasks. So it is possible that knowledge that was primarily being applied to the spelling task could now be similarly used in the reading task as well. Use

of verbal explanations as a source of data has proved vital as it has highlighted differences in performance and understanding. Although children's spelling representational levels were often higher, reading performance was always consistently better. This suggests that while spelling can involve implicit representations (as shown in Chapter 2), explicit representations are used first for carrying out spelling tasks as shown by the prevalence of recognition errors and early phonological explanations. However, this phonological knowledge is not applied as often in early reading as a great deal of success depends on a fall-back to implicit representations explaining why children cannot explain their reading process or decode similar errors.

It is beyond the scope of this thesis to say whether we do have shared spelling and reading representations, although the facilitative effect of context for both spelling and reading performance (as shown in Chapter 5) certainly adds to the growing body of support for shared processing. However the longitudinal study has shown that even though representations may be shared, they may not always be equally applied across spelling and reading tasks, explicit representations may be used first in spelling. Children's developing explicit representations do appear unstable and incomplete leading to frequent errors and inconsistency within and between tasks. From this description the representations seem to resemble that of the poor adult readers and spellers documented by Katz & Frost (2001) and Dietrich & Brady (2001) rather than the consistent adults of Holmes & Davis (2002).

1.4: How can using RR levels aid our understanding of contextual facilitation of reading and spelling?

In the investigations reported in Chapters 2, 3 and 4 the RR levels enabled spelling and reading representations to be conceptualised in a new way; according to whether they are implicit or explicit, according to whether knowledge is consciously accessible and verbalisable and according to the type and nature of the errors that were made. The longitudinal study also demonstrated the complexity of the process of explicitation by showing that representations are often incomplete, sometimes knowledge can be applied

in spelling not yet used in reading and there can be a difference between performance and understanding. These findings have built upon existing models of spelling and reading development by providing insight into the underlying representational change.

Thus far, tasks employed by Critten et al. (2007) and in this thesis had primarily assessed children's implicit representations and their early explicit representations concerning orthographic and phonological knowledge. However in these tasks single words were administered in the absence of any supporting context and without requiring the children to bring their semantic knowledge to bear on performance. Given that real-life literacy experiences invariably occur within a context, it was vital that the issue be considered in the thesis. The joint models of spelling and reading development (e.g. Frith, 1985, Ehri, 1998, 1999, 2002, Share, 1995) consider contextual facilitation but the emphasis is placed on the cues the context provides in early spelling and reading; thus acting as an implicit facilitator. However the continuing effect context may have throughout the developmental process is not considered. The issue is given more prominence for development in others models, predominantly connectionist (e.g. Plaut et al, 1996, Harm & Seidenberg, 2004) but these focus more on reading or word recognition, rather than reading and spelling. Many studies using adults (e.g. Farrer et al, 2001, Reimer, 2006) and special samples of children (e.g. Nation & Snowling, 1998, Laing et al. 2001) have successfully demonstrated the importance of semantic information for successful reading. Given how interconnected the two skills appear to be there is now a prime opportunity to consider how semantic information may influence spelling as well.

One exception is the Lexical Quality Hypothesis (Perfetti & Hart, 2002) that assumes shared representations for reading and spelling. Therefore the "triangular" composition of semantics (comprised of meaning and syntactic information), phonological and orthographic information is employed in a similar fashion to Plaut et al. (1996) and Harm & Seidenberg (2004) however the fundamental difference is that it is advocated for successful spelling as well as reading. The LQH explains that the three constituents have to become integrated over time if fully specified representations are to form. Thus if any of the constituents are missing or lack detail then difficulties in spelling and reading will

occur. Perfetti & Hart argue that if phonological and orthographic information is under specified then semantics can play a facilitative role. Indeed studies of semantic facilitation in poor spellers (Hilte & Reitsma, 2007) and poor readers (Berends & Reitsma, 2006) do seem to support the LQH.

In the light of this, the studies detailed in Chapter 5 used the RR levels to extend our understanding of contextual facilitation. Aside from the recent study of Hilte & Reitsma (2007), semantic facilitation of spelling has been under-researched when compared to reading. So the first aim of the study was to see whether in a common literacy scenario typically developing children would demonstrate greater accuracy in spelling as well as reading within a sentence context rather than without. Results suggested this to be the case as children could read and spell more words within the sentence context. Although the improvement was more marked in reading, the fact that spelling was also facilitated supports the notion of context as an implicit facilitator for both skills.

The RR levels were then used to examine the issue from a new perspective. If context facilitates performance would it not also facilitate children's understanding, i.e. make their verbalisations more explicit? This would be intuitive if context does compensate for any underspecified phonological and orthographic information. Findings from Chapter 5 provide some support for this as 2/3 of the sample for reading and 1/3 of the sample for spelling demonstrated higher representational levels when the task had a context compared to without. This seems to suggest that context can also facilitate explicit understanding as well as providing implicit cues for performance.

A final and intriguing contribution made by the studies in Chapter 5 is related to the way information becomes integrated within representations over time. Perfetti & Hart (2002) simply suggest that continued experience with words is the key and while there is no doubt it plays a role the RR model would suggest that representational development involves more than just external triggering and involves endogenous processing, again the notion of "active" representations to which reference has already been made. As we have seen the process of explicitation involves active change: abstraction, interpretation

and application of knowledge. Can these processes account for how phonological, orthographic and semantic information becomes more integrated over time? The following answer is partly speculative but is based on the analyses described in Chapter 5. When context facilitated were examined and it was found that if children's underlying representations were undergoing transition (their predominant level occurred closer to 50% than 100% of the time) then their representational level was likely to be higher with contextual support. Although significant effects were found only for reading, the same tendency was shown in spelling. This is not to say that one exposure to context is enough to cause redescription, it simply facilitates performance/understanding on the task. Indeed Hilte & Reitsma (2007) explain that it takes time for the semantic connections to strengthen.

The use of the RR levels therefore allowed examination of contextual facilitation in both spelling and reading, performance and understanding. It also posed questions, the answers to which may aid our understanding of how and when semantic information facilitates phonological and orthographic information and how the three constituents become more integrated over time.

2: Implications for existing models

Three main implications for existing models of spelling and reading development can be suggested in the light of these findings.

2.1. An implicit-explicit framework should be incorporated into models of spelling and reading development.

Previous studies suggested that implicit processes may play a key role in early spelling (e.g. Steffler, 2001, Critten et al. 2007) and early reading (Thompson et al. 1996, Fletcher-Finn & Thompson, 2000, 2004) while initial stages/phases of the classic models of Frith (1985) and Ehri (1998, 1999, 2002) could be construed as detailing implicit processing by describing automatic recognition. However if this is the case then these

strands of research should be integrated by incorporating an implicit-explicit continuum as a framework for understanding development. In this thesis the RR model has been used in this way to explain not just the nature of the initial implicit representations but suggesting how children develop beyond these to form active explicit representations which are involved in abstracting, interpreting and applying phonological and morphological information. The nature of representations underlying the change detailed in descriptive models have been exposed and conceptualised in a novel way using verbal explanation as a rich source of data.

Although there are potential difficulties (acknowledged earlier) associated with using children's verbal reports, examining them in conjunction with performance and recognition choices increases the likely validity of the model. It is also important to emphasise how useful verbal explanation are in differentiating between implicit and fully explicit knowledge: task success occurs in both cases and only by asking children to explain how they were able to read words or understand why words were spelt correctly could conclusions be made regarding the explicitness of the underlying knowledge.

2.2. Joint models provide a more cohesive framework to understand reading and spelling development.

In Chapter 1 it was explained that there would be a focus on joint models of spelling and reading (e.g. Frith, 1985, Ehri, 1998, 1999, 2002) as it was apparent that their use would maximise the contribution of the RR model to our understanding of spelling and reading representations. Furthermore, as the studies in this thesis involve both spelling and reading it seemed logical to refer to these models. Despite Ehri's (2000) arguments that the two skills are almost impossible to separate, Caravolas et al's (2001) findings of an inter-connected developmental path and assertions by Holmes & Davis (2002) among others that representations are shared for reading and spelling there are studies and models that have looked predominantly at either spelling (e.g. Nunes et al. 1997, Critten et al. 2007) or reading (e.g. Thompson et al. 1996). Connectionist models (e.g. Plaut et

al, 1996, Harm & Seidenberg, 2004) also often concentrate on word recognition and assume that the same principles would be true of spelling.

However this thesis has demonstrated particularly in the longitudinal study that there are considerable benefits of investigating both spelling and reading, certainly in models of representational development. By using the RR model it was apparent that as Frith (1985) predicted the two skills are inter-connected in development as many children displayed phonological understanding in spelling before reading. Furthermore the findings suggest that although reading tends to rely on implicit representations for a longer period of time, while spelling draws upon more explicit representations, as these representations start to reach the latter explicit levels knowledge can be generalised across spelling and reading tasks leading to comparable performance and understanding. For an integrated picture of how spelling and reading representations develop both skills should therefore be examined.

2.3. Contextual facilitation should be incorporated into models of spelling and reading development.

A wealth of research highlights the importance of semantic information in successful reading, particularly connectionist modelling (e.g. Plaut et al. 1996, Harm & Seidenberg, 2004). However aside from the criticisms levelled at these models by Karmiloff-Smith (1992) and Castles & Nation (2006), semantic information in relation to spelling has not been given the same comprehensive treatment. As documented earlier joint models of spelling and reading consider the importance of semantic information for successful reading and spelling although Frith (1985) and Ehri (1998, 1999, 2002) tend to limit its influence to implicit cueing in early development. The Lexical Quality Hypothesis (Perfetti & Hart. 2002) provides a much more comprehensive view of how semantic, phonological and orthographic information work together but again the focus is on how semantic information improves performance.

This new application of the RR model suggests that context does not only facilitate accuracy in spelling and reading but that it may also aid explicit understanding. Furthermore it suggests that context facilitates throughout the developmental process and is possibly most effective when underlying representations are in transition.

3: The Spelling and Reading Explicitation Model: SREM

To integrate all of these findings a new model of spelling and reading development is proposed: the Spelling and Reading Explicitation Model (SREM). The empirical basis for the model is drawn from the findings presented in the thesis, although some parts are speculative and will require future study to consolidate.

3.1:Principles:

1. The model is based on the Representational-Redescription model (Karmiloff-Smith, 1992) and adapted for this domain employing an implicit-explicit framework.
2. The findings of the longitudinal study (Chapters 3 and 4) and Frith's (1985) pace maker predictions are used to try and understand how the two skills develop via a process of explicitation.
3. The model concerns the nature of underlying representations accessed via verbal explanations and therefore should be seen primarily as a model of how children's understanding develops rather than of performance development.
4. The model should be viewed as a phase-type model akin to that of Ehri (1998, 1999, 2002). If a child is at a particular level for certain word-types and spelling rules that is not to say that will be their overall level for all spelling/reading tasks. It is predicted that as new principles/rules of literacy, e.g. –ed, silent "e" are learnt then they will develop through the same explicit processes.
5. Context exerts an influence throughout the developmental process both in terms of performance and explicit understanding. It is predicted that it is most facilitative when underlying representations are in transition.

3.2: Phase One: Automaticity without insight

Pre-implicit information gathering

Children experience the sounds and visual appearance of words from a very young age. Gradually rudimentary knowledge of letter sounds and names accumulates as children start to realise that spoken words relate to the written forms they see in books, on signs etc. Children may start to guess what a written word says often using the first letter as a cue, e.g. reading *sold* as a frequent word such as *said* or *sand*. However as yet children will not have formed the implicit representations that will allow them to correctly recognise words and there is no insight yet into why words may be spelt correctly or incorrectly.

Implicit representations

The development of implicit representations will overlap with pre-implicit information gathering as children start to build-up a sight-word vocabulary. These representations are akin to snap shots of words drawn directly from the environment and may be automatically applied in reading and spelling tasks. This is not to say, that children know every single letter in the word, but that there is just enough of visual information to allow identification. The context plays a significant role in this process as an implicit facilitator. Implicit representations lead to task success, e.g. correct recognition but this process cannot be consciously accessed or verbalised. As they are held in isolation they cannot be generalised to other tasks or analysed in terms of component parts.

When reading, children may be able to correctly identify words but they will be unable to read similar errors, e.g. *solded* derived from *sold* or explain their reading process: either offering no explanation "I just knew it" or repeating letters ad verbatim: "I read it s-o-l-d". In spelling, children may be able to recognise the correctly spelt version of a word when told the word to find or to correctly produce a target word but they are unable to explain why words are spelt correctly or incorrectly, for e.g., "I just knew it was right", "I just knew it was wrong". Sometimes they may try to make a response but it will be clear that no explicit knowledge is being accessed, for e.g. when asked why the error word filld

is spelt incorrectly the reply may be: “because it has l”. Of course the correct version of filled also has l.

It is predicted that although implicit representations can be utilised for spelling purposes they are more likely to be accessed when reading. This may account for why reading performance always tends to be better than spelling throughout development. However when representations progress beyond these early implicit forms into explicit representations, they are first utilised in spelling.

3.3: Phase Two: Onset of explicit knowledge

A shift occurs to the *active* phase of representational development with the emphasis on endogenous processing, rather than just passive absorption of input from the environment. Theories relating to phonological and morphological principles will be abstracted interpreted and stubbornly applied sometimes to the detriment of performance. As knowledge can be consciously accessed children may start to provide basic explanations for their reading and spelling processes providing insight to the underlying representations. These early explicit representations may be first applied to spelling (a pace maker prediction) as children tend to utilise just implicit representations in reading for longer. However spelling performance will still lag behind that of reading as these representations are incomplete and tend to contain errors.

E1A

At this level children will show abstraction of phonological principles, e.g. basic phoneme-grapheme, grapheme-phoneme mappings, phonemic blending, consonant clusters etc that they will start to apply when spelling and reading. When words can be spelt or read using these principles then success will be achieved but when they cannot, phonological recognition errors may occur, for e.g. identifying filld as filled, opend as opened. In spelling although recognition and production errors may occur, children start to offer simple phonological explanations for why words are spelt correctly and incorrectly, for e.g. when asked why they believe filld to be correctly spelt they may say:

"it should have two l's but no e in it". Morphological rules such as –ed are not recognised again reflected in explanations, e.g. when asked to explain why solded is spelt wrong you may expect a response that will refer to the fact that –ed has been put on the end of sold, however a typical E1A response would be: "it's wrong as it has two d's and an e".

When reading, children at this level may identify an error version of a word as the correct form but read it as the target word, e.g. saying that opend is opened. However despite these errors children start to be able to communicate their reading processes in basic explanations, for example when asked how they read the word sold a response might be: "it has o an l in the middle and that makes ol". Children may also apply these principles to unfamiliar words and errors and attempt to decode them.

E1B

At this level children will have abstracted a theory related to principles of morphology and similarly to E1A in applying the rule it may lead to spelling and reading success but equally to errors if over-applied. In spelling, recognition and production errors may occur in relation to this rule. For example overgeneralisation of –ed to irregular verbs, e.g. solded and nonverbs, e.g. softed. Verbal explanations may incorporate this rule, e.g. when asked why they believe solded to be correctly spelt the response might be: "it has to have –ed". When reading these errors may continue as children may insist that solded says sold and softed says soft. When explaining their reading process the rule will again be referred to, e.g. when asked how they read sold (spelt solded) the response might be: "it has s-o-l which is sol and then add ed to make sold".

As children learn and interpret new spelling and reading principles there is likely to be an overlap between E1A and E1B depending on the word types employed by the task. These early explicit representations are therefore incomplete and are likely to lead to inconsistencies across tasks. Contextual facilitation is predicted to play an important role in the transition beyond this phase as it may compensate for under specified phonological and morphological knowledge.

3.4: Phase Three: Generalisation of knowledge

The process of explicitation continues and more stable and fully explicit representations develop. These representations will be equally utilised in spelling and reading rather than spelling as a pace maker (Phase Two). As a result there will be more consistency in performance and understanding across reading and spelling tasks as knowledge can now be fully generalised. Children start to utilise input from the environment again and therefore recognise exceptions to the phonological and morphological rules they have abstracted. This new flexibility leads to improved performance akin to that in the implicit level but with fully explicit understanding as its basis. This is reflected in the verbal explanations provided that reflect an understanding of rules and how "words work", that is, how to segment and analyse words in terms of their component parts. Context is predicted to facilitate this process particularly in terms of the ability to verbalise.

E2/E3

When spelling children will produce or recognise a correctly spelt word as they realise there are exceptions to rules, e.g. not all words need –ed. They will also be able to explain more fully why words are correctly or incorrectly spelt although it is possible to distinguish between an E2-type response and an E3-type response, demonstrating the gradual acquirement of explicit insight. For example when asked why the word filled is spelt correctly, a child at E2 may reply: "it has two l's and an –ed' whereas a child at E3 may reply "it has the word fill and then add –ed to make it past (tense). These subtle differences can also be seen when considering why the word solded is incorrectly spelt. A child at E2 may say: "the –ed should not be there" whereas a child at E3 may say: "it has the word sold but –ed has been added to it and it should not be there".

When reading children will identify and read correct spellings of words but a significant change is that they can now read errors that are similar to the target words: this shows generalisation of knowledge in order to read unfamiliar and nonsense words. Explanations also provide insight into reading processes although again subtle differences

can be seen at E2 and E3. When asked how they read filled, a child at E2 may say: 'f and ill make fill and then I added –ed to make fill" whereas a child at E3 may say "f and ill make fill and then –ed actually makes a d sound so fill and d make filled"

Table 6.1: Summary of the SREM (Spelling and Reading Explicitation Model) derived from the RR model (Karmiloff-Smith, 1992)

Phases of the model	Typical characteristics	Performance/Explanations
One: Automaticity without insight (emphasis on input from the environment)	Pre-implicit information gathering and the development of implicit representations that cannot be consciously accessed or analysed in terms of component parts. I-reps may be used for longer and more successfully in reading.	I-reps will lead to task success but there will be an inability to explain spelling and reading rules or processes, e.g. why words are spelt correctly/incorrectly or generalise knowledge, e.g. decode unfamiliar words
Two: Onset of explicit knowledge (emphasis on endogenous processing)	Very active representational development involving the abstraction, interpretation and application of phonological (E1A) and morphological (E1B) theories. These representations may be applied first in spelling and tend to be incomplete leading to inconsistencies across spelling and reading tasks.	Over-application of the theories may produce errors, e.g. filld, solded and a detriment in performance. Simple explanations can now be given referring to the abstracted rules.
Three: Generalisation of knowledge (balance between information in environment and	More stable and fully explicit representations develop as exceptions to the abstracted rules are recognised leading to	Success in spelling and reading tasks will occur and knowledge can be generalised to read unfamiliar words.

internalised theories)	a new flexibility. Information is generalised across spelling and reading tasks leading to more consistent performance.	Explanations reflect spelling and reading rules and processes, e.g. why words are spelt correctly/incorrectly, reference to component parts when explaining how words were read.

4: Future Studies

Use of the RR model has provided a new perspective for understanding the representations underlying spelling and reading development and the SREM is proposed as a model integrating these findings. This new theoretical framework for development coupled with new methodologies for analysing children's spelling and reading representations provides a sound foundation for future research arising from the individual studies in this thesis as well as the predictions made by the SREM.

PI versus Implicit

Further empirical work is required to test the notion of early pre-implicit information gathering and the development of implicit representations referred to in the SREM as the Automaticity without Insight phase. From studies in Chapters 2, 3 and 4 it has been possible to conceptualise what typical characteristics occur at the pre-implicit and implicit levels for spelling and reading. However the relationship between them remains under-specified. There is an unanswered question whether children develop implicit representations for automatic recognition without a rudimentary knowledge of letter names and phonics or whether both develop simultaneously. As referred to in Chapters 1 and 4 of this thesis, stimuli were chosen for investigative purposes. The word set used in the longitudinal study was too difficult for many of the children at the start of the study, explaining why so many (N=52) were deemed pre-implicit for reading. This was necessary to study the developmental progression. However if easier and shorter words

had been used we may have seen implicit processing and some task success, e.g. at, it instead of cold, filled. If a study could be done with younger children, perhaps 3.5-4.5 years it will be possible to examine the development of both sight-word vocabulary and early letter and sound knowledge. It is feasible that children are accessing many implicit representations before they even learn any letter sounds or names. The youngest children used in this thesis were 4.5 years and so already knew the majority of their alphabet and phonic alphabet, if unable to use it for decoding purposes.

Different rules

Different stimuli sets have already been referred to in the above point and also feature in this next research recommendation. As discussed earlier the stimuli used to investigate underlying representations and representational change were derived from Nunes et al. (1997) as the –ed rule is a typical example of the complexity in the English orthography with the regular/irregular distinction. Furthermore Nunes et al. had documented errors arising from the overgeneralisation of this rule to irregular verbs and nonverbs. Their model of spelling development was used as a basis for Critten et al's (2007) identification of spelling representational levels. Indeed children's development over time as demonstrated longitudinally with this word set highlights the phonological and morphological theories and errors characteristic of the first explicit (E1) level.

The second phase of the SREM predicts that as children learn new phonological and morphological rules the same processes will occur of abstraction, interpretation, application and possibly errors as they incorporate and handle the information. Therefore future empirical research should involve use of the same method and representational levels to follow the development of other rules but employ new word sets, e.g. the silent "e" rule may include words that employ the rule such as name, cake and words the "e" may be overgeneralised to, colde instead of cold for example. This would demonstrate whether the findings of the longitudinal study can be extrapolated to other rules as the SREM would predict.

Pace makers

The differences in development between groups 1 and 2 in the longitudinal study and Frith's (1985) pace maker predictions lead to the proposal within the SREM that E1 representations are used first in spelling while reading relies on implicit representations for longer. However when the third phase of knowledge generalisation is reached similar performance and understanding would be predicted across spelling and reading tasks. These claims require a stronger empirical foundation based on using different word sets as previously indicated. It could be that any differences across children's spelling and reading representational levels would not occur in the same manner and a more stable co-development in performance and understanding would be documented (akin to adult representations as reported by Holmes & Davis, 2002). Indeed not all children showed mismatches in their spelling and reading representational levels so this certainly merits further investigation.

Adults

The findings from the longitudinal study suggested that as developing representations appear to be incomplete and unstable (certainly at E1) they resemble those of the poor adult spellers/readers as reported by Katz & Frost (2001) and Dietrich & Brady (2001). Future work would add insight to these propositions by the application of representational levels to test adults as well, both typically developing and those with literacy difficulties. Careful consideration would have to be given in such studies to the choice of word sets and may have to include much harder words. This would determine more empirically how developing representations may or may not differ from adult representations. As adults we still access implicit representations and we still make mistaken assumptions when spelling and reading that children at E1 do, so possibly the differences are less pronounced. Studies could see how explicitly adults are able to explain their spelling and reading processes. The children tested in this thesis are being taught these principles in explicit terms according to recent Government initiatives, e.g. The National Literacy Strategy (DfES) and will incorporate this language into their own representations. However adults may find this difficult as their spelling and reading abilities have become automatised. Furthermore they may have experienced different types of spelling and reading instruction at school.

Contextual facilitation

The findings reported in Chapter 5, suggest that context is most facilitative when underlying spelling and reading representations are in transition and indeed may aid the process of explicitation. However more work is required to consolidate this. If children can be identified (via the representational levels) as undergoing transition might contextual tasks be used to effect representational development? Intervention studies would provide the best opportunity to test this.

Intervention and Assessment for Education

There is considerable potential to use spelling and reading representational levels for assessment and intervention in educational settings. Traditional measures of reading and spelling are over concerned with accuracy, i.e. how many words are spelt or read correctly. However representational levels and the recognition tasks they are derived from provide a different perspective that may help teachers to identify specific problems children may be having. By using verbal explanations to infer spelling and reading processing, this will highlight when theories are being over-applied or when there is an inability to identify component parts in decoding for example. In response, teachers could emphasise exceptions to these rules or teach blending or segmentation strategies. As the assessments are conducted individually it may help teachers to identify literacy targets for each child. It would be possible to develop different word sets encompassing the development of different rules so that a broad picture of spelling and reading ability could be established.

Integration with other models of cognitive development

As briefly indicated in Chapter 1 this thesis is not the first research to apply a general model of cognitive development to try and understand spelling and reading development. The Overlapping Waves model (Sigler, 1996) of strategy use has been used to understand variability in the procedures that children employ as they learn to spell (e.g. Rittle-Johnson & Siegler, 1999, Kwong & Varnhagen, 2005) and more recently to learn to read (e.g. Farrington-Flint & Wood, 2007). This thesis has also highlighted the variability that

can occur between similar tasks, for e.g. the three spelling tasks in Chapter 2 and the mismatches in spelling and reading representational levels as shown in Chapter 4. The RR model does have a multi-representational facility and therefore it would be possible to explore spelling and reading in terms of both models of cognitive development.

One possible study would be to examine whether strategies children are employing stem from implicit or explicit representations. For example Farrington-Flint & Wood (2007) report that children may achieve task success when reading explaining that they already knew the word and had recognised it straightaway. This is characterised as a retrieval strategy. However presenting children with a recognition task with error alternatives would shed light on whether this success arose from implicit representations or whether children are then able to access fully explicit representations to explain reading processes. By combining the principles of current models of cognitive development a fully realised picture of spelling and reading processing could emerge, both in terms of underlying representations and the procedures children employ.

5: Conclusion: What has using the RR model contributed to our understanding of spelling and reading representations in children?

Using the RR model of cognitive development has allowed conceptualisation of children's spelling and reading representations in a way not possible before. As children read and spell they draw upon representations that may be implicit in nature or at varying levels of explicitation. Making this distinction has enabled examination of whether knowledge is consciously accessible and can be communicated verbally. The focus therefore has not just been restricted to words children are able or unable to read and spell but extended to their understanding of their spelling and reading knowledge and processes. For example, a child may display task success that is based on implicit representations but be unable to consciously access or verbalise how this success was achieved. In contrast, early explicit representations may produce some errors but children have progressed in their understanding and started to form and communicate rudimentary theories. As a result of this the nature and type of errors produced has been

highlighted as an important part of representational development as children try to interpret and apply and sometimes incorrectly overgeneralise phonological and morphological information.

Viewing the development of spelling and reading representations as a process of explicitation, demonstrated in the longitudinal study, integrates previous research suggesting that early reading (e.g. Thompson et al. 1996, Ellis, 1997, Fletcher-Finn & Thompson, 2000, 2004) and spelling (e.g. Steffler, 2001, Critten et al. 2007) is implicit in nature. Indeed increased integration is precisely what Sadoski & Paivio (2007) argued could be achieved if a general model of cognitive development was applied to literacy. Furthermore it builds upon existing models of spelling and reading development (e.g. Frith, 1985, Ehri, 1998, 1999, 2002) by suggesting how initial spelling and reading progresses beyond the automatic visually based recognition described in their initial logographic and pre-alphabetic stages/phases. The incorporation of phonological and morphological knowledge described in their later stages/phases can be construed as the development of increasingly explicit representations. The key point here is how *active* these explicit representations are, children go beyond passively absorbing information from the environment and interpret, analyse and form theories of how to spell and read. This endogenous processing may produce errors but as children start to recognise exceptions to the rules they have adopted, fully explicit representations allow flexibility in application and allow knowledge to be generalised across tasks.

Critten et al. (2007) had previously developed methodology for analysing children's spelling representations derived from the RR levels and a similar method was developed in the course of this thesis for reading. These new research tools have not only been used to conceptualise underlying representations but to track how spelling and reading develop in relation to each other building upon work with adults (Holmes & Davis, 2002, Katz & Frost, 2001, Dietrich & Brady, 2001) and to examine Frith's (1985) pace maker predictions. Furthermore it allowed study not just of how the context may facilitate spelling and reading accuracy but how it may facilitate children's explicit understanding and ability to communicate. Results suggested that context may facilitate the most when

underlying representations are in transition building upon the Lexical Quality Hypothesis (Perfetti & Hart, 2002).

To conclude the use of the RR model has provided a new perspective on the nature of children's reading and spelling representations and how they develop. Furthermore, spelling and reading representational levels and the use of children's verbal explanations is a new methodology designed to access underlying representations and is concerned not just with what children can do but what they understand. Finally these research findings have been integrated into a new model of spelling and reading development derived from the RR model: the Spelling and Reading Explicitation Model. Further empirical questions have been identified arising from this, from both psychological and educational perspectives. The ability to read and spell affords children a wonderful freedom and enjoyment and this thesis has extended our understanding of the representations underlying these two vital skills.

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Appendix I: Case Studies from the Longitudinal Study

These case studies demonstrate both the explicitation in children's reading and spelling knowledge over time and the slightly different patterns in development shown by the two groups.

High Achievers Example: Carl

Table 1: Carl's performance in spelling, reading, recognition and the four PhAB tasks at each time point.

Measure	**T1**	**T2**	**T3**	**T4**
Spelling	0	1	3	4
Reading	7	9	8	9
Recognition	4	5	6	7
Alliteration	9	7	10	10
Allit/pictures	9	9	10	10
Rhyme	8	9	17	17
N/W Reading	6	8	9	15

Table 2: Carl's allocation to spelling and reading representational levels at each time point, and number of levels improved

Measure	T1	T2	T3	T4	No Levels	Diff
Spelling	E1A	E1B	E1B	E2	2	0
Reading	IMP	E1A	E1A	E2	3	

Tables 1 and 2 indicate the progress that Carl made throughout the study in terms of performance and understanding of spelling and reading.

At the start of the year we can see that although as yet unable to spell any of the words he had reached E1A for his understanding of spelling. His abstraction and application of a phonological theory was evidenced by typical examples of his spelling production, e.g. kisd for kissed and errors in recognition, e.g. choosing kissd for kissed and not recognising the importance of –ed. He was also able to give basic phonological explanations on the spelling recognition task: e.g.: the word set, *kissed, kissed, kissd*

Experimenter: Why is kissd correct?
Carl: it's got k-i-ssd (sounds out)
Experimenter: Why is kissed wrong?
Carl: it's got e in it and it shouldn't
Experimenter: Why is kised wrong?
Carl: it's got e in it again

At time one we can see that although Carl's reading production is noticeably better than his spelling this is due to implicit representations and therefore his understanding of spelling is more sophisticated. As discussed earlier Frith (1985) would suggest this is because phonological knowledge can be applied first to spelling. Carl's spelling errors are phonologically plausible but his reading errors simply share the initial letter of the target word, e.g. sand for sold (echoing Caravolas et al. 2001). He also cannot explain how he reads words or generalise his knowledge to read the error alternatives:

Experimenter: How did you read the word ground?
Carl; I thinked very hard.
Experimenter: What does this word say? (pointing to grouned)
Carl: it says groundy
Experimenter: What does this say? (pointing to grounded)
Carl: it says groundy

At time two we can see that as his spelling and recognition improved slightly his reading production had already reached ceiling. His spelling and reading understanding had also

become more explicit. In terms of spelling he had begun to abstract a theory of the morphological rule of –ed and was beginning to recognise it as a unit and refer to it in his explanations as to why words are wrong. However he was kept at E1B due to problems explaining why words are correct, just listing letters ad verbatim:

Experimenter: Why is sold correct?
Carl; it's got s-o-l-d (sounds out)
Experimenter: Why is soled wrong?
Carl: it's got –ed
Experimenter: Why is solded wrong?
Carl: it's got -ed

His understanding of reading also improved although still lagging behind that of spelling slightly. Despite his ceiling performance in single-word reading, errors were creeping in to his recognition, identifying error words as target words but reading them as the target word. He was accessing phonologically based error representations and was able to provide some basic explanations for how he reads words:

Experimenter: Which word is real? (points to filled, filld, fild)
Carl: that one, (points to filld) and it says filled
Experimenter: How did you read it?
Carl: I did f-i-uld, filled
Experimenter: What does that say? (points to filled)
Carl: it says fil-ed
Experimenter: How did you read it?
Carl: it's f-i-l-l and then e-d

At time three Carl continued to make progress on his spelling production correctly forming phonologically plausible words, e.g., lost, soft and although he made an error on his reading, filled was read as fill-ed, performance was still approaching ceiling.

However his understanding of spelling and reading remained unchanged following a morphological theory for spelling and a phonological theory for reading.

However four months later at the end of the study Carl had made quite a lot of progress. His reading production was back at 100 %, his recognition improved, as had his spelling. Clearly the latter was still his weakest but out of the four he spelt correctly one shows correct use of the –ed rule: filled. This showed that his understanding of –ed was now filtering through into his spelling production and this showed real progress. His understanding of spelling had also improved by one more level to E2 showing that an increasing balance between theory and information in the environment iproduced more explicit representations, better recognition and more comprehensive explanations:

Experimenter: Why is kissed correct?
Carl: it's got two s and an –ed
Experimenter: Why is kised wrong?
Carl: it should have two s but the –ed is good
Experimenter: Why is kissd wrong?
Carl: it doesn't have –ed

The most striking change though can be seen in Carl's understanding of reading as it caught up and matched that of spelling. This demonstrates the trend seen in children from group 1 where understanding was increasingly matching once the E1B level had been passed for spelling. This indicates explicit knowledge representations that can be equally applied to spelling and reading tasks even if the nature of the tasks is slightly different. Carl also demonstrated another group 1 trend as he had a greater rate of reading development, improving by three levels. He can now more explicitly demonstrate how he reads words, breaking them up into component parts and generalising his knowledge in order to read the errors.

Experimenter: Which is the real word? (points to lost, losed, losted)
Carl; that one (points to lost) and it says lost.

Experimenter: How did you read it?

Carl: there's lo and then I added it to st to make lo-st, lost

Experimenter: What does this say? (points to losed)

Carl: it says losed

Experimenter: How did you read it?

Carl: it's the word lose and then d to make lose-d, losed

Experimenter: What does this say? (points to losted)

Carl: it says losted.

Experimenter: How did you read it?

Carl: it's the word lost and then just add ed to it, lost-ed, losted

Carl's progress has not only demonstrated the explicitation process and the relationship between performance and understanding, he has shown that although understanding of spelling initially acted as a pace maker, his understanding of reading had caught up by the end of the study.

Low Achievers Example: Joanne

Table 3: Joanne's performance in spelling, reading, recognition and the four PhAB tasks at each time point.

Measure	**T1**	**T2**	**T3**	**T4**
Spelling	0	0	1	3
Reading	0	3	7	7
Recognition	3	6	3	5
Alliteration	7	7	9	9
Allit/pictures	7	8	8	8
Rhyme	7	6	9	13
N/W Reading	0	0	6	9

Table 4: Joanne's allocation to spelling and reading representational levels at each time point, and number of levels improved

Measure	T1	T2	T3	T4	No Levels	Diff
Spelling	PI	IMP	E1B	E1B	3	1 > S
Reading	PI	PI	IMP	E1A	2	

Tables 3 and 4 indicate the progress that Joanne made throughout the study in terms of performance and understanding of spelling and reading. She is a useful contrast to Carl as at the start of the study she failed to spell or read any of the words and showed poor recognition. Her spellings bore little resemblance to the target words unlike the phonologically plausible errors made by Carl: e.g., s for soft. When reading she did not even attempt a guess and would name the initial letter of the word but nothing else. Accordingly her understanding of both spelling and reading was deemed pre-implicit as there was only rudimentary knowledge of letter names and sounds. For spelling she only identified target words at below chance level and could not explain why words were correct or incorrect:

Experimenter: Why is losted correct?
Joanne: it's got l in it
Experimenter: Why is lost wrong?
Joanne: I don't know
Experimenter: Why is losed wrong?
Joanne: I don't know.

Similarly for reading she could not read any of the words she chose as being the real word and therefore could not explain how she read them.

Experimenter: Which of these is the real word? (points at slept, slepted, sleped)
Joanne: that one (points at slept)
Experimenter: What does it say?

Joanne: it says sock
Experimenter: How did you read it?
Joanne: I just knew

At time point two we can see that Joanne made some progress in her single-word reading and recognition although she still could not spell any of the words, e.g. sof for soft although her errors were improving. Despite this her understanding of spelling had improved to implicit as she was recognising target words above chance level. However she could not justify her choices or explain why the error alternatives are incorrect.

Experimenter: Why is cold correct?
Joanne: it's got c
Experimenter: Why is coled incorrect?
Joanne; it's got l
Experimenter: Why is colded incorrect?
Joanne: it's got l

Her reading however remained at the pre-implicit level despite her slight performance improvement in the single-word task. This has not translated into the recognition task. We can therefore see the mismatch between spelling and reading as understanding of spelling was starting to act as a pace maker, just as it did for Carl.

At time point three Joanne's progress continued with her first correct spelling: soft and much improved reading performance. However her recognition dropped which makes sense when we see that her representational level for spelling was E1B. The progress of two levels in four months is impressive and can be seen in the aspects of phonology and morphology used in her explanations. It can also be seen in the recognition errors being made as her theories are over generalised:

Experimenter: Why is sleped correct?
Joanne: it's got sl

Experimenter: Why is slept wrong?
Joanne: it's got p-t not –ed
Experimenter: What is slepted wrong?
Joanne: it's got to have p not t before the –ed

Her understanding of reading also improved although the rate was slower than for spelling (another contrast to Carl) as she was now displaying implicit representations choosing and reading target words above chance. This is an interesting contrast to her recognition score on the spelling task: there is evidence here of unstable or multiple representations that are tapped according to task. In the reading recognition task she was still unable to read errors and only explained how she reads words by listing letters ad verbatim:

Experimenter: Which is the real word (points to ground, grouned, grounded)
Joanne: this one (points to ground) and it says ground
Experimenter: How did you read it?
Joanne: g-r-o-u-n-d (says each letter name)
Experimenter: What does this say? (points to grouned)
Joanne: um, grunder
Experimenter: What does this say/ (points to grounded)
Joanne: um, grunder again

At the end of the study, although Joanne's single-word reading stayed the same her recognition and spelling production improved although the latter was still dominated by phonological errors: no correct use or otherwise of –ed. Her understanding of spelling remained the same at E1B although her improvement in recognition may signal some change. Understanding of reading had reached E1A and was only behind spelling by one level. Joanne was now starting to choose errors as real words but reading them as the target word. Basic phonological explanations were starting to emerge:

Experimenter: Which of these is the real word? (points to filled, filld, fild)

Joanne: this one (points to filld) and it says filled
Experimenter: How did you read it?
Joanne: f-i-l-l is fill
Experimenter: What does this say? (points at filled)
Joanne: its fill-ed
Experimenter: What does this say? (points at fild)
Joanne: filled as well but its spelt wrong, should have two l's

At the end of the study Joanne's levels of explicit knowledge of spelling and reading were lower compared to Carl's and there was still a mismatch between her reading and spelling levels. However her rate of improvement was comparable and it is plausible to suggest that if tested again perhaps in another four months she may have show similar scores to Carl, certainly using this set of stimuli. A final interesting aspect to draw attention is performance on the PhAB tasks. Carl reached ceiling on the alliteration tasks very quickly and Joanne was showing this trend by the end of the study. However Joanne's non-word reading abilities were still much lower even at the end of the study. Although she was applying her phonological knowledge and pre-existing knowledge of similar words to non-words she was still struggling to decode a little. This is complementary to the basic phonological skill she was showing in her E1A understanding of reading.

Conclusion

The case studies of Carl and Joanne have proved useful. The in-depth analysis of performance and understanding has demonstrated the process of explicitation that can occur in spelling and reading representations over time. Furthermore it has demonstrated the difference between children in the two groups particularly in the relationship between spelling and reading understanding. Finally and importantly Joanne's case in particular has shown how incomplete developing representations are leading to different performance and understanding on similar tasks and likely access to multiple representations.