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The development of children's orthographic knowledge: A microgenetic perspective

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**THE DEVELOPMENT OF CHILDREN'S ORTHOGRAPHIC KNOWLEDGE:
A MICROGENETIC PERSPECTIVE**

by

Ann C. Sharp

**Bachelor of Science
University of Utah
1991**

**Master of Education
University of Utah
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**A dissertation submitted in partial fulfillment
of the requirements for the**

**Doctor of Philosophy Degree in Learning and Technology
Department of Educational Psychology
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ABSTRACT

The Development Of Children's Orthographic Knowledge: A Microgenetic Perspective

by

Ann C. Sharp

**Drs. Ralph E. Reynolds & Gale M. Sinatra, Examination Committee Chairs
Professors of Educational Psychology
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Literacy scholars traditionally described spelling development as a stage-like progression of increasing orthographic understanding measured by orthographic feature errors children used but confused (Henderson, 1980; Ehri, 1992). Overlapping Wave theorists defined spelling development as a series of adaptive choices between sophisticated and unsophisticated spelling strategies measured by the type and amount of strategies children used (Siegler, 1996). To disentangle discrepancies found between the alternative viewpoints, the current study: replicated and extended a previous investigation that described spelling development as overlapping waves (Rittle-Johnson & Sieger, 1999); investigated differential feedback conditions as a source of spelling growth; and examined correlates between orthographic features and spelling strategies used by low-ability first-grade students. The study used a trial-by-trial microgenetic approach combining statistical and observational methods. The study found evidence of spelling development proceeding in accumulative phases, continuously, and in overlapping waves concomitantly. Results defined three feature-strategy

relationships: 1) direct relationships between orthographic feature knowledge and spelling strategy use, 2) time-sensitive relationships dependent on the depth of orthographic understanding, and 3) stable relationships not affecting strategy use. Individual differences in children's growth rate uncovered the Matthew effect (Stanovich, 1986). Additionally, the study illustrated the advantages of a microgenetic mixed design.

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CHAPTER I

INTRODUCTION

Developmental Debates

Developmental psychologists have debated for decades whether children's cognitive development proceeds in stages mediated by innate tendencies or in small incremental degrees mediated by experience and learning (Bjorklund, 2000). These different perspectives have been discussed within and across various domains, including the development of spelling ability. A third more recent alternative suggests that cognitive development proceeds adaptively and is characterized by overlapping waves (Siegler, 1996). Cognitive psychologists such as Piaget, Vygotsky, and Siegler offer viewpoints that illustrate each debated perspective.

Piaget suggested that development was stage-like. He characterized development progressing in discrete levels of acquisition that displayed thinking, beliefs, and behaviors differing in kind and influenced by innate tendencies (Slavin, 2000). Each of his four stages of development represented a qualitatively different way of thinking than the previous or following stages. He saw development as preceding learning.

Vygotsky postulated that development was continuous. He characterized development as progressing recursively in a generally forward sequence that

displayed thinking, beliefs, and behaviors smoothly increasing in degrees. He suggested that experience, others, and the environment influenced development, and that practice mediated change (Wink & Putney, 2002). He saw learning as preceding development.

Siegler (1996) suggested that development occurred gradually over time, and adaptively as children chose among a variety of beliefs, thinking and behaviors at any one time. He characterized development as overlapping waves during which children held on to established thinking and strategies even though they were more advanced. Sometimes, early, unsophisticated strategies prevailed and then became less frequent. Yet, some unsophisticated strategies prevailed and remained constant. He saw adaptiveness in learning as preceding development.

Siegler's theory aligned with Vygotsky's in that ability developed recursively, in a somewhat continuous fashion. However, changes in ability overlapped one another instead of flowing incrementally, and those changes were mediated by adaptive decisions not experience. (Refer to Figure 1 in Chapter 2).

Subsequent literacy scholars and psychologists have echoed these diverse perspectives on development. The stage-like progression outlook theorized that reading and spelling developed in levels described by the kind or type of decoding or encoding a child displayed (Ehri, 1991; Frith, 1985). As children encountered more and more words their immature decoding and encoding behavior adjusted to meet the increasing demands of the writing system. Children moved into the subsequent stages under the right circumstances,

including an increase of phonological awareness and intent to encode all the letters (Gough & Hillinger, 1980).

The continuous perspective hypothesized that advancement in reading and spelling acquisition happened when quality in word representation increased (Perfetti, 1992; Perfetti, 1997). Quality of word representation increased as children's sensitivity to letter sequence and position accumulated with experience in reading and writing. At the same time, letter-sound correspondences created a redundant effect as children simultaneously recognized words when reading and produced them by pronouncing letter-sound correspondences. Sensitivity to spelling patterns and redundancy of sound associations aided the quality of words represented in memory until word recognition became automatic.

The overlapping wave perspective suggested that incremental spelling growth occurred as individuals made adaptive choices among strategies they used to spell words (Rittle-Johnson & Siegler, 1999). Spelling behavior changed over time as children adapted a variety of strategies to the goal of being correct, as children chose the most effective strategies more often, and as strategies became increasingly quick and accurate. This point of view characterized spelling development as an overlapping of sophisticated and unsophisticated spelling strategies chosen adaptively.

These three theories of the development of reading and spelling leave us wondering just what path children do take when acquiring these critical skills. Does reading and spelling development occur as discrete stage-like changes that progress in kind? Is development an accumulative, continuous change that

progresses in degrees? Or, is spelling development an accumulative, continuous change that progresses in overlapping adaptive strategy use? One of my goals for this study was to provide a more theoretically precise description of spelling development with the hope of resolving some of the existing discrepancies.

To accomplish my goal, I took a preliminary look at the empirical studies investigating the development of spelling ability. Empirical spelling studies represented only two developmental perspectives: the stage theory proposed by Henderson (1981), and other literacy scholars (Ehri & Wilce, 1982; Gentry, 1982; Schlagal, 1989) and the overlapping wave theory proposed by Rittle-Johnson & Siegler (1999). The Vygotskian viewpoint had little or no representation among empirical spelling studies. Perfetti (1992) theorized the continuous stance for reading acquisition; however, actual empirical studies supporting the theory were limited. I found only one study (Rieben & Saada-Robert, 1991) where findings referred to support for Perfetti's theory, but focused more on the notion of an interactive construction. This allowed me to narrow the scope of my study to an investigation of spelling stages and the overlapping wave model. As I questioned the two theory's ability to coexist, I found differences in their methodological approaches, and I found literacy theorists within the stage-like progression perspective questioning theoretical tenets.

Stage theorists noted that spelling stages were less distinct and less well defined as they transitioned (Treiman, 1993; Ehri, 1992). Schlagal (1992) states, "The invented spelling of individual children do not always fit exclusively into a

single stage. At any one time, some spellings of a child may be correct while others may fall across one into another of the orthographic stages" (p. 46).

Discrepancies within the literature pointed to alternative views about spelling development. Rieben and Saada-Roberts (1997) raised the issue that conformed more to an interactive construction than a stage theory. In their words: "If we consider the flexibility in strategy use as a psychological phenomenon rather than just background noise, then we must also find an explanation for it" (p. 313).

In addition to theoretical concerns, methods used to study spelling development vary. Stage theorists collected data that used misspelled words, and they analyzed them using orthographic feature errors. The overlapping wave theorists collected data by observing children's spelling strategies and interviewing the children immediately after they spelled each word. Also, only once had observation of overt behavior followed by immediate retrospective self-report been applied to spelling development (Rittle-Johnson and Siegler, 1999).

Statement of Problem

These contrasting theories and data sources called for further investigation. The current study was designed to extend the work begun by Rittle-Johnson and Siegler (1999) through the investigation of the following research questions:

1. Can Siegler's (1995) Overlapping Wave Theory characterize orthographic development?
2. Will differential feedback influence accuracy rate in spelling acquisition, providing evidence of growth?

3. What is the relationship between spelling strategy use and observed spelling error patterns?

The first question asked if the current study could find evidence of the overlapping wave model. Three elements were essential to establish support of the model among the spelling behaviors of the participants. Those elements are variability, gradual change, and adaptability.

I examined variability by identifying the types and numbers of strategies used by children as they spelled words. A qualitative analysis identified spelling strategies and tabulated the range of strategies used, changes in strategy use, and use of strategies in combination. Quantitative methods verified classifications of strategies, percentage of strategy use, and significance in increase or decrease of use with each strategy.

Adaptive choice was determined by using an accuracy rate for each spelling word as a difficulty measure. Rittle-Johnson and Siegler (1999) showed that the more difficult the word, the more adaptive was the student's behavior. Therefore, children used more strategies to spell words that were more difficult and used fewer strategies when they were less difficult. Therefore, two conditions were created to highlight the relationships between errors of words spelled in one condition and percentage of strategies used to spell them in the other.

Rate of development was determined three ways. First, evidence showed changes in use of strategies through the variability analysis over sessions. Second, a related analysis evaluated changes in efficiency over sessions

measured by accuracy and speed. Third, growth trajectories predicted developmental growth in total word accuracy.

My second question asked if differential feedback was effective in influencing spelling growth. I created differential feedback conditions to answer this question. I randomly assigned children to one of two treatment groups and used multilevel modeling techniques to estimate student growth trajectories and to examine feedback effects (Raudenbush & Bryk, 2002).

The third question examined whether spelling stages and elements of the overlapping wave model shared any relationships. A qualitative comparison was conducted between error feature analysis and strategy use to determine relationships between the two developmental models. I conducted an error feature analysis on children's spelling attempts and compared strategy use data across spelling trials drawn from the variability data.

I accomplished the extension of the Rittle-Johnson and Siegler (1999) study in several ways. I used a microgenetic methodological approach with a mixed research design. Rittle-Johnson and Siegler used a longitudinal design. Furthermore, I added differential feedback conditions, and I investigated not only spelling strategies children used but also orthographic feature understanding.

Hypothesis

I hypothesized that evidence in support of the overlapping wave model would be found. Children would use multiple strategies to spell words. They would use more strategies to spell difficult words than they would use to spell less difficult

words and gradually the more effective strategies would increase over sessions. Also, adaptive choice would lead to more accurate spellings and increase the effectiveness of spelling strategies.

In addition, I reasoned children would use more strategies more effectively when given feedback about an expert's reasoning in contrast to children who received feedback about correctness only. This would provide evidence that feedback with expert reasoning was an effective training for enhancing the rate of development.

Finally, I hypothesized that a positive correlation between error feature analysis and strategy use would reveal a relationship between the words children spelled and the process used to spell them. This relationship would depict a path of development where the mechanism that drives and constricts spelling development would denote an interaction between overlapping waves and discrete stage-like characteristics. In these ways, the current study would extend the work started by Rittle-Johnson and Siegler (1999).

CHAPTER II

REVIEW OF RELATED LITERATURE

Describing Cognitive Development: A Debated Issue

Educational psychologists describe development as the changes that take place in an individual as they adapt and mature over time. Maturation and experience from birth to death transform an individual's physical, social, moral, and cognitive characteristics (Slavin, 2000). Psychologists define cognitive characteristics as the processes and faculties of acquired and manipulated knowledge. Therefore, they define cognitive development as an individual's growing mental capabilities (Bjorklund, 2000). Children look and behave differently than adults, and they think differently. As a toddler one's notion of "reading" is centered primarily on the act of pretending. However, adults have multiple meanings and applications for reading (i.e. reading a book, traffic signs, and body language).

Developmental psychologists have studied and described the evolution and mechanisms of how change develops. Theories have often produced divergent conclusions. One disagreement has centered on how psychologists describe development. The debate was over whether development progresses in a pronounced, distinctive, qualitative stage-like way (in kind) or in an incremental, cumulative, quantitative way (in degree).

Those who thought development were distinctive, pronounced, and stage-like viewed development as a series of periods during which a person's physical, mental, or psychological performance was different from the periods preceding and following it (Bjorklund, 2000). Stage theorists defined stages in terms of typical or average age at which expected growth had a beginning and an end. Inborn functions drove stages of growth where innate tendencies constrained developmental changes. Maturational changes then created a transformation that produced a qualitatively different person than the individual was in the previous stage (Borich & Tombari, 1997).

In contrast, those who thought development was incremental and quantitative thought development had three attributes (Borich & Tombari, 1997). First, development was a continuous and smooth acquisition of new skills as the individual moved from one learning situation to another. Children's cognitive skills (e.g., thinking, reading, writing, and speaking) improved as children grew and developed. Second, development was cumulative. Old skills laid a foundation for newer skills, which resulted in increasingly complex sophistication. Finally, development was hierarchical. Complex skills came after prerequisite skills. Fundamentally this viewpoint described developmental change as an opportunity to learn while mastering necessary prerequisite skills (Slavin, 2000).

At the head of the debate were two predominant psychologists, Piaget and Vygotsky. Piaget's perspective led him to develop a stage-like theory and his research demonstrated evidence for his theory. Vygotsky's perspective led him to

view development proceeding in a cumulative, continuous way and his theory challenged Piaget's point of view.

The Piaget and Vygotsky Debate

Piaget postulated four stages of cognitive development: sensorimotor, preoperational, concrete operational, and formal operational (Slavin, 2000). Piaget theorized that patterns of thinking guide human behavior. He called these patterns "schemes". Schemes were mental structures that organized information, and each individual used them to process their world and to help them choose behaviors. Schemes were maturational and inherently genetic. Humans' biological predisposition towards creating schemes could be adapted when new information was introduced. Learning could not progress until one was developmentally ready.

Adaptation referred to the process of schemes responding to and adjusting to exposure to the environment. Piaget described this as the process of assimilation and accommodation. Assimilation took new experiences and fitted them into existing schemes. For instance, beginning spellers would have a scheme of matching sounds in speech to letters that represented the sounds. Each new phoneme-grapheme match they would make assimilated into their scheme of spelling. The scheme might include such things as *b* says /b/, and if you put /b/, /ă/, and /t/ together they would spell *bat*. Accommodation was modifying existing schemes to fit new experiences. Accommodation occurred when the beginning speller tried to spell *bait* and found his phoneme-grapheme matching scheme producing the word *bat*. Matching sounds to letters had not created a response in

the same way other phoneme-grapheme matching did. A modification of the characteristics of spelling words then occurred immediately (i.e., some words could not be spelled using straight phoneme-grapheme matching).

When an individual could not fully handle a new experience with existing schemes, the new situation created a state of disequilibrium. Equilibration was the process of trying to balance present understanding with new experiences. According to Piaget (Slavin, 2000) this inconsistency forced a natural process to occur which focused on restoring the balance. Old schemes were adapted either through assimilation or accommodation until a restored sense of equilibrium occurred. Equilibration was the process that facilitated learning. Children's old ways of thinking about the world emerged into new ways of thinking. The emergence of new thinking was the onset of a new stage.

Thus, Piaget believed that acquisition of knowledge and skills occurred in distinct stages that display knowledge and skills to be different in kind. Transitions from one stage to the next were fairly abrupt as adaptation responded to disequilibrium. In addition, human development progressed through fixed sequences governed by inborn factors. These innate tendencies were constantly striving to make sense of the world. As children manipulated and interacted with their environment they made cognitive changes.

In contrast, Vygotsky (1978) theorized that learning involved the steady internalization of the culture's different *sign systems* through the help of instruction and the help of others. A sign system consisted of symbols of a culture that helped people think, communicate, and solve problems. The number

system, writing system, and a culture's language were examples of sign systems. When individuals learned that a symbol of the sign system had meaning, this understanding guided the development. Improvement came over time with practice. Development was a recursive process that required successive practice and continual application of the part to the whole (Wink & Putney, 2002). Practice allowed a sign system to become internal and self-regulated. Development occurred gradually as these sign systems internalized.

The zone of proximal development was a level of development that was above an individual's present level. This zone was the optimum level at which an individual could learn and was considered the level at which development occurred. Learning through conversation and collaboration preceded development as tasks within this zone helped higher mental performance to improve (Wink & Putney, 2002). Scaffolding, help from an adult or more advanced mentor, provided support for social learning and problem solving, and operationalized over time mediated by language and action. (Table 1 displays the debated points between Piaget and Vygotsky and succinctly summarizes the issues surrounding the kind versus degree debate.)

Incremental versus Stage View of Literacy Development

The same developmental debate continued in the cognitive study of literacy acquisition. Ehri and Perfetti argued over the qualitative versus quantitative and discontinuous versus continuous issues in describing how children acquired word knowledge (Rayner, Foorman, Perfetti, Pesetsky & Seidenberg, 2001). Ehri and other literacy stage-theorists (Chall, 1983; Ehri, 1991; Frith, 1980; Gough &

Table 1

Piaget and Vygotsky

Piaget	Vygotsky
Discontinuous/ Innate	Continuous/ Environmental
Discontinuous	Continuous
<ul style="list-style-type: none"> ➤ Occurred in distinct stages. ➤ Based on kind or type. ➤ Qualitatively different behaviors, thinking and beliefs. ➤ Change occurred abruptly. ➤ Governed by inborn factors. ➤ Abrupt transitions. 	<ul style="list-style-type: none"> ➤ Occurred in a recursive flow. ➤ Based on degree or amount. ➤ More complex behaviors, thinking and beliefs. ➤ Change occurred gradually. ➤ Governed by the environment. ➤ Smooth transitions.
Innate	Environmental
<ul style="list-style-type: none"> ➤ Linked to innate tendencies. ➤ The child was an active organism. ➤ Resulted from manipulation of environment. ➤ Development preceded learning. 	<ul style="list-style-type: none"> ➤ Linked to interaction w/others. ➤ The child was a social being. ➤ Resulted from interaction with others. ➤ Learning preceded development.
Piaget and Vygotsky Agree:	
<ul style="list-style-type: none"> ➤ Development was sequential and the sequence was the same for all. ➤ The rate children developed was variable and differed from child to child. ➤ Skipping sequences of development was impossible. 	

Hillinger, 1980) suggested that behaviors children displayed characterized stage-like development. Reading developmental stages based themselves on a series of different types of decoding strategies children used. Children attempted to read in the earliest stage by using associations between the visual form (letters) and the spoken word. They did not yet recognize complete words or connect individual sounds to letters. Referred to as the logographic stage, children learned to read words by their shape or by some logo that accompanies the word (Frith, 1980). Gough and Hillinger (1980) referred to this process as paired-associate learning, because children were pairing a visual cue with the spoken word in order to read words. A subsequent stage was when children began to recognize that sounds map onto letter symbols. Children read words using partial letter cues. Names of letters bridged phonology (Ehri, 1991), and eventually phonemes were mapped to letters. Referred to as the alphabetic stage, children started to use and to understand the alphabetic principal. Finally, in the orthographic stage (Frith, 1980), children achieved a sufficient knowledge of spelling patterns by recognizing their reoccurrence across words as they read unfamiliar words.

The alternative view for the development of word knowledge was an incremental argument. According to this viewpoint, change in reading behavior was a result of the amount and complexity of knowledge that accumulates gradually and with experience (Perfetti, 1992). In other words, increased sensitivity to the structure of words and the sounds they represent grows and increases until word identification becomes fast, accurate and automatic.

Perfetti (1992) explained this view of reading development as accumulative process. He proposed that more and more words became a part of the lexicon (an abstract mental structure that holds words) as children increased their amount of reading. Word representations increased in two ways. First, the amount of letters that specifically represented correct spellings increased. For instance, a beginning reader would only partially represent the word *black* with a “b/” in their memory. Over many successful attempts to read *black* the child’s memory would begin to recognize with increasing accuracy all the letters in their correct positions. Perfetti referred to this as specificity or precision. Second, redundancy of sounds occurred as specific grapheme-phoneme (letter-sound) correspondences were repeated with word pronunciations. Sounds at the letter and word level provided a redundant presentation that aided in high-quality word representations. A reader moved from sounding-out words to automatically retrieving words as precision and redundancy increased the quality of word representations.

Ehri (1991) and Perfetti’s (1992) debate was another example of the quantitative and qualitative developmental debate. Kind versus degree and abrupt transitions versus gradual change were a part of the conversation for decades. Piaget and Vygotsky (Slavin, 2000), and Ehri and Perfetti (Rainer, et al., 2001) demonstrated the difficulty of precisely describing developmental progressions. The argument has been difficult to resolve. There is an abundance of evidence to support both sides of the issue. Flavell (1971) took the debate head on and argued against stage theory. His review of the four main

assumptions of stage theory provided insights that help us better understand the issues surrounding the debate.

Stage View of Development Argued

Flavell (1971) presented stage theory as having four main assumptions. The first assumption was that stages were qualitatively different from each other with each stage having its own unique set of characteristics. Flavell referred to these characteristics as “developmental novelties” because they were not merely improved or more efficient but exclusive. The qualitative view of development suggested describing progress in kind rather than degree. However, Flavell would argue that change seemed to proceed both in kind and in degree. He suggested incremental practice mediated eventual qualitative changes.

The second assumption characterized stages as discontinuous with little transition from one stage to the next. They were abrupt and step-like. New behaviors appeared suddenly and functioned at a mature level from the onset. All skills and thinking within the stage made the leap at once. The transition period between the initial appearance of each skill and the skill's state of functional maturity was zero (Bjorklund, 2000; Flavell, 1971). Flavell pointed out that this viewpoint led to the conclusion that individuals spent their time “being” rather than “becoming.” Cognitive psychologists witnessed steady growth in too many examples of intellectual development to support such a theory (Bjorklund, 2000). For instance, the acquisition of language throughout early childhood was an innate cognitive skill that developed in a regular sequence over the span of a few years (Lenneberg, 1967). The development of babbling, even though presented

in five stages, progresses steadily over 9 to 18 months from reflexive crying to sounds filled with a variety of intonations and rhythm (Stark, 1978). Myelination was a biological example of continuous growth. Myelin is a fatty substance that surrounded the neurons in the brain. Myelin promotes faster transmission of electrical signals as it builds up around the nerve fibers. The process of myelination starts before a child is born and steadily continues into adolescence and beyond (Bjorklund, 2000).

A third assumption was the notion that various characteristics defining a given stage developed simultaneously. The entire assembly of stage-level skills and thinking occurred in a closely related manner. This was referred to as homogeneity (Bjorklund, 2000), or concurrence (Flavell, 1971). Cognition was relatively thought to be uniform. A toddler acts like a toddler in everything he/she says and does (Bjorklund, 2000). There was evidence of orderly and sequential behaviors throughout different populations and over time. Most children would go through the same sequence of developmental behaviors as they grew from infancy to adulthood, although not necessarily at the same rate (Flavell, 1971). The ambiguity surrounding concepts like “simultaneous” development, and skills and thinking progressing “together” argues this assumption (Flavell, 1971).

The fourth assumption of stage theorists was that stage-specific skills and thinking became organized and interrelated to form cognitive structures. These structures were defined as a set of cognitive skills or concepts that were somehow interrelated to constitute an organized whole (Flavell, 1971). Generally, structures referred to some part of the living organism like muscles or limbs that

grew and changed. Cognitive structures were hypothetical. They were mental constructs, faculties, and abilities that underlie intelligence and change with maturity (Bjorkland, 2000), like the lexicon.

Although psychologists debated stage theory, the last aspect of the theory they did not. The existence of cognitive structures and their interactive relationship with internal or external activity was well accepted (Bjorklund, 2000). Internal and external activity referred to different sources of stimulation affecting the structure. The structure was external when activity was stimulated by sources originating outside the structure. This stimulus was often experience. For instance, an individual's lexicon grew and changed over time in direct relationship to the degree the individual experienced reading and writing (Stanovich, 1986). The structure was internal when activity was stimulated by sources originating inside the structure. This stimulus was use of memory. For instance, the lexicon grew and changed over time in direct relationship to the degree the individual remembered a known word like in the act of comparing it with an unfamiliar word.

Flavell's (1972) analysis of stage theory's four underlying assumptions underscored the complexity of describing cognitive development. Piaget and Vygotsky debated its complexities, and the debate reverberated within the field of literacy influencing what we know about reading and spelling. Flavell suggested:

Stage-to-stage development is most conspicuously marked by genuinely qualitative changes in the child's repertoire of cognitive "items" (cognitive skills, rules, strategies, etc). Such development also entails cognitive

modifications of a more quantitative sort, however, and these may play an important role in the genesis of the more dramatic, stage-defining, qualitative changes (Flavell, 1971, pg. 450).

Is development an interaction between these two ways of progressing? Do they coexist? Literacy theorists have called for more fine-grained studies clarifying the realities behind the controversy (Ehri, 1992; Ellis, 1997). Answers to these questions about spelling development depend somewhat upon the foundation of our prior knowledge. The historical debates provide a foundation for further inquiry. Also, the historical framework of the study of spelling offers a more precise description of spelling development. The conceptual changes made by cognitive psychologists and literacy scholars show insights and greater understanding of the nature and complexity of spelling. The following historical perspective sets the tone for the current investigation.

Spelling Development

An Historical Perspective

Research psychologists have been interested in spelling for a relatively short time. Although spelling was a subject of intense study, particularly in the first half of the 20th century, psychologists have been slow to take note. Evidence of this could perhaps be illustrated by looking at the *Handbook of Psycholinguistics* (Gernsbacher, 1994), a reference book dedicated to covering the basic topics of the field. This text had no references to spelling. Perfetti (1997) and Treiman (1997) had observed this relative neglect of spelling research as well. The

neglect was attributed to three major established views: (a) Linguists who give scientific privilege to spoken language above written language (Jaffre, 1997), (b) a general public notion that spelling was more of a literacy convention than a scientific problem (Jensen, 1962; Spache, 1940), and (c) cognitive psychologists' view of spelling as a less challenging mental process than reading, which had proven to be a deceptive notion (Perfetti, 1997).

Evidence of these less enthusiastic attitudes toward the study of spelling has been demonstrated among researchers and educators alike. For instance, in the 1960s researchers used spelling behavior to investigate how individuals recalled memorized sequences (Jensen, 1962), a task not considered very challenging. Currently, educators assign weekly lists of random words to memorize and retrieve during an end-of-the-week spelling test (Thompkins, 2003). Despite beliefs that words should be learned by rote memorization and that spelling is a mere convention, observant researchers began to appreciate children's creative attempts to invent spellings. Durkin (1966) discovered that the ability to spell seemed to lead to an ability to read for children whose writing came first. Her discovery attracted the interest of many psychologists and educators.

One of those individuals was C. Chomsky. Her seminal research (1971) focused on the nature and development of early writing behaviors. She noticed that when children did not know how to read, their spellings did not conform to convention. Instead, children used their knowledge of letter names and sounds as they attempted to sound words out. She concluded that children's attempted

spellings developed into a greater incorporation of the phonemic structure of the English language.

Read was a student of C. Chomsky's. His linguistic background and interest in children's writings provided energy for further examination of spelling behavior. While observing preschoolers, upper-class children from professional families, he found that some of them began to write words on their own without formal instruction. Their attempts demonstrated a crude understanding that letters symbolized sounds in words. These crude attempts were nicknamed inventive spelling.

Read (1986) was the first to demonstrate the interesting characteristics of children's invented misspellings. For instance, he discovered that children spelled words using letter names (i.e., EGL for *eagle*) and omitted preconsonantal nasals (i.e., BOPY for *bumpy*). Preconsonantal nasals were letters like *m* and *n* that were made as a result of air passing through the nasal passage and when spelled occurred in front of another consonant (Bear et al., 2000). Read's work provided evidence that young children's attempts at spelling were not a result of rote memorization (Spache, 1940), but instead a deduction of correspondences between sounds and letters.

C. Chomsky and Read's research set the stage for others. Much of the subsequent spelling research (Ehri, 1982; Frith, 1985; Henderson, 1980; Treiman, 1993) had changed largely based on the foundation of their findings. Other scientists adhered to the underlying logic and impressive regularity of the English spelling system C. Chomsky helped to uncover (Chomsky, 1970;

Templeton, 1980). Scientists still looked for the same errors that Read discovered and interpreted them in similar ways (Read, 1986; Treiman, 1993).

By the 1980s scientists recognized spelling as a complicated cognitive process (Frith, 1980a), and children's invented spellings as a creative induction of the writing system (Read, 1986). Spelling was now a way to encode speech. Although spelling was still subject to social contracts enforced by authority (i.e. the dictionary), spelling was now more than an arbitrary conventional phenomenon. Yet, C. Chomsky and Read only implicitly suggested that the writing system was a linguistic structure.

Treiman's (1993) work was the first explicit attempt to link spelling development with a psycholinguistic approach. She showed how spelling was a manifestation of linguistic structures. Spelling was the encoding of linguistic forms, phonology, and morphology, into writing (Jaffre, 1997; Perfetti, 1997). She provided evidence that these linguistic forms directly impacted spelling acquisition.

Treiman explicitly linked the linguistic form of phonology to spelling. Phonology was a part of linguistics that concerned itself with sound patterns. Phonology has several levels of abstraction. The smallest unit of sound in speech was the phoneme unit. This phonological level had proven to be a crucial factor in the acquisition of reading and spelling. Phoneme awareness was essential because the ability to spell an alphabetic language like English required a child to segment sounds into phonemic units. In other words, to learn to spell (and to read as well) a word like *cat* was consciously segmented into three small

units /k/, /ă/, and /t/. Speaking the word was without conscious awareness of the word's segmented parts, so being able to speak the word was of little help (Shankweiler & Liberman, 1972).

Treiman (1993) pointed out that phoneme to grapheme mappings were not a simple straightforward process. In English there were some graphemes that represented more than one phoneme (i.e., *k*, *c*, *ck*). These multiple representations of sound were not always possible to predict when they occurred within a spelling, because of exceptions to the rules. Also, some graphemes had more than one phoneme (i.e., the vowels, *a*, *e*, *i*, *o*, and *u* have multiple sounds).

In addition to phonology, Treiman explicitly linked the linguistic form of morphology to spelling. Morphology was the linguistic form that concerned itself with meaning. Morphemes were the smallest unit of speech that carried meaning. For instance, "s" was a morpheme unit often found on the end of a noun indicating a plural meaning. Morphological considerations often overrode phoneme/grapheme considerations. This was because in English consistently spelled morphemes made phoneme-grapheme mappings inconsistent (i.e., *sign*, *signal*, and *sane*, *sanity*). We keep the morpheme spelling even if the pronunciation changes. Treiman showed that these linguistic forms, phonology and morphology, impacted spelling.

Treiman's (1993) results showed that children do attempt to represent phonological forms such as phonemes of words when spelling, but do not usually understand or incorporate morphological forms accurately without instruction. Also, she provided evidence that classification of spelling errors should include a

consideration of which phoneme is represented by which letter. This was because children's attempts to spell words were attempts to represent the sounds of words.

A correlation existed between the realization of the complexity of the spelling process and the number of spelling research studies. Researchers now postulated theories about spelling and even debated them. Moreover, a linguistic analysis of the English language provided insights not only into spelling but also into reading development, and literacy scholars began to pursue the relationship of reading to writing in a quest to understanding the nature of their development.

Henderson and Beers (1980), Ehri (1992) and Frith (1985) demonstrated that spelling was not just a creative encoding of speech suggested by Chomsky and Read nor merely tied to linguistic forms as suggested by Trieman. They noticed when looking at the characteristics of children's misspelled words that they could categorize spelling attempts into stages of spelling growth. They determined that using letter names and omitting preconsonantal nasals were error features that were typical of an initial stage where understanding of letter-sound correspondences began (Ehri, 1992; Henderson, 1980).

Spelling Development Theories

Most spelling development theories traditionally assumed spelling to be a stage-like process. They hypothesized several developmental models as seen in the work of Frith, Henderson, and Ehri. The description and comparison of their theories of spelling development follows.

Frith's Stages

Frith (1985) proposed a three-stage model for reading and spelling: logographic stage, alphabetic stage, and orthographic stage. The logographic stage was when the child did not know the word but guessed it based on the word's appearance. The alphabetic stage was when a child decoded a word letter by letter using a direct mapping between phoneme and grapheme. The alphabetic stage provided foundational knowledge that allowed children to later decipher unknown words and nonsense words. The orthographic stage was the final stage where children analyzed words instantly into orthographic units (multiple-letter groupings) and bypassed phonological conversion. Frith implied that practice at this stage led to identifying whole words without sounding out letters.

Frith's model suggested interdependence between reading and spelling. She made three claims: 1) Reading logographically lead to spelling logographically. 2) Spelling alphabetically preceded reading alphabetically and acted as a pacemaker for reading development. 3) Reading orthographically preceded spelling orthographically and acted as a pacemaker for spelling orthographically. In this way, reading and spelling strategies were interdependent and mutually supported each other as they developed. One stage of reading development was a pacemaker to another stage of spelling development, which was a pacemaker to the next level of reading (Frith, 1985). Alternative views to Frith's interdependence theory were the notions that reading and spelling shared the

same lexical source (Perfetti, 1997) and that general word learning processes influenced both reading and spelling interactively (Ehri, 1997).

Henderson's Stages

Henderson (1980) developed a spelling stage theory by wondering whether the spelling of children who learned to write at a public school, resembled the spelling of the high socio-economic status preschool children Read had observed. Henderson and his doctoral students at the University of Virginia's McGuffey Reading Center examined the spelling of elementary school children (Templeton & Bear, 1992). They proposed a theory of spelling development that included six distinct stages based on their findings: nonphonetic, semiphonetic, phonetic, within word pattern, syllables juncture, and derivational constancy (Schalgal, 2001). A brief description of each stage follows:

Nonphonetic stage. The first level of spelling development was the nonphonetic stage. In the beginning of this stage children pretended to write. Their writing may look letter-like but to an adult it appeared to be mostly scribbling and was unreadable. Even correct letterforms appeared random and unconnected to speech. Children even used numbers as part of spelling attempts. A few letters, especially those in the child's name, may have been recognizable, but there was no understanding on the child's part that letters represented sounds. Their earliest efforts showed no evidence of phonological insights and therefore, were nonphonetic (Read, 1986). For instance, one child wrote BQS2NF and reported that she was writing a letter to her grandmother.

Semiphonetic stage. The second stage of spelling development was the semiphonetic stage. Partial alphabetic knowledge was emerging as children used the names of letters and the sounds of letters embedded in the letter name to help them spell words. Children would often use BD for *bed* or RUDF for *Are you deaf?* They substituted the names of the letters for the relevant sounds. Often the vowels and the final sounds were omitted (Morris & Perney, 1984). Children in this stage were just beginning to recognize that graphemes (letters) correspond with phonemes (sounds), and their understanding was incomplete. They slowly became more aware of phonemes based on their experience of exploring the sounds within a syllable as well as through the influence of instruction (Perfetti, Beck, Bell, & Hughes, 1987). Usually children discerned first the initial sounds followed by the final sounds and then the medial sounds (Morris, 1999).

Phonetic stage. The phonetic stage showed spellings that included letters for most of the phonemes in the word, although spellings often omitted letters whose sounds in speech were hard to detect. Consonant blends in both the initial and final positions were often partially represented. Letters frequently omitted were preconsonantal nasals and schwa vowels as illustrated in the word *jump* often spelled at this stage JUP, and the word *tunnel* often spelled TUNL. For the most part children spelled short consonant-vowel-consonant (CVC) words correctly. Vowel sounds sometimes represented the name of the vowel that fit closely with the point of articulation (e.g., BAD for *bed*, or SEK for *sick*). Spellings represented long vowels correctly but without the orthographic features that set

them apart (e.g., SMIL for *smile*). Past tense *-ed* endings and the plural *s* were often represented phonetically so *marched* would be spelled MRCHT and *tens* would be spelled TENZ. In fact, as children explored phoneme-grapheme relationships their spellings were more phonetically accurate than complete retrieval suggested. As they grew in experience with phonics instruction and reading connected text their spellings grew more complete and more conventional (Schlagal, 2001).

Within word pattern stage. During the within word pattern stage children started paying attention to English orthography. More abstract features of the writing system became part of their analysis. They recognized that *ck* never began a word but may end one, and they became less likely to spell *cut*, CKUT. They began to notice and pay attention to silent vowel markers like the silent *e*. At the same time they often confused silent vowel markers, spelling SNAIK for *snake* or FELE for *feel*. Overgeneralizations were common. It was not unusual for a child to use the silent *e* with words that don't need one (e.g., NETE for *net*).

Within word spellers started to realize that not all words were consistent with letter-sound correspondence rules. They came to know that even though *have* and *some* did not have long vowel sounds, the words spelled as if they did. As they began to pay attention to spelling patterns and noticed how spelling patterns drove specific phonemes, children were able to let go of their preoccupation with speech sounds and concentrated more fully on the patterns within words (Invernizzi, M. 1992).

Syllable juncture stage. The fifth stage of spelling development was the syllable juncture stage. Children in this stage were now looking at spelling patterns across syllables. They had mastered the basic patterns in one-syllable words and were looking at polysyllabic words where inflected endings often required manipulation of the root word (i.e., hop/ hopping versus hope/hoping). The junctures between syllables could be challenging especially since there were a number of exceptions to rules. This stage's greatest complexity occurred when prefixes were absorbed in the spelling of a root and were reflected in both the pronunciation and spelling (i.e., addition and community). The syllable juncture stage required developing spellers to acquire another layer of abstraction distinct from the spelling patterns learned during the within word stage.

Derivational constancy stage. The final stage of spelling development was referred to by three different names: derivational relations stage (Bear et al., 2004), derivational constancy stage (Schlagal, 2001), and the correct stage (Gentry, 1982). In this stage, spellers learned about the derivational principles of some polysyllabic words that focused on roots and word meanings. They learned that the pattern-sound correspondences often gave way to meaning, and in spite of pronunciation, spellings remained constant to their Latin or Greek roots (i.e., *nation* and *national*). The derivational relation stage described confusions about schwa sound spellings (i.e., BENAFIT for *benefit*); silent consonants (i.e., CONDEM for *condemn*); vowel alternations in derivationally related pairs (i.e., COMPUSITION for *composition*); silent letters (i.e., INDITEMENT for *indictment*); and uncommon roots (EXHILERATE for *exhilarate*). These common confusions

eventually gave way to competent spelling. The final stage was termed derivational constancy to imply that if mature or competent spellers do commit an error, the error was likely to be of the derivational type. That was why such proficient spellers, such as those who competed in the National Spelling Bee, went to great lengths, even the formal study of a number of languages, to understand derivations (R. Schlagal, personal communication, December 20, 2004).

Ehri's Stages

Reading acquisition more than spelling influenced Ehri's (1991) proposed stages. Also, influenced by Henderson's work, she compared and contrasted her theories to Henderson's (Templeton & Bear, 1992). One primary contrast was the differences in focus between Ehri and Henderson. Ehri's four distinct stages focused on the nature of the correspondence between written units and spoken units. These correspondences were central to reading and spelling development. Being able to segment spoken words into phonetic constituents and to relate them to letters was the most important skill beginning readers and spellers acquired (Share, Jorm, Maclean, & Matthews, 1984). In comparison, Henderson focused on spelling features he called layers of orthographic invariance. These layers became more and more apparent to developing spellers as they inductively pursued sound-letter correspondences. Growing understandings were displayed in the orthographic features individuals used and confused.

Both Ehri and Henderson used children's invented spelling to infer the development of the child's understanding of orthographic-phonological

correspondence. They agreed upon the premise that the development of reading and spelling required working out the connection between written and spoken words. Specifically, reading and spelling required segmenting spoken words into phonetic constituents and recognizing how letters in spelling corresponded to them. Both Ehri (1997) and Henderson (1992) concurred that reading and spelling developed in synchrony.

Ehri's (1992) stages directly related the description of development to the reading process. She defined the stages using terms that denoted the reading process. They included: (a) Precommunicative, which was equivalent to Henderson's nonphonetic (originally preliterate); (b) semiphonetic, which was identical to Henderson's semiphonetic (originally prephonetic); (c) phonetic which was partly equivalent to Henderson's phonetic (originally letter name), but also covered some features of Henderson's within word pattern stage; and (d) morphemic which was partly equivalent to the within word pattern stage and covered Henderson's later two stages (Ehri, 1992).

Over the years Henderson and Ehri's theories became more closely aligned as they defined better the characteristics of the first three stages. However, Treiman was not as supportive of their stage theory. She avoided using stages to categorize her findings. Treiman based most of her analyses on data aggregated over the whole school year, although she did sometimes compare the first semester with the second semester. In her words:

Although the children's spellings certainly improved across the course of the school year, I believe that the developmental stages proposed by the Virginia

Researchers are too simple. Semiphonetic, phonetic, and transitional spellings are less distinct and less well defined than they first appear to be (Treiman, 1993, p. 31).

The many independently proposed stage models for spelling agreed on the distinction of at least three stages: logographic, alphabetic, and orthographic, although they may have called them by different names. They disagreed on the exact number of stages, the mechanisms that drove development from one stage to the next, and what underlying features constitute a stage. Ehri (1992) and Henderson (1980) both agreed that the process of learning how to read and spell required working out the connection between the segmented phonemes of the spoken words and their corresponding written graphemes. Frith (1985) countered that instead of stages of spelling and reading progressing concurrently they progressed along unrelated paths. Reading and spelling development acted as pacemakers to each other. Despite their efforts, Treiman questioned the entire notion of stage-like progression in spelling and ignored its influence in her work.

Questioning Stage Theory in Literacy Development

Treiman (1993) was not the only skeptical expert. Rieben and Saada-Robert (1997) posed an important question. They asked if stage-based models were good heuristics for describing the acquisition of reading and spelling. Ehri (1992) reminded us that stage theories in spelling were empirically quite limited and at present primarily conceptual. Ehri, like Ellis (1997), called for longitudinal studies that plotted individual children's spelling in more depth. Studies needed to mark when spelling features appeared. She felt the consistency of the features'

appearance and what affect one feature's appearance had on another feature needed more explanation.

Also, Ehri was concerned with the notion of maturation when describing spelling acquisition. Growth implied that maturation might be driving spelling development. Yet, most children would not naturally develop into mature spellers without instruction. She suggested that we not only needed to know more about the particulars of the different stages, but we also needed to be concerned with how researchers characterized development. Ehri stated:

Description of *growth* in terms of stages is misleading because it implies an unfolding of capabilities according to a maturational timetable rather than an instructional schedule. Of course there may be limits to what instruction can accomplish. However, reading and writing skills are not likely to evolve simply from exposure and practice, particularly during the beginning period. Otherwise we would not find reading disability the major source of concern that it is (Ehri, 1992, p 319).

Rieben (1991; 1997) called for a more systematic study of stages. He focused on strategies rather than features. He pointed to the realization that descriptions of change in strategy use for reading and spelling overlapped, and we did not know enough about the nature of their interaction. For example, stages traditionally described relatively abrupt changes. However, no one had observed abrupt transitions in reading and spelling. In spite of this, literacy theorists generally accepted that one type of strategy replaced another in such a manner that the assigned stage lost ambiguity (Frith, 1985).

A contradiction to stage theory was implicit in controversy regarding the logographic stage. Not all reading researchers thought that the logographic stage was necessary because many students bypassed this stage (Ehri & Wilce, 1985). Also, some data suggested that the logographic stage and phonology stage coexisted (Reiben & Saada-Robert, 1991; Seymour & Elder, 1986; Seymour & Evans, 1992).

A study by Reiben and Saada-Robert (1997) questioned stage theory. They observed spelling strategy variability among children 5 and 6 years old who searched for and copied words in an effort to produce text. Children made no exclusive use of any single type of strategy during any given period of observation. Instead children demonstrated flexibility using elementary strategies and more advanced strategies concurrently. The evidence showed large within-subject variability.

From their results, Reiben and Saada-Roberts suggested four general phases of development. They suggested that general phases (rather than distinct stages) contained the description of simultaneous use of less sophisticated strategies with more advanced ones. Their results questioned stages defined by the exclusive use of particular strategies and supported interactive development with flexible strategy use. They asserted that strategies were more than background noise; that is, strategies were a psychological phenomenon that we needed to take seriously.

Summarizing Spelling Development

In conclusion, we now know that spelling requires a complex understanding of language and the writing system. Spelling is an orthographic system where units of speech map onto letter constituents (Treiman, 1993). Further, we understand that spelling ability develops in synchrony with reading ability, each influencing the other (Ehri, 1997; Frith, 1980a, Henderson, 1992; Perfetti, 1997), and that it follows a sequential path.

Nonetheless, lack of precision clouded this description of spelling development. Was it incremental or stage-like? (Reiben & Saada-Roberts, 1997). Even stage theorists admitted that defined stages were not as clear as they appeared (Ehri, 1992; Schlagal, 1992). Studies like Reiben & Saada-Roberts (1997) pointed to the role strategies played in spelling development, and described growth happening in large phases but with great overlapping variability in strategy use. This lack of precision called for fine-grained studies in spelling development that targeted a more precise description. One recent study attempted to do so (Rittle-Johnson & Siegler, 1999). This study looked at children's spelling strategies. It described spelling development not as a stage-like progression but rather as overlapping waves. Influenced by the work of Siegler, the study's purpose was not to provide a more precise description of spelling development but rather to provide support for the overlapping wave theory.

The Overlapping Wave Theory

Siegler (1996) challenged stage theorists. He argued that stage theory's conceptualization was a narrow perspective based on how children thought about a given topic at a specific time and did not sufficiently address the mechanisms that drove change. Siegler (1996) developed a theory with two factors that facilitated change: the variability of children's thinking, and the adaptive way children chose to approach problem solving. His theory allowed change to happen incrementally, which is consistent with the quantitative approach. Siegler referred to his theory as the Adaptive Strategy Choice Model.

Siegler (1996) named the Adaptive Strategy Choice Model for the central role adaptiveness played in selecting strategies. Multiple possibilities allowed more than one strategy to complete any given task or to solve any given problem. Children chose certain strategies more frequently because they were more effective, while at the same time using other less effective strategies, and eventually extinguishing the less effective ones. Children adaptively selected strategies based on the difficulty of the task. The more difficult a task, the more strategies children chose to accomplish the task. The concept of multiple strategies adaptively chosen illustrated a metaphor of overlapping waves. Consequently Siegler's Adaptive Strategy Choice Model was also the Overlapping Wave Theory.

For the overlapping wave theory to exist, evidence of variability, adaptiveness, and gradual change were essential. Siegler (Siegler, 1996; Van Whye, 2005) defined variability as the ability to think about solutions to problems

in several different ways or knowing multiple strategies to generate one answer. Variability was an advantage. In fact, children who displayed multiple strategies for solving a problem subsequently learned more than those who displayed fewer strategies (Siegler, 1995). (Figure 1 depicts Siegler's Adaptive Strategy Choice Model.)

Figure 1. "Overlapping waves depiction of cognitive development",
from **EMERGING MINDS: THE PROCESS OF CHANGE IN**
CHILDREN'S THINKING by Robert S. Siegler, copyright © 1996 by
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Siegler (Siegler, 1996; Van Whye, 2005) believed that adaptation was the mechanism by which change occurred. Adaptation played a fundamental role in the evolution of cognitive development. Individuals demonstrated adaptiveness when they actively chose environments that maximized their strengths. Change occurred when the environment created challenges in which individuals responded in distinctive ways. Siegler framed his model based on Darwinian notions of adaptability and are a synthesis of Darwin's original work on adaptation.

Siegler (1996) saw strategies as competing with one another. Children chose a slower, less sophisticated strategy over a faster, more sophisticated one in favor of being accurate when first learning a new skill. However, children increasingly used the more sophisticated strategy with practice and maturation. The goal was effectiveness by being as fast and as accurate as possible. Individuals adapted as they selected the strategies that best accomplished this. Change occurred through the adaptive choices children made when selecting which strategies to use. In this way, change was always gradual as an individual chose a more efficient strategy while a less efficient one faded.

Siegler (1996) evidenced adaptability by categorizing strategy use into two main types: retrieval from memory and backup strategies (i.e., any strategy not retrieval). Retrieval was faster than a backup strategy and required the child to have adequate information of a domain to be possible, but was not always accurate. Siegler (1996) considered retrieval a strategy type because he reasoned that retrieval required a conscious decision to consult one's memory.

Backup strategy types were slower multiple strategies but were at first more accurate than a retrieval strategy.

Adaptive choice occurred when individuals used more backup strategies than the retrieval strategy during more difficult tasks. Backup strategies on harder problems tended to be more accurate even though slower than retrieval. Retrieval was faster and more accurate after enough experience. In these two ways, children adapted to their circumstances. Siegler measured adaptive choice by determining a correlation between problem difficulty and number of backup strategy attempts as opposed to retrieval attempts.

Several research studies provided substance to Siegler's variability and adaptiveness concepts in a variety of domains. For variability, psychologists found multiple and varied strategy use in the domains of math (Siegler & Robinson, 1982), scientific reasoning (Schauble, 1990), and memory (Fletcher & Bray, 1997). For example, Siegler and Robinson (1982) observed variability among three, four, and five year olds learning to add. McGilly & Siegler's (1990) investigation saw multiple strategy use among children remembering lists of numbers, and again Schauble (1990) documents it when children identified factors that influenced the speed of a racecar. Multiple strategies at any one trial and a combination of strategies over repeated trials were exhibited in all three studies. Children held onto ineffective strategies or reasoning even after researchers presented more effective ones. Children's less sophisticated thinking often resurfaced over several trials and they never completely rejected it.

Ineffective strategies occurred less often over time as the children became more and more experienced.

Siegler and Shrager (1984) found evidence for adaptiveness when they asked four and five year olds to add one-digit addends. They split the math problems into two different groups. One group of addends could be added using fingers. The other group required sums large enough that the children's fingers were not enough (i.e. one addend greater than 5 with sums of 11 and 12). These children's performance showed a strong relationship between the number of backup strategies used and problem difficulty ($r = .81$). Participants used back up strategies more than they used retrieval on the most difficult problems. Similar high correlation was duplicated across demographic groups, (Kerkman & Siegler, 1993), children with disabilities, (Geary, 1990), and adults (Geary & Wiley, 1991). Individuals made adaptive choices between retrieval and back up strategies when problems were more difficult.

Further, a study done by McGilly and Siegler (1990) provided insights into a methodological procedure that enhanced the power of the observational results. Dividing children into two groups, observed only and observed with immediate retrospective self-report, a comparison highlighted the effectiveness of interviewing children immediately after a task. The combination of observation and immediate retrospective self-report proved a more sensitive index in determining strategy use than observation alone, and immediate self-report did not itself influence the strategies the children used.

Although these conclusions were positive, Siegler's notion of retrieval as a strategy was confusing. Was retrieval a strategy? Literacy literature often associated retrieval or accessing one's memory as being automatic. Retrieval in this sense could not be strategic.

Siegler (1996) recognized the distinction between strategic retrieval and automaticity. He identified conscious choice to explain the defining difference. To Siegler, retrieval required consciously trying to access memory. Automaticity did not. Automaticity was any behavior that was fast, accurate, and hard to inhibit. However, when did retrieval stop becoming a strategy and start becoming automatic?

Children learning how to spell their names provide us with an example of the dilemma. Children consciously choose which letters to use during the onset of learning how to spell their names. Strategies may include: copying the letter sequence from another source, sounding out the letters, or checking their memories. Checking their memories at this point is a conscious decision that may or may not involve accuracy or speed. For Siegler this characterizes retrieval. However, children eventually "retrieve" the spelling of their name unconsciously. In fact, children can spell their names quickly, accurately, and even when preoccupied with other thoughts. In these cases automaticity subsumes Siegler's definition of retrieval. Retrieval at this point is now unconscious. Identification of the observable strategy -- checking one's memory -- has become ambiguous.

I found in Siegler's studies no defining line between retrieval as a strategy and retrieval as automaticity. Specifically in Rittle-Johnson and Siegler's (1999) spelling study retrieval was always a conscious decision, a strategy type, capable of adaptive selection. Rittle-Johnson and Siegler (1999) strove to integrate the role of automaticity with the role of explicit spelling strategies. They defined automaticity as retrieval where rapid phonological and morphological processing was not under conscious control and did not involve explicit application of rules. Although they supported the separation of "fluid, automatic processing from controlled, conscious use of strategies" (p. 334), their application of retrieval inadvertently intertwined itself with spelling strategies they referred to as backup strategies. A spelling backup strategy was any controlled, step-by-step method for constructing a sequence of letters for the purpose of producing a word. The distinction between the two approaches became somewhat obscure in their presentation. Retrieval fell under observed and reported strategies when reported in Table 1 (p.337). Further confusion accumulated when they did not require characteristic of the retrieval classification.

This treatment of the notion of retrieval brought into question the identifying of adaptive choice. Was adaptiveness inaccurately identified when the observation of retrieval may or may not be strategic? Finding away to separate retrieval from automaticity became an important goal for the current study.

Siegler's Adaptive Strategy Choice Model, despite this discrepancy, suggested a strong alternative for describing the path development takes. A variety of studies over a variety of domains provided strong evidence. The

variability of children's thinking, and the adaptive way children chose among alternative strategies led to a much different perspective of cognitive development than stage theorists suggested.

Comparisons between the overlapping wave model and stage theory revealed two apparent differences. One difference was the path development followed. Instead of development occurring in step-like fashion, development depicted a series of overlapping waves. Second, the rate of growth was continuous and gradual not discontinuous and abrupt. The distribution of the waves changed over time because the strategies children used most often changed with practice and age. Despite these important differences, Siegler (1996) contended that the overlapping waves model could encompass the stage-like depiction of change. He reasoned that, as a limited case, the model collapsed into staircase progressions, which allowed both explanations to be plausible.

The differences between Siegler's (1996) model and stage-like theory were significant. They brought to consideration other facets of development not extensively studied. His work showed the importance of variability and adaptability as key factors in describing cognitive development. Children were observed thinking about multiple solutions to problems, using multiple strategies to generate one answer, and selecting strategies according to problem difficulty. In addition, studies highlighted a method of observation using immediate self-report that was sensitive to uncovering multiple strategy use. Now future studies carried a more sure promise of clearer observational results.

Siegler encouraged cognitive development's reinterpretation within a framework of overlapping waves. He believed this portrayal to be more typical of childhood development (Siegler, 1996). His work reached the study of spelling and challenged the traditional spelling development viewpoint of stage-like progression.

Spelling Development as Overlapping Waves

The purpose of Rittle-Johnson and Siegler's (1999) study was to explore the application of the overlapping wave model to a non-algorithmic domain. The previous studies were all in algorithmic domains. An algorithmic domain is an area of knowledge where specific strategies have always yielded a correct answer. Examples of algorithmic domains are math computations, telling time, and memory skills. For instance, addition is algorithmic, because a child who has correctly executed the addition procedure will always arrive at a correct answer. In contrast, an example of a non-algorithmic domain is English spelling. There is still a probability that a word will be spelled incorrectly even if the rules of English orthography are followed. Thus, spelling development provided Rittle-Johnson and Siegler an opportunity to investigate the model's applicability in a non-algorithmic domain.

Rittle-Johnson and Siegler (1999) found three coexisting elements in spelling behavior: (a) A variety of strategies being used at one time, (b) adaptive choices when selecting between those choices, and (c) gradual change. These three elements were fundamental to the overlapping wave model (Siegler, 1996).

Consistent with Siegler's (1996) view, variability defined and classified strategy use into two types. Retrieval as a spelling strategy occurred when children consulted their memory to spell words, but the children did not necessarily spell the words correctly. Retrieval applied to parts of the word like syllables and other letter constituents, or to the entire word. Rittle-Johnson and Siegler (1999) reasoned that children chose to use retrieval when they have enough background and experience to allow consultation with memory. Siegler (1996) claimed this conscious choice happened before automaticity of the words occurred.

Retrieval contrasted with backup strategies, which consisted of all other ways the spelling task had been accomplished. Some examples of spelling backup strategies included sounding out a word letter-by-letter or using a rule to help you spell. Backup strategies were always slower than retrieval and assumed to be selected based on adaptive choice (Siegler, 1996).

Rittle-Johnson and Siegler (1999) assumed that children did not necessarily choose adaptively even when a variety of strategies were a part of their repertoire. However, when children demonstrated a desire to be reliably accurate and to select strategies that efficiently helped them, they were adaptive. They tested adaptability under two conditions.

In the first condition, they allowed children to take as much time and use as many strategies necessary to spell words. Unrestricted backup strategies defined the "allowed" condition. The second condition was the "prohibited" condition. The goal of the "prohibited" condition was to restrict backup strategies and to

encourage only retrieval. Siegler (1995) reasoned that most likely when children used retrieval only, harder words would be spelled incorrectly. He created an index of word difficulty by restricting backup strategies in the prohibited condition.

The index of word difficulty was a correlation between the percent of correct spellings of the word in the prohibited condition with the number of backup strategies used for the word in the allowed condition. The index assessed adaptation. Although restriction of all backup strategies was impossible, Rittle-Johnson and Siegler reasoned that children would use less backup strategies when: (a) Instructions encouraged a child not to use them, and (b) researchers interrupted children when observed trying to use them.

Rittle-Johnson and Siegler (1999) investigated the spelling behavior of the same children over a two-year session. Thirty students participated in grade one and twenty-three of them participated again in grade two. The children attended a private urban elementary school where they received daily spelling lessons from an instructional textbook.

Each child spelled 30 words from two lists. Each list was composed of beginning, middle, and end of the year words from their spelling books. Both lists had words with similar patterns. For instance, "cat", "fish", and "clown" were on the first list; and "bat", "dish", and "frown" were on the second. This was done to counterbalance the lists presented in the allowed condition and prohibited conditions. During grade two, the lists had fifteen new words and included nine words from the previous year. The study repeated these nine words because of their difficulty in grade one. Grade 2 word lists were composed in the same

manner as grade one lists using the grade two spelling book. Other than the use of beginning, middle, and end of the year spelling words, the study made no attempt to reflect spelling levels or developmental progression.

Each child spelled one list of words under each of the two conditions. Children spelled one list of words under the allowed condition where children used backup strategies, and one list under the prohibited condition where researchers encouraged retrieval. Half of the children participated first in the allowed condition while the other half participated in the prohibited. Then children switched conditions on the second list of words. During the allowed condition the researcher asked children immediately after spelling a word, "How did you figure out how to spell ____?" If they did not know, the experimenter probed with questions like, "Did you just know how to spell it? Sound it out? Use another word to help you spell it? Use a rule? Do anything else?" In the prohibited condition the researcher interrupted children when they observed them using a backup strategy and asked them to begin writing the letters. In both conditions children identified a picture of each word before spelling it.

Rittle-Johnson and Siegler videotaped all spelling sessions and recorded the solution response times from the video. Timing started when the child identified a picture of the word and finished when the child raised his or her pencil from the paper. Solution response times helped verify whether the strategy used was retrieval or a backup strategy. Retrieval times were always faster than backup strategies.

A trial-by-trial analysis of strategy use allowed Rittle-Johnson and Siegler (1999) to identify which strategies children used in grade one and two, how often children used them, how accurate and effective the strategy was, how adaptively children chose among the strategies, and how strategy use changed from grade one to grade two. Researchers assessed strategies through observations of spelling behavior and interviews they conducted immediately after observation of the behavior (immediate retrospective self-report). The combination of observation and interviews allowed researchers to verify observed strategy choice and to represent unobserved strategy choice. The verification and representation produced results that showed evidence for variability, adaptive choice, gradual change and effectiveness for strategies. Each of these findings is described below.

Rittle-Johnson and Siegler's (1999) results provided further evidence that variability in strategy use does exist. They observed six spelling strategies: retrieval, sounding-out, retrieve/sounding-out, drawing analogies, relying on rules, and visual checking. Analogies were unobservable and based on the self-report of the children when they reported using another word to help spell. Children always used rule use and visual checking in connection with other strategies but with so many varied combinations the researchers collapsed them into two categories.

Literacy literature in contrast suggested that the following strategies would be found: accessing memory (i.e. letter strings accessed from memory but not necessarily accurate or complete, Rittle-Johnson & Siegler, 1999); visual cuing

(i.e. letters do not correspond to sound, Ehri, 1991; Henderson, 1980); sounding-out using partial phonetic cueing (Ehri, 1991; Henderson, 1980); sounding-out using grapheme-phoneme mapping or letter-sound correspondences, (Ehri, 1991; Henderson, 1980); use of spelling rules (Bear, et al, 2000); analogy (using another word to spell an unfamiliar word, Ehri, 1997); and visual checking (writing down a spelling and then visually checking to see if it looks right, Perfetti, 1997). Rittle-Johnson and Siegler found most of these collapsing sounding out strategies into one category and not including visual cuing.

Students used multiple strategies for any one word. Grade one students individually used an average of two to five strategies over each trial, and they used six strategies over time. Grade two students used an average of two to six strategies. The most common strategies used were retrieval and sounding out, and children used them to spell words for more than 80% of the trials in both grades. In addition, children in both grades flexibly combined strategies to spell a single word. The flexible use of six different strategies contrasted the stage-like views of spelling development where children's errors placed into one stage.

Strategy choices confirmed adaptive behavior as children used more backup strategies on the more difficult words. This was true even though backup strategies did not yield more accurate results. Four specific changes seemed to improve speed and accuracy: (a) Increased retrieval, (b) decreased use of the slowest and least accurate strategy, (c) increased use of faster and more accurate strategies, and (d) increased efficiency (speed and accuracy) for all strategies. The addition of new strategies reflected a growing sophistication of

the understanding of English orthography. The use of these strategies did not have an impact on speed or accuracy at least within the time span of this experiment.

Changes in strategy use from grade one to grade two showed a slow gradual progression. The number of strategies individuals used as their spelling matured reflected a slow progression. A larger number of words were retrieved in grade two than in grade one. A smaller number of words were sounded out in grade two than in grade one. Yet they still used retrieval and sounding out as their most frequently used strategies. Rule use and visual checking also increased in grade two but only by 6% and 4% respectively. Individuals added at least two new strategies by grade two and deleted at least one strategy, not a significant change. Analogy and visual checking were the most commonly added strategies and retrieve/sound-out the most commonly deleted one. The overall pattern of change revealed a slow gradual progression towards more effective strategy use.

The accuracy and speed with which children spelled words measured effectiveness of strategies. Children generally improved in speed and accuracy over the two years even though grade two words were more difficult than grade one words. In grade one 86% of the retrieved words were spelled accurately and took an average of 11 seconds to spell, where as only 22% of backup strategies resulted in a correct spelling and took an average of 17 seconds. In grade two 96% of the retrieved words were spelled accurately and took 6 seconds to spell. Only 57% of the backup strategies resulted in accurate spellings and took an average of 11 seconds.

Sounding out was the least efficient backup strategy. It led to accuracy only 15% of the time for grade 1 students and 34% of the time for grade two students. Only 50% of the grade one and 68% grade two errors were phonemically correct even when Rittle-Johnson and Siegler considered phonemically plausible spellings. A phonemically correct spelling is when the words are spelled so that a plausible letter represents each sound of the word, but the word is not spelled conventionally (i.e., KANDEE for candy).

From these results Rittle-Johnson and Siegler (1999) provided evidence that spelling development met the stipulations of variability, adaptability, and gradual growth. Spelling development emerged into a depiction of overlapping waves by focusing on strategy use rather than orthographic feature errors (i.e., the traditional way to measure spelling development). Rittle-Johnson and Siegler's results caused me to wonder about the use of spelling strategies as opposed to an analysis of spelling errors. They are two very different measures. Overlapping wave model looked exclusively at strategy use where spelling stage theory looked exclusively at feature error analysis (Schlagal, 1989). What if researchers combined these two methods in an analysis? Would spelling development look more like waves or stages or something new? These questions underscored my motivation to design a study that might offer answers.

Motivation for the Current Study

The overlapping wave model suggested that efficient use of spelling strategies drove development. Children adaptively chose more effective spelling

strategies that gradually replaced less effective strategies. However, spelling theorists suggested that as sequences of letters became more accurately represented in memory then spelling development progressed from one stage to the next (Ehri, 1992). Which theory held more explanatory power? How does strategy use contribute to our understanding of developing memory representations?

Rittle-Johnson and Siegler's (1999) study and previous stage development studies became a springboard for the current study. Was it possible to duplicate evidence for multiple strategies, adaptive choice, and gradual change in spelling in another population using similar methods? If the current study combined the stage theory method of post hoc error feature analysis along with observation of strategy use, would it uncover interactions between strategy use and spelling errors? Could a trial-by-trial study using both error feature analysis and observation of strategy use produce a clearer picture of how change occurs by revealing the mechanisms that drive development? I made a decision to explore these questions by duplicating the Rittle-Johnson and Siegler study, but with some differences in purpose and methods.

Extending the Findings of Rittle-Johnson and Siegler

To extend the findings of Rittle-Johnson and Siegler (1999) the current study focused on different goals and methods. Rittle-Johnson and Siegler's primary goal was to demonstrate that a non-algorithmic domain such as spelling was consistent with the overlapping wave model. Their secondary goal was to provide further evidence of their model as a more accurate theoretical description of

cognitive development in general. The primary goal for the current study was to provide a more effective explanation of how change occurs in spelling development specifically. The study explored the mechanisms that drive and constrict spelling development, and replicated Rittle-Johnson and Siegler's (1999) findings of variability, gradual change, and adaptive choice in the development of spelling. A second goal was to explore how the variability and adaptability of strategy use might interact with spelling feature errors.

Methodologically, the current study was highly influenced by Rittle-Johnson and Siegler's (1999) study. However, there are several differences. Like Rittle-Johnson and Siegler, observation included immediate retrospective self-reports that identified spelling strategies children used for each word. Self-reports uncovered evidence of multiple strategies adaptively chosen. Unlike Rittle-Johnson and Siegler, analysis included error feature analyses of misspelled words in addition to the observational data. Error feature analyses uncovered evidence of progress in orthographic understanding. Their study was longitudinal extending over a two-year period. The current study employed a microgenetic approach (Siegler, 1995), which encompassed an in-depth analysis over a nineteen-week period. The microgenetic method encompassed several important techniques that provided potential success for answering my research questions.

The Microgenetic Method

Most methods used to study cognitive development were either longitudinal in nature or cross-sectional. Longitudinal and cross-sectional methods were very

successful in yielding information about the stability of individual differences as well as age-related differences. Additionally, they revealed the general sequential nature of change and its hierarchical characteristics. Longitudinal studies looked at change by following the same children over a long period of time. Cross-sectional studies compared different populations of children at different ages. Both methods contrasted children's performance at different ages on a cognitive task.

The problem these methods ran into was the lack of observational density. The researchers did not observe a sufficient number of trials over a concentrated period of time. Precise information about the generative process was insufficient. The data collected demonstrated what happened before and after the change, but researchers had to infer the process. Researchers needed to catch change in the moment change occurred in order to understand what happens (Siegler, 1996).

Siegler (1996) provided a useful allegory for conceptualizing the degree to which observations needed to take place. He asked us to imagine two different news reports about a hurricane. The first report used the aid of two snapshots flashed on a TV screen. Both snapshots gave detail to the scene, but only inferences could be made about how the destruction actually occurred. In contrast, the second news report displayed live footage of the hurricane in action. Observers needed less guessing about what went on during its destructive moments. This high level of resolution was what the microgenetic method offered.

A microgenetic method was capable of providing a more movie-like rendition of change. The microgenetic method had three key characteristics: (a) Researchers made observations over as long a time span as possible when rapid change was taking place; (b) researchers prepared an intense trial-by-trial analysis using qualitative and quantitative measures; and (c) the observer was sampling dense changes in the children's competencies as they occurred (Siegler, 1996). Dense sampling provided a high concentration of observations especially important in understanding the change process and revealing what occurs during the course of development.

Psychologists carried out microgenetic studies in two ways. The first approach presented a novel task and observed how children's understanding changed as they coped with the task (Schauble, 1990). In the second approach the psychologists chose a task from the child's everyday environment, such as learning to spell; made an educated guess as to what types of experiences led to improved performance levels; then provided those types of experiences in a higher concentration than normal (Siegler & Jenkins, 1989; Siegler, 1995). This approach resembled training studies. They were similar in that researchers increased exposure to experiences that facilitated change. They were different in that training studies typically investigated the effectiveness of the training. The microgenetic method investigated how cognitive change occurred when exposed to the training.

The concept of a microgenetic method has been around since the forefathers of developmental psychology. Werner performed experiments in the 1920s he

referred to as *genetic experiments*. These experiments gathered repeated examples of a psychological event for the purpose of uncovering change. Werner (1925) designated a psychological event as any incident where learning occurred. In his experiments the event was an increase in the ability to hear highly similar tones. His experiments focused on a single event, but he postulated the method could extend to processes that lasted over several weeks (Werner, 1948).

Vygotsky was another developmental psychologist who favored a microgenetic approach to studying development. He postulated the importance of studying changes that occurred over a relatively brief timeframe. He thought the approach increased the opportunity to watch change unfold and gain information about more of the dimensions involved in development by observing repeated sessions of a child's behavior (Vygotsky, 1978).

Siegler suggested five different dimensions in which the microgenetic method yielded information. Siegler (1996) defined those dimensions as path, rate, breadth, variability, and sources of change. A brief description of each follows.

The first defined dimension was path. Some cognitive psychologists described the path as a stage-like progression that is distinct and hierarchal. Others viewed the path as a gradual accumulative process; still others saw the path to be like overlapping waves. The microgenetic method, using trial-by-trial sampling, has the potential to track individual's progress and to reveal the type of path that characterizes change.

The second dimension of change was rate. How fast does change occur? Was change slow and gradual or abrupt? Results of previous microgenetic studies supported the concept of a gradual change over time (Rittle-Johnson & Siegler, 1999; Schauble, 1990; Siegler, 1995; Siegler & Jenkins, 1989). They consistently showed change to be a gradual adoption of more advanced strategies and more advanced thinking (Bjorklund, 2000).

Breadth of change referred to how widely the change generalized to other cognitive abilities. For example, when children gained the ability to do a new strategy, did they use that strategy on other applicable problems or in other applicable situations? Did they overuse the strategy by applying it to problems or circumstances in which the strategy did not apply? Did children only use the strategy on types of problems where they discovered the strategy, and then after more experience apply the strategy to other applicable problems? Again, microgenetic methods had the potential to answer these types of queries.

The fourth dimension of change was variability. Variability referred to differences among individuals and within individuals. Variability was the numbers of strategies used at any one time, the combinations of strategies used during a single trial and over time, the changes made in strategy choices, and the variability of speed and accuracy of strategy application. This data yielded information along the other dimensions of path, rate, and breadth of how change occurred.

The fifth dimension was source of change and researchers observed it through the reliance of training-like experiences. Exposure to rules, feedback,

peer interaction, and cognitive conflict provided meaningful catalysts for developmental change (Siegler, 1996).

Siegler (1995) focused on the five above-mentioned dimensions to further increase our insights on how change occurred. He studied Piaget's classic number conservation problem as an example of the microgenetic method's possibilities. Number conservation was a well-studied problem in cognitive development and results from its studies helped lead to conceptualization of stage theory. Siegler deliberately applied the microgenetic method to the development of number conservation because he wanted to provide evidence that the microgenetic method could substantially increase our knowledge and to provide evidence that cognitive development did not necessarily progress in stages.

A secondary goal of Siegler's study was to determine if explaining a more knowledgeable expert's reasoning would lead to an increase in rate of growth. In prior studies there had been evidence that this type of feedback favorably affected learning for adults (Chi & VanLehn, 1991). Siegler wanted to see if this type of feedback affected learning for children. Also, he hoped to reveal feedback using an expert's reasoning as a source of development.

Siegler (1995) found children who explained a more knowledgeable person's reasoning learned considerably more than children exposed to other types of feedback. Children experiencing the successful feedback gave more distinct types of explanations and gave a greater number of explanations during

individual trials. Also, they reached a more sophisticated understanding of the problem more quickly.

Siegler's findings revealed all five dimensions of change: (a) Paths of development showed that different types of explanations overlapped one another; (b) rate of development was slow as children gradually changed to a more advanced way of understanding; (c) breadth of change was uneven as addition and subtraction transformations yielded more understanding than other types of transformation problems; (d) the source of change was feedback type received; and (e) variability was evident at all levels of analysis.

Siegler's (1995) number conservation study provided evidence of the microgenetic method's value in obtaining developmental information, and the study highlighted an effective training method. The microgenetic approach's potential for garnering information about how spelling development occurred was high. Its fine-grained approach offered opportunities to resolve the issues surrounding how spelling development occurred. In addition, feedback produced significant influence on development.

The microgenetic approach required observation of individual children over several trials to obtain the detailed data necessary. Successful retrieval of information included the analysis of children's explanations, which captured their thinking as well as gave validation to their overt behavior. Finally, observations spanned over a long enough time so that the changes anticipated were captured, dependent on the demands of the task and the capabilities of the children. The microgenetic approach entailed a mixed-method design incorporating

quantitative and qualitative analysis and yielded substantial information in determining how change occurred. Although the microgenetic method underscored an analysis procedure that was time consuming and energy intensive, the benefits outweighed the demands. Therefore, I decided to use a microgenetic approach for the current study and to use feedback only and feedback plus expert's reasoning to satisfy the training-like condition.

CHAPTER III

METHODOLOGY

Participants

Three transitional first grade classes from three elementary schools participated in this study. A transitional first grade classroom has two characteristics: 1) the class has a minimum size of ten to fifteen students, and 2) schools screen the admitted students for potential reading failure by a screening instrument and/or by teacher recommendations. I selected this at-risk reading population based on their potential for significant growth. Original participating classrooms had 13, 11, and 11 students each (10 females and 25 males) making a total of thirty-five children who were six to seven years old. During the study, four students moved leaving 31 participants, 13, 8, and 10 students respectively (8 females and 23 males). The schools were located in a large western school district. All schools served a medium to high SES population as established by free and reduced lunch (i.e., FRL = 26%, 21.3%, and 18.9%). Each classroom provided daily spelling instructions. Students had received four months of formal spelling instruction when I administered the pre-assessments in January.

Measures

Spelling Inventories

The study employed six different spelling inventories. Bear, Invernizzi, Templeton, and Johnston's, (2004) Primary Spelling Inventory established baseline performance. Two sets of spelling inventories, Spelling Inventory I and II (Bear et al., 2000), and two spelling lists from Rittle-Johnson and Siegler (1999), measured the outcome variables. Sets of spelling lists were necessary to accommodate conditions defined by Rittle-Johnson and Siegler (1999). A final spelling inventory duplicated Spelling Inventory I and II and measured outcome variables that established rate of growth. All spelling inventories consisted of 15 individual words.

The Primary Spelling Inventory (Bear et al., 2004) provided foundational information for what participating children did and did not know based on error feature analysis and allowed placement of students on a stage-level continuum. Also, the inventory's raw scores provided a measure for determining participant's initial status of spelling performance at the onset of the study.

The Primary Spelling Inventory was similar to Inventory I and II in that similar spelling patterns were used (i.e., consonant-vowel-consonant, silent *e* words, etc.) and in that words were categorized into levels of spelling development. The Primary Spelling Inventory differed from Inventory I and II in that the words did not necessarily have the same spelling features (i.e., fan, pet, and rope in comparison with *ship*, *when*, and *lump*). Spelling Inventory I and II were similar to each other in both spelling patterns and features. For example, Inventory I used

bed, ship, and lump, where Inventory II used *net, trip, and dump*. All spelling inventories provided information about children's levels of development and provided evidence of orthographic reasoning.

Rittle-Johnson and Siegler (1999) developed an additional set of spelling lists, which I used in this study. They constructed their lists from the beginning, middle, and end of a grade one spelling book. Like the Bear et al. (2000) Spelling Inventories, Rittle-Johnson and Siegler designed their lists to have similar spelling patterns and features. For example, one list included *hat, dish, and clown*. The second list included *bat, dish, and frown*.

I created a final supplemental spelling inventory to duplicate the orthographic features, spelling patterns, and progression of orthographic difficulty found in Inventories I and II. The fifteen words closely replicated the spelling patterns and spelling features represented in the Bear et al.'s (2000) inventories. For example, Inventory I and II contained the words *bed, net, marched, and parched*, and the supplemental inventory matched those words with *red* and *charmed*. I designed the supplemental list to equal word difficulty in Inventory I and II, to allow more accurate discernment of growth rate, and to avoid ceiling effects.

Automaticity Baseline Measure

The automaticity baseline was a mean score derived from the solution response times of ten words specifically selected to induce spellings that would be accurate, quick, and effortless. I gathered the measure during the first week of the study. The automaticity baseline provided a way to distinguish words retrieved from memory that had reached automaticity. The measure was

calibrated in letters per second. The ten words selected were recommendations made by the three classroom teachers. Out of those ten words only those achieving accuracy were timed post hoc using a video recording of the event. (See Appendix A for all spelling inventories and lists.)

Solution Response Times

Solution response times calculated how long a child took to spell a word. Timings were derived post hoc using the recorded videos. Timing began when children placed their pencil on the paper to begin and ended when they lifted their pencil from the paper. The purpose of solution response times was to help overcome ambiguity between spelling trials where the researcher did not observe strategies but the children reported using them. For instance, when the researcher did not observe children using a spelling strategy but children self-reported they did, the solution time helped verify the child's self-report. If the solution time was similar to the slower solution response times required for a strategy and slower than the automaticity baseline measure, then I assumed the self-report was accurate (Rittle-Johnson & Siegler, 1999). Also, solution response times determined the degree a spelling strategy had become automatic by comparing solution response times with the automaticity baseline measure.

Conditions

Restricted and Unrestricted

Restricted and unrestricted refer to conditions Rittle-Johnson and Siegler (1999) used to help determine adaptive behavior in spelling strategy use. Rittle-

Johnson and Siegler referred to these conditions as prohibited and allowed. For the current study I changed the labels “prohibited” and “allowed” to “restricted” and “unrestricted”. I thought that these terms better clarified and represented the conditions they defined. This is because the central difference between the two conditions is in whether spelling strategies have been restricted from use or not.

In the *unrestricted* condition students were given ample time to spell the words on the inventory. I encouraged them to do whatever they needed to do to spell the word correctly. The *restricted* condition limited the time allowed for children to spell the words. I told children to spell whatever came to their minds as quickly as possible (Rittle-Johnson & Siegler, 1999).

Unrestricted Condition

The unrestricted condition contained two additional data collection activities: immediate retrospective self-report and feedback. The first activity followed after participants spelled individual words. After taking as much time as needed to spell each word, I asked children for an immediate retrospective self-report on what spelling strategies they used. I asked children, “How did you figure out how to spell ____?” Or, “What did you do to decide on those letters?” On the occasion they didn’t know, I probed with, “Did you just know how to spell it?” “Did you sound it out?” “Use a rule?” etc. The second activity was a feedback session where children learned if they had been accurate. Feedback occurred after the administration of the spelling inventory and was presented under two conditions described below. Spelling inventories in the unrestricted condition were video recorded.

Restricted Condition

I prompted children in the restricted condition to write spelling words as quickly as possible. If observed trying to use a strategy, I interrupted them and reminded them to begin writing the letters. This condition did not require immediate retrospective self-report or feedback, but analysis included timings and videotaping. Rittle-Johnson and Siegler (1999) did not assume that children would suppress all spelling strategies under this condition, but they reasoned that adequate decrease in the strategy's use would occur when an experimenter discouraged such use.

Feedback Conditions

Within the *unrestricted* condition I randomly assigned the 35 participants to two different feedback groups: feedback only and feedback with expert explanation. The participants in the *feedback only* group learned if their generated spellings were correct. The children in *feedback with expert explanation* condition learned if their spellings were correct and explained how they thought the experimenter knew they were correct. I said, "How do you think / knew that?"

Unfortunately, most of these at-risk participants were unable to respond to this question. When this occurred, one or more words contained in the inventory with similar features would be selected to demonstrate the feature rule in question and then the child would be asked again, "How do you think / knew that ____ was incorrect or correct?" For instance, if children spelled *boat* correctly, I would explain the "two vowels go walking rule" using the word *train* as an

example, and then the child would be asked again, "How did I know *boat* was correct." If children spelled *jerking*, JRKING, feedback from myself would include the r-control vowel rule using *perching* as an example.

I selected a maximum of six words for feedback based on types of feature errors the child was making. I reasoned that selection of words based on feature errors would maximize the potential for quality feedback. Feature errors are representative of levels of orthographic understanding and researchers use them to discover what level of understanding the child has achieved (Ehri, 1989).

The feedback conditions were a divergence from the original Rittle-Johnson and Siegler (1999) study. Their developmental investigation did not include feedback conditions. However, within the microgenetic framework some aspect of "training" is required to promote higher levels of developmental growth. Previous studies verified when experimenters asked children to explain an expert's reasoning, explanations accounted for improved accuracy of a child's judgment (Siegler, 1995).

Procedures

I administered the Primary Spelling Inventory as a whole group activity within each classroom during the first two weeks of January to the 35 original participants. I individually administered the automatic baseline measure at the same time.

I individually administered the spelling inventories during the following nine weeks. During Session 1(weeks 3-5) I administered Spelling Inventory I and II,

followed by the administration of Rittle-Johnson and Siegler's (1999) spelling lists during Session 2 (weeks 6-9). I administered spelling inventory sets under the unrestricted and restricted conditions. I placed children into one or the other condition by dividing the randomly assigned feedback groups in half. Half of the children in each feedback group participated in the unrestricted condition first, and half of the children in each feedback group participated in the restricted condition first. I presented each list of words equally often. I used the results from Session 2 for the analysis of adaptability but dropped them from all other analysis. (A full explanation of the design modification is found within the Results chapter.)

I administered posttests from the study during Session 3 (weeks 9-11) but later eliminated them. A Hierarchical Linear Modeling expert and myself spent several weeks (weeks 12-15) investigating an inconsistency found in the Hierarchical Linear Modeling results. Solutions to anomalies found in the measures resulted in administering Spelling Inventory I and II to those participants who had not taken one or the other. This occurred during Session 4 (weeks 16-17). The first administration of Inventory I and II made this decision possible because they had been counter balanced. I administered the supplementary spelling inventory during Session 5 (weeks 18-19). I refer to session 4 and 5 through out this paper as 2 and 3, since results from Session 2 and 3 were dropped. All design modifications were a joint decision made between my dissertation chairs and myself under consultation with the

Hierarchical Linear Modeling expert. (See Appendix B for data collection schedule and modifications.)

Research Design

The microgenetic method incorporates both qualitative and quantitative analysis qualifying the method as a mixed design. A mixed methods design provides unique opportunities to substantiate statistical data using empirical observation. This provides the potential to uncover information that researchers cannot discern when they use quantitative or qualitative analysis in isolation (Johnson & Onwuegbuzie, 2004). This study attempted to combine quantitative and qualitative analyses based on the fundamental principle of mixed research, which stipulates that the combining of analyses should occur when the results complement both methods' strengths and have nonoverlapping weaknesses (Johnson & Turner, 2003).

Collected trial-by-trial (i.e. spelling word by spelling word) data for the statistical analysis came from the performance baseline, automaticity baseline, spelling inventories, and solution response times. Collected trial-by-trial data for the qualitative analysis consisted of observations of children's overt spelling behavior, their immediate retrospective self-report, and their spelling responses. The design defined a trial as the spelling attempts of single words by each child.

Hypothesis Restated

I restate my hypotheses for purposes of clarity. Hypothesis 1: I hypothesized that children would use multiple strategies to spell words. They would use more strategies to spell difficult words than they would use to spell less difficult words, and gradually the more effective strategies would increase over sessions. Also, adaptive choice would lead to more accurate spellings, and increase the effectiveness of spelling strategies. Thus, I hypothesized that support for the overlapping wave model would be found.

Hypothesis 2: In addition, I reasoned children who received feedback plus expert reasoning would use more strategies more effectively than children who received feedback about correctness only. Thus, evidence would show that feedback with expert reasoning was an effective source for developmental enhancement.

Hypothesis 3: Also, I hypothesized that a positive correlation between error feature analysis and strategy use would reveal a relationship between the words children spelled and the process used to spell them. This relationship would depict a path of development where the mechanism that drives and constricts spelling development would denote an interaction between overlapping waves and discrete stage-like characteristics.

CHAPTER IV

RESULTS

Introduction

I begin by presenting evidence of three components necessary to suggest the overlapping wave model: variability of the spelling strategies used, rate strategies developed, and adaptiveness of choices in selection of possible strategies. Next, I examine the influence of feedback on the participants' spelling development using a Hierarchical Level Modeling (HLM) technique to estimate spelling growth trajectories. The HLM growth curve analysis also examined the effects of initial spelling status and classroom influence.

I then present a full description of relationships between spelling strategies and orthographic features derived from the qualitative analysis. I outline explanations of qualitative methods, and detailed descriptions of display and componential matrices. Finally, I offer a summary of the qualitative findings.

Reliability and Validity of Strategy Classifications

A preliminary analysis determined the coding of strategy behaviors. First, the analysis identified two types of spelling behaviors: accessing memory and overt spelling strategy use. Accessing memory referred to behavior that demonstrated direct retrieval of a spelling pattern from memory where the researcher perceived

no overt strategy. An overt strategy was a strategy that the researcher directly observed (e.g. sounding out, using a rule, visual checking, etc.) Second, I divided data from observation and children's self-report into two main classifications: unambiguous and ambiguous. If observation and self-report of a spelling strategy matched then this was an unambiguous classification. However, when observation and self-report of a spelling strategy did not match it was an ambiguous classification. The two classifications maintained both types of spelling behaviors and established a foundation for four analysis conditions of strategy behavior.

Under the unambiguous classification were two analysis conditions: 1) accessing memory when observed behavior and self-report agreed, coded *Access Memory Observed and Reported* and 2) strategy use when observed behavior and self-report agreed, coded *Strategy use Observed and Reported*. Under the ambiguous classification were two other analysis conditions: 3) overt spelling strategy observed but the student reported accessing memory, coded *Strategy use Observed but Not Reported*; and 4) no strategy observed but the student reported using one, coded *Strategy use Not Observed but Reported*. These classifications and analysis conditions were consistent with those used by Rittle-Johnson and Siegler (1999). An independent rater trained by the experimenter determined the reliability of the coding. The independent rater agreed on 86% of all spelling trial analysis conditions with the examiner. Two judges resolved the differences achieving a 96% rater-reliability.

I conducted a multivariate test of between-subject effects to show statistically significant differences among the four analysis conditions and to determine classification validity. I found significant differences between the conditions on accuracy rate (words spelled correctly), Wilk's Lambda $F(3,926) = 16.569$, $p < .005$ and spelling solution time (the amount of time children took to spell a word), Wilk's Lambda $F(3,926) = 4.322$, $p < .005$. Table 2 presents the descriptive statistics for the four analysis conditions. I accomplished these comparisons by calculating each relationship's trial percentages, correct spelling percentages, and solution time means.

Table 2

Mean Accuracy Rate and Solution Time by Strategy Conditions

Analysis Conditions	% Of trial	Accuracy	SD	Solution Time	SD
Access Memory Observed and Reported	.11	.48	.50	7.90	6.08
Strategy use Observed and Reported	.67	.18	.38	9.94	5.71
Strategy use Observed but Not Reported	.08	.30	.46	10.20	6.72
Strategy use Not Observed but Reported	.14	.27	.44	9.11	4.92

Once I established differences between the analysis conditions, I conducted a follow-up Bonferroni analysis to determine significant relationships between

accuracy rates and solution response times of the students' generated spellings and to compare the differences between the two unambiguous analysis conditions with the ambiguous ones. The accuracy rates and spelling response times from the unambiguous *Access Memory Observed and Reported* became one baseline measure. A second baseline measure came from accuracy rates and spelling response times from the unambiguous *Strategy use Observed and Reported*. These two baseline measures allowed me to compare the two unambiguous analysis conditions to each other. This is because I expected accessing memory to be more accurate and faster than using a spelling strategy. In this way, accuracy and speed validated the children's self-report for the unambiguous analysis conditions.

Also the baseline measure resolved inconsistencies within the ambiguous classification. When a child reported accessing memory but the researcher observed strategy use, the unambiguous baseline information provided a comparison that resolved the inconsistency. I assumed that the two ambiguous analysis conditions would align themselves in accuracy and speed with one or the other unambiguous analysis conditions, allowing the inconsistencies between observation and self-report to be overcome. In addition, the mean for the automaticity baseline gave further power to a comparison in clarifying differences within *Access Memory Observed and Reported*.

Findings on unambiguous classifications showed solution response times faster on trials within *Access Memory Observed and Reported* than on trials within *Strategy use Observed and Reported* (M difference = 2.04, $SE = 0.61$, $p <$

.005). Findings were similar for accuracy. Accessing memory was more accurate than using a strategy (M difference = 0.30, SE = 0.04, p < .001). These two unambiguous analysis conditions consisted of 78% of all the spelling trials. Unambiguous analysis conditions were consistent with Rittle-Johnson and Siegler's (1999) findings.

Only 8% of all spelling trials were inconsistent when classified as *Strategy Use Observed but Not Reported*. The follow up Bonferroni analysis of trials for this mismatched analysis condition showed children who claimed accessing memory but observed using a strategy less accurate than those who were both observed and reported accessing their memory (M difference = 0.18, SE = 0.06, p < .05). Also, solution response times for the trials of those children classified in this mismatched analysis condition showed slower spelling solution response times than the children who were both observed and reported to have accessed their memory (M difference = 2.29, SE = 0.87, p < .05). These statistics suggested that children were using a strategy despite their self-report. This finding was inconsistent with Rittle-Johnson and Siegler's findings.

In addition, the current study provided evidence of children preferring to access memory rather than sounding out words. For example, one child was observed sounding out the word and then reporting just knowing it. When pressed by the examiner, "Are you sure? I thought I heard you doing something." The child then admitted, "Oh, you caught me! I really sounded it out. I was just pretending." Another child after sounding out a word and reporting he knew it from memory said, "I can spell real good! I am smarter than my Dad!"

Self-reports like these suggested that children favored being able to access their memory to using a spelling strategy. Consequently, spelling trials within the *Strategy use Observed but Not Reported* were coded using the observed behavior.

The fourth analysis condition, *Strategy Use Not Observed but Reported* consisted of 14% of trials. To verify children's self-report in these ambiguous spelling trials, I assumed that if children used a strategy covertly, then solution response times and accuracy rates would resemble the unambiguous overt strategy spelling trials. This was the case. Ambiguous solution response times ($M = 9.11$) were more congruent with the unambiguous overt strategy data collection type ($M = 9.94$) than with the unambiguous accessing memory data collection type ($M = 7.90$). Also, accuracy rate (27%) was more similar to the unambiguous overt strategy analysis condition (18%) than the accuracy rate of the unambiguous accessing memory analysis condition (48%). Comparisons of solution time means and accuracy rate percentages validated children's self-report in the fourth analysis condition. Overall validity of children's self-report achieved 92% of all spelling trials.

Refining the Four Observation-Self Report Classifications

A further refinement of the four observational-self report analysis conditions used the automaticity baseline measure as a way to delineate the unambiguous spelling trials coded as *Accessing Memory and Reported*. These coded trials separated into accessing memory automatically and accessing memory strategically. The automaticity baseline measure compared the solution response

times of the classified trials, separating the classifications. The results of this comparison showed slower solution response times observed when children spelled words on the inventories (7.90 letters per second), than when children spelled words on the automaticity baseline measure (1.50 letters per second). The differences in solution response times suggested that children accessing their memory were not necessarily doing it automatically. Therefore, a further division of spelling trials coded as *Accessing Memory and Reported* separated into two sub groups: words spelled accurately and words spelled inaccurately.

The two subgroups were labeled accessing partial feature representation (observation of words spelled from memory but inaccurate) and accessing complete feature representation (observation of words spelled from memory and spelled conventionally). Once separated, accessing partial feature representation was neither accurate nor fast (mean solution time 7.90 letters per second). However, it was still significantly faster than the occurrence of observed overt spelling strategies (M difference = 2.04, $SE = 0.61$, $p < .005$). On the other hand, accessing complete feature representation trials coded were 100% accurate, and out of these accurate trials 50% met the automaticity baseline solution time requirements at Session 1, 65% met the speed requirement at Session 2, and 69% met it at Session 3. Despite the occurrence of automaticity, this study defined these trials as strategy use. I made this decision based on inconsistent solution response times and evidence from efficiency correlations that showed no significant change in children's speed overall when accessing their memory. Even though signs of automaticity were evident, not all trials conformed to the

automaticity baseline measure. This indicated that children were not yet automatic on some trials where they used accessing complete feature representation and execution was slow.

Additionally, I identified spelling strategies on the assumption that within any one spelling trial children used strategies both alone and in combination. For example, I assumed the word drive spelled DRIV with no overt strategy seen or reported to be Accessing Partial Feature Representation. However, if at the same spelling trial I observed the use of the silent e rule or the child self-reported its use or the spelling itself showed the use of the silent e rule, then I considered this spelling trial a combination of accessing complete feature representation and a strategy where children used rules.

Spelling trials coded using the other three analysis conditions (Strategy use Observed and Reported, Strategy use Observed but Not Reported, and Strategy use Not Observed but Reported) were divided and classified into specific overt spelling strategies. The observational data revealed seven overt strategies. I define all nine spelling strategies as follows (see Table 3):

1. Accessing Complete Feature Representation (*complete retrieval*) was the process of accessing spelling features from memory to correctly spell the word. Words spelled using this strategy resulted in conventionally spelled words. The researcher observed no overt use of a spelling strategy and the children's self-report indicated knowing the word.

2. Accessing Partial Feature Representation (*partial retrieval*) was accessing partial spelling features from memory to spell words incompletely. For example,

letters were retrieved in backward order or legal phonemic substitutions were used (i.e. incorrect choice of letter(s) for a phoneme but the error symbolized the phoneme, CHOOD for *chewed*, or SHOPING for *shopping*).

The researcher observed no overt use of a spelling strategy and the children's self-report claimed just knowing the word.

3. Random Place Holder Selection (*guessing*) was a strategy used when the child did not know what letters to choose. She or he wrote a string of letters or substituted one or two letters by merely guessing. There was little or no phonological logic or morphological awareness to the child's choices (e.g. MELP for *float*, or MOXCK for *marched*). The child's writing usually revealed this strategy, but occasionally children self-reported it.

4. *Sounding Out* was coded when the child used phoneme/grapheme matching, segmenting the sounds of a word, and matching each sound with a letter or digraph. Observation and/or the child's self-report indicated this strategy.

5. Orthographic Rule Use (*rule use*) was applying orthographic understanding to help spell words. Examples of rules children used were vowel markings, consonant and vowel digraphs, and the orthographic understanding that all syllables must contain at least one vowel. Observation of *rule use* was usually through the children's writing and/or their self-report.

6. *Analogy* was using another word to help spell the current word. For example, one child spelled the word *clown*, then self-reported using the word *down* to help her. "I just changed the *d* for *cl*," she reported. Self-report detected *analogy*.

Table 3

Spelling Strategies

Strategy Classification	Strategy Name	Definition	Source of Identification
Accessing Complete Feature Representation	Complete Retrieval	Accessing spelling features from memory to correctly spell words.	No overt behavior and self-report indicated knowing the word.
Accessing Partial Feature Representation	Partial Retrieval	Accessing partial spelling features from memory to spell words incompletely.	No overt behavior and self-report claimed knowing the word.
Random Place Holder Selection	Guessing	A string of letters having no phonological or morphological logic	Child's writing and self-report.
Sounding Out	Sounding Out	Phoneme/grapheme matching,	Observation and self-report.
Orthographic Rule Use	Rule Use	Applying orthographic rules to help spell words.	Child's writing and self-report.
Analogy	Analogy	Using another word to help spell a current word.	Self-report.
Visually Checking	Visual Checking	Perceptually checking a word to see if it looks right.	Observation.
Copying	Copying	Visually consulting a visible source.	Observation.
Pattern Recognition of Frequent Letter Constituents	Chunking	Common letter patterns are used to help spell unfamiliar words.	Child's writing, observation, and self report.

7. *Visually checking* was perceptually checking the word to see if it looked right. A successful example of *visually checking* was observed when the child checked her spelling after writing HUNP and changed the final preconsonantal blend from an N to M to spell correctly *hump*. Observation identified this strategy.

8. *Copying* was visually consulting a visible source. This occurred when children referred to a word displayed on their classroom wall letter by letter. Children spelled the word *bunnies* and *red* in this manner. Observation and self-report identified the classification.

9. Pattern Recognition of Frequent Letter Constituents (*chunking*) was using common letter patterns to help spell unfamiliar words. For instance, many children knew the *ing* chunk and successfully used it when spelling *shopping* or *jerking*. Others reported knowing the *ed* chunk to spell *red* and *bed*. The child's writing, observable behavior and the child's self report indicated this strategy.

Evidence of the Overlapping Wave Model

Variability of Spelling Strategy Use

Once reliability and validity of children's self-report was established and strategies identified and defined, an analysis determined evidence of the overlapping wave model. Several statistical methods investigated whether children in this sample demonstrated variability in strategy use. Simple frequency counts were made to establish percentages of those who used strategies and how often strategies were used. In addition, a repeated measure analysis was used to analyze strategy use over time with a post hoc Tukey to determine the

significance of those differences. Correlations measured efficiency by comparing accuracy rate and spelling solution response times for specific strategies.

Range of Spelling Strategies Used

I created frequency counts to calculate the percentage of children who used each of the nine identified strategies and the percentage of overall use of each strategy. Also, I calculated the number of strategies used per trial and per individual. Findings showed every child using multiple strategies to spell words during each developmental point. Overall, individuals used 2 to 7 types of strategies, $M = 5.14$. Individuals used more than one strategy within a single trial 89% of the time, with a range of 1-4 strategies per trial. At least one individual used eight of the nine strategies at each developmental time point. The most common strategy used was *sounding out*. One hundred percent of the participants used *sounding out* at least 38% of the time during each developmental time point. The least common strategy used was *copying* with only 3% - 12% of the students using this strategy at any one session and never more than once. I eliminated *copying* from the analysis because of its infrequent use (see Table 4).

Changes in Strategy use

I examined frequency of strategy use for the fifteen spelling trials over each session. This analysis was qualitative using coding and tabulation. Additionally, I conducted an analysis with repeated measures to compare the frequency of use of each strategy over the three spelling sessions. This analysis determined

changes in frequency of use of particular strategies over time. A post hoc Tukey test identified significant differences between the three time points.

Table 4

*Percent of Children Who Used Each Strategy and
Percent of Strategy Use*

Strategy	Percentage of Participants Using a Strategy			Percentage of Strategy Use for Entire Group		
	Session 1	Session 2	Session 3	Session 1	Session 2	Session 3
Complete Retrieval	61	96	100	5	10	11
Partial Retrieval	87	90	94	20	17	16
Guessing	55	29	32	8	1	1
Sounding Out	100	100	100	48	39	38
Rule Use	68	100	100	11	24	25
Analogy	19	16	19	2	00.6	00.7
Visual Checking	19	42	39	2	3	2
Copying	3	12	3	00.1	00.4	00.1
Chunking	58	90	94	6	6	7

Children used some strategies consistently at each developmental time points. All participants consistently used *sounding out* ($M = 12.84, 12.16$, and

12.23) and *partial retrieval* ($M = 5.39, 5.23, \text{ and } 5.10$) over the three sessions. *Analogy*, ($M = 0.42, 0.19 \text{ and } 0.23$) *visual checking*, ($M = 0.45, 1.06 \text{ and } 0.55$) and *chunking* ($M = 1.61, 2.00 \text{ and } 2.13$) were used very seldom (9% of the total use of strategies) by a range of participants (16% to 94%). *Rule use* and *complete retrieval* increased over time and *guessing* decreased.

Repeated measures analyses investigated if increase or decrease in strategy use was statistically different over time. With Sphericity supported, results showed that *complete retrieval* (Sphericity Assumed = 82.344, $F(2,60) = 26.566$, $p < .005$, practical significance = 0.47) significantly increased over the three developmental time points. The assumption of Sphericity was upheld. The post hoc Tukey tests found significant differences from Session 1 ($M = 1.26$, $SD = 1.55$) to Session 2 ($M = 3.03$, $SD = 1.85$) and from Session 1 to Session 3 ($M = 3.42$, $SD = 1.98$) but not from Session 2 to Session 3.

Rule use (Sphericity Assumed = 512.344, $F(2,60) = 32.914$, $p < .005$, practical significance = 0.52) significantly increased over the developmental time points. The assumption of Sphericity was upheld. Post hoc Tukey tests showed significant differences from Session 1 ($M = 2.94$, $SD = 2.97$) to Session 2 ($M = 7.71$, $SD = 4.61$) and from Session 1 to Session 3 ($M = 8.10$, $SD = 4.10$) but not from Session 2 to Session 3.

Guessing significantly decreased. The multivariate results were used because sphericity was violated (Wilk's Lambda = .724, $F(2,29) = 5.529$, $p < .01$, practical significance = 0.28). The post hoc Tukey tests found significant differences from Session 1 ($M = 2.03$, $SD = 2.92$) to Session 2 ($M = 0.42$, $SD = 0.85$) and from

Session 1 to Session 3 ($M = 0.35$, $SD = 0.55$) but not from Session 2 to Session 3. Due to the number of hypothesis, a Bonferroni correction controlled error rate and adjusted the p value for each comparison ($p < .005$). Figure 2 shows the increase and decrease of the three strategies that significantly changed over the three developmental sessions.

Figure 2. Percentage of students using strategies over sessions.

Comparisons over the three different sessions showed changes in individual children and their use of specific strategies. Twenty-three of the 31 participants added at least one new strategy over sessions, ranging from one to four added strategies per student. More than 38% added *visual checking* and/or *chunking*

and 25% added *complete retrieval* and/or *rule use*. Analogy was the only other strategy added to a child's repertoire and 16% of the participants added it. These five strategies yielded highly efficiency results. At Session 3, out of total words correct 35% related directly to *rule use*, 43% to *complete retrieval*, and 22% to *visual checking*, *chunking* and *analogy* combined. The only deleted strategy was *guessing* with 38% of the participants deleting it by the third developmental point. The overall results showed variability in strategy use over all three sessions when children spelled words (see Table 5 for descriptive statistics).

Table 5

Descriptive Statistics for Change in Strategy use Over Three Sessions

Strategy	<u>Session 1</u>		<u>Session 2</u>		<u>Session 3</u>	
	Mean	SD	Mean	SD	Mean	SD
Complete Retrieval	1.26	1.55	3.03	1.85	3.42	1.98
Partial Retrieval	5.39	3.04	5.23	3.73	5.10	3.24
Guessing	2.03	2.92	0.42	0.85	0.35	0.55
Sounding out	12.84	2.46	12.16	3.05	12.23	3.40
Rule use	2.94	2.97	7.71	4.61	8.10	4.10
Analogy	0.42	1.06	0.19	0.48	0.23	0.50
Visual Checking	0.45	1.48	1.06	1.55	0.55	0.85
Copying	0.03	0.18	0.13	0.34	0.03	0.18
Chunking	1.61	2.25	2.00	1.18	2.13	1.23

Rate of Growth in Strategy use

The statistical results from the variability analysis showed general tendencies for individual strategy change as relatively slow. *Sounding out* and *partial retrieval* remained stable throughout the three sessions showing no change over time. Few participants used *analogy*, *visual checking*, and *chunking*. These strategies' mean use over the three sessions showed little use during Session 1 and a slight increase in use over sessions. The repeated measures analysis found significant changes in use for complete retrieval, rule use, and guessing as previously demonstrated, but only from Session 1 to Session 2 where nine weeks had elapsed between developmental points. These repeated measures results suggested gradual slow progress towards use of more sophisticated strategies.

The repeated measures analysis examined whether the number of strategies children used changed over time. This analysis showed that number of strategies used per trial per session did increase significantly (Sphericity Assumed = 530.67, $F(2,60) = 16.257$, $p < .005$, practical significance = .35). The assumption of Sphericity was upheld. The Bonferroni correction was applied. A post hoc Tukey showed significant differences from Session 1 ($M = 26.97$, $SD = 5.15$) and Session 2 ($M = 31.94$, $SD = 6.63$) and from Session 1 and Session 3 ($M = 32.13$, $SD = 6.26$), but not from Session 2 to Session 3. The number of strategies that children were using to help spell words was increasing, between Session 1 and Session 2 where nine weeks had elapsed but remained stable between Session 2 and Session 3 where two to three weeks passed. These findings indicate children's gradual improvement.

Efficiency Correlations Showing Developmental Growth

Cognitive psychologists define efficiency over time as becoming both accurate and fast (Reynolds, Trathen, Sawyer & Shepard, 1994). Specifically for this analysis, accuracy measured the number of correct orthographic features used and speed measured differences in solution response times between the automaticity baseline measure taken during weeks one and two and the spelling response times taken during individual spelling trials. I chose orthographic features as a response measure because accuracy in orthographic features traditionally represented spelling development (Chomsky, 1970) and effectively represented spelling growth over time. By using the automaticity baseline as a comparison, solution time differences represented the child's growing ability to become automatic and therefore more efficient. I calibrated differences in solution response times in seconds per letter for each word.

Two repeated measures analyses examined whether orthographic features and children's speed were improving over sessions. Feature accuracy significantly increased over sessions. The assumption of Sphericity was upheld. (Sphericity Assumed = .806, $F(2,60) = 101.676$, $p < .001$, practical significance = 0.77). In the post hoc Tukey tests showed significant differences between all three sessions: Session 1 and 2 ($M = 0.43$, $SD = 0.13$), between Session 1 and 3 ($M = 0.65$, $SD = 0.11$) and between Session 2 and 3 ($M = 0.60$, $SD = 0.10$).

Also, speed increased over sessions. The assumptions of Sphericity was violated therefore the multivariate results were used (Wilk's Lambda = .543, $F(2,29) = 12.222$, $p < .001$, practical significance = 0.46). In the post hoc Tukey

tests significant differences were found between Session 1 and 2 ($M = 2.84$, $SD = 1.02$ and from Session 1 and 3 ($M = 2.00$, $SD = 0.52$) but not between Session 2 and 3.

A series of correlations compared individual strategies with accuracy and solution response times used per session. The comparison showed evidence of individual strategies improving in efficiency between degree of orthographic feature accuracy and speed. There was a significant correlation between *complete retrieval* and correct orthographic features. *Complete retrieval* increased in frequency, as orthographic features improved in accuracy (Session 1, $r = .47$, $p < .01$; Session 2, $r = .64$, $p < .01$; and Session 3, $r = .57$, $p < .01$). There was no significant correlation between speed and *complete retrieval*. Children were becoming more and more accurate at spelling orthographic features but not in spelling them more quickly (see Table 6 for descriptive statistics).

Rule use significantly increased over sessions with a significant correlation between *rule use* and correct orthographic features, such that as *rule use* increased in frequency, orthographic features improved in accuracy (Session 1, $r = .42$, $p < .05$; Session 2, $r = .79$, $p < .01$; and Session 3, $r = .64$, $p < .01$), and as *rule use* increased in frequency, speed decreased in rate ($r = -.41$, $p < .05$, Session 3). By Session 3 *rule use* was associated with a decrease in rate and an increase in accuracy. This same significant correlation between strategy use and speed repeated itself with *partial retrieval*, such that as *partial retrieval* increased

in frequency of use, speed decreased (Session 3: $r = -.39$, $p < .05$). There was no relationship between accuracy of orthographic features and *partial retrieval*.

Guessing significantly decreased. As expected, there was a significant correlation between *guessing* and orthographic features, such that as *guessing* decreased in frequency, accuracy improved (Session 1, $r = -.72$, $p < .01$; Session 2, $r = -.36$, $p < .01$). *Guessing* was almost eliminated by Session 3 and was associated with a significant correlation between *guessing* and speed, such that as *guessing* decreased in frequency speed increased ($r = .45$, $p < .05$).

Sounding out had no significant correlations with orthographic feature accuracy or speed until Session 3. At that point, there was a significant correlation between *sounding out* and accuracy, such that as *sounding out* decreased in frequency feature accuracy improved ($r = -.41$, $p < .05$). The results suggested that as feature accuracy improved, *sounding out* was not as useful in spelling words accurately.

Analogy, *chunking*, and *visual checking* had non-significant correlations with orthographic feature accuracy and speed.

Adaptive Choice

A correlation coefficient calculated errors of each word in the restricted condition with the percentage of backup strategies used on each word in the unrestricted condition. The more difficult the word was the more often participants misspelled the word and the more difficult the word the more participants used multiple strategies. The relationship between percent of backup strategy use and problem difficulty determined adaptability.

Table 6

*Descriptive Statistics for Individual Strategies
and Efficiency Correlations*

<i>Strategies</i>	<i>Session</i>	<i>Mean of frequency in strategy use</i>	<i>SD</i>
Complete Retrieval	1	1.26	1.55
	2	3.03	1.85
	3	3.42	1.98
Rule Use	1	2.94	2.97
	2	7.71	4.61
	3	8.10	4.10
Guessing	1	2.03	2.92
	2	0.42	0.85
	3	0.35	0.55
Sounding out	1	12.84	2.46
	2	12.16	3.05
	3	12.23	3.40
Partial Retrieval	1	5.39	3.04
	2	5.22	3.73
	3	5.10	3.24
Analogy	1	0.42	1.06
	2	0.19	0.48
	3	0.23	0.50
Visual Checking	1	0.45	1.48
	2	1.06	1.55
	3	0.55	0.85
Chunking	1	1.61	2.25
	2	2.00	1.18
	3	2.13	1.23
Orthographic Feature Accuracy	1	0.43	0.13
	2	0.60	0.10
	3	0.65	0.11
Speed	1	1.36	1.00
	2	0.59	0.43
	3	0.53	0.48

Note: Range 0-15

For the current study, the correlation between word difficulty and strategy use showed that the number of strategies used to spell difficult words was less than

the number used to spell easier words. The amount of variance shared between the two measures was within the meaningful range (Tabachnick & Fidell, 2001) but low ($r = -.37, p < .05$). This finding was the opposite of what was expected. These results suggested that these at-risk struggling spellers were demonstrating little adaptiveness in their performance.

Evidence of Effectiveness of Feedback

I used Hierarchical Linear Modeling, HLM, (Raudenbush & Byrk, 2002; Boyle & Willms, 2001) to measure growth trajectories in spelling development and to examine effectiveness of feedback in achievement of spelling success. I administered feedback conditions during the unrestricted spelling trials. In addition, I conducted an examination of individual differences in growth based on initial status, ending status, and classroom differences.

Analytic Procedures

I estimated a two-level model using the HLM program, Version 6.0 (Raudenbush, Byrk, Cheong, & Congdon, 2001). At Level 1, HLM procedures fitted a growth curve to the time series data. I set Session 3 at zero to determine differences in final status, and used results from the Primary Inventory pretest as a covariate predicting spelling growth. I used feedback and classroom differences as predictors with dummy codes set to zero for Feedback Only and Classroom 3. Measures were the raw scores from spelling Inventories I, II and III representing number of words correct.

An unconditional two-level growth model first estimated a spelling growth trajectory for students. Second, a conditional two-level model regressed the spelling outcomes on the hypothesized individual level predictors of student achievement. In both models, Level 1 was composed of a longitudinal growth model that fitted a linear regression function to each individual student's spelling achievement scores over the three sessions. Equation 1 specifies the Level 1 model.

$$Y_{ti} = P_{0i} + P_{1i} \times TIME + e_{ti} \quad (1)$$

Y_{ti} is the outcome (spelling achievement) for individual i at time t , P_{0i} is the intercept or status parameter for individual i at the final developmental time point, P_{1i} is linear growth rate over the three time points for individual i , and e_{ti} is the residual term representing unexplained variation from the latent growth trajectory.

At Level 2, the analysis modeled variation in the status (P_{0i}) and growth rate (P_{1i}) of students first unconditionally in terms of the mean status and growth of students and individual residual terms. The equations 2,a and 2,b specify the unconditional model. P_0 is the intercept set at Session 3 (final status). P_1 is the time slope (growth rate). B_{00} and B_{10} are the mean status and mean growth of the students. R_0 and R_1 are the student level residual terms.

$$P_0 = B_{00} + R_{0i} \quad (2,a)$$

$$P_1 = B_{10} + R_{1i} \quad (2,b)$$

In the conditional model, I added initial status, feedback, and classroom differences to the equation. The equations below specify the conditional Level 2 model.

$$P_{0i} = B_{00} + B_{01} (CORRECT) + B_{02} (FEEDBACK) + B_{03} (CLASS1) + B_{04} (CLASS2) + r_{0i} \quad (3,a)$$

$$P_{1i} = B_{10} + B_{11} (CORRECT) + B_{12} (FEEDBACK) + B_{13} (CLASS1) + B_{14} (CLASS2) + r_{1i}. \quad (3,b)$$

As can be seen in equations 3,a and 3,b, variation in the status and growth of students were modeled conditionally as a function of the mean status (B_{00}) or mean growth (B_{10}) of students, students' initial status ($CORRECT$), feedback condition ($FEEDBACK$), and classroom differences ($CLASS1$ and $CLASS2$), and respective student level residual terms, r_{0i} or r_{1i} .

Data Screening

Preliminary inspection of the time series data indicated a sharp gain at Session 2 and then a leveling off at Session 3 in number of words spelled correctly (see Figure 3).

Figure 3. Time Series Data.

The unusual data pattern suggested that there were problems with instrumentation. Originally, comparisons were based on orthographic features and spelling patterns. A closer examination of spelling inventories revealed an unrecognized inequality in difficulty between the sets of spelling lists. Spelling words within sets were equally difficult, but the list used at Session 2 was less difficult than the list used at Session 1. The amount of CVC (consonant, vowel, consonant) words, types of vowel patterns, and whether or not easy suffixes were included varied among the lists.

Therefore, I added an additional criterion to provide supplementary information for comparison. The criterion added was number and type of orthographic features. The three levels of difficulty were determined applying the following criteria. First, the least difficult showed orthographic patterns that ranged from late semiphonetic to within word pattern stage, 40% CVC words, two consonant digraphs, three consonant blends, two types of within word vowel patterns, no suffixes and all high frequency word selection (Rittle-Johnson and

Siegler's, 1999 spelling lists). Second, the medium difficulty showed orthographic patterns that ranged from late semiphonetic to early syllable juncture stage, 40 % CVC words, three consonant digraphs, four consonant blends, three types of within word vowel patterns, one suffix and 80% high frequency word selection (Bear, et al's, 2004 Primary Inventory). Third, the most difficult showed orthographic patterns that ranged from late semiphonetic to early syllable juncture stage, 27% CVC words, five consonant digraphs, seven consonant blends including preconsonant nasals, five types of within word vowel patterns including a vowel diphthong, five suffixes and 66% high frequency word selection (Bear, et al's, 2000 Inventories I and II) (see Table 7).

Difficulty level difference between spelling word lists violated essential premises of studying change over time. An essential assumption for growth curve analysis was that continuous measures should "have identical meaning across the developmental period of study" (Boyle & Willms, 2001, p. 144). Spelling inventories not only needed to duplicate orthographic features and spelling patterns, but also needed to duplicate the rate at which orthographic features become more complex.

Table 7

Criteria for Word List Difficulty

Criterion	Least Difficult	Medium Difficulty	Most Difficult
Orthographic Pattern Range	Late Semiphonetic to Within Word Pattern Stage	Late Semiphonetic to Early Syllable Juncture Stage	Late Semiphonetic to Early Syllable Juncture Stage
CVC words	40 %	40%	27%
Consonant digraphs	2	3	5
Consonant blends	3	4	7
Within word vowel patterns	2	3	5
Suffixes	0	1	5
High Frequency Words	100%	80%	66%

A necessary modification to the study design accommodated this anomaly. I dropped developmental points, Session 2 and Session 3, from the growth curve analysis, which included spelling lists from Rittle-Johnson and Siegler (1999) and the Primary Inventory post assessment. I added two more observational sessions, Session 4 and Session 5. To avoid a possible ceiling effect the more difficult spelling lists, Bear et al.'s (2000) Inventory I and II, were chosen as a measure for analysis. Also, a supplementary third spelling inventory was created that duplicated the orthographic features, spelling patterns, and progression of

orthographic difficulty found in Inventories I and II. (See Appendix A for Spelling Inventories.)

Session 1 was nine to twelve weeks before Session 4, and Session 5 was one to three weeks after Session 4 creating a fixed unequal measurement schedule, a variation in growth curve analysis that was acceptable (Boyle & Willms, 2001). Data from Session 2 and Session 3 applied now only to the adaptability question and was dropped from other analyses. Therefore when I have reported the findings of Session 1, 2 and 3, I have in reality reported Session 1, 4 and 5. (See Appendix B for adjusted time schedule.)

HLM Findings

Unconditional Two-Level Model for Spelling Achievement

Table 8 presents descriptive statistics on Feedback, final status, and classroom differences. At final status, students spelled 4.15 words correctly (N = 31 students) on average with a minimum of zero correct and a maximum of 10.05 correct out of a possible fifteen. The means displayed for Feedback and Classroom 1 and 2 indicate sample proportions that make up each group. The students in the feedback condition where feedback elicited an expert's explanations consisted of .55 of the sampling. Consequently .45 of the students were in the feedback condition where the researcher told children if their spellings were right or wrong. Classroom 1 had .32 of the sample and Classroom 2 had .26, leaving Classroom 3 with .42 of the sample. Classroom 3 and Feedback Only were used as the reference conditions.

Table 8

*Descriptive Statistics for Unconditional Two-Level Model for
Spelling Achievement*

Variable Name	N	MEAN	SD
Feedback	31	.55	.51
Classroom 1	31	.32	.48
Classroom 2	31	.26	.44

Note: Final Status, $M = 4.15$, $SD = 2.36$, and range = 0-10.05 correct.

Table 9 presents the results of the two-level unconditional model. Calculation of 95% confidence intervals for the achievement level (3.11, 4.51) and growth estimate (0.92, 1.50) indicated that both parameter estimates were different from zero. Table 10 presents variance estimates. Chi-square tests demonstrated that students differed in achievement level and rate of achievement growth. These results indicated that there were individual differences from one student to another in spelling achievement at the final time point and in the rate of growth in spelling achievement over the three sessions.

Table 9

Two-Level Unconditional Model Results for Spelling Achievement

Fixed Effects	Estimate	SE	<i>t</i>
Mean achievement status, β_{00}	3.81	0.34	11.16***
Mean growth, β_{10}	1.21	0.14	8.51***
Random Effects	Variance Component	df	χ^2
Individual achievement, r_{0i}	3.08	30	163.67***
Individual growth, r_{1i}	0.30	30	47.05*
Level 1 error, e_{ti}	0.82		

Note. SE = Standard Error

* $p < .05$. *** $p < .001$.

Conditional Two-Level Model for Spelling Achievement

Table 10 presents the results of the two-level conditional models. At the top of the table under Fixed Effects, the estimates indicated that initial status (beginning performance baseline accuracy) and classroom differences (accuracy means achieved among students in each classroom) were related to final status levels (accuracy at last session). The number of words spelled correctly at the beginning of the developmental session was positively related to the number of words spelled correctly at final status ($\beta_{01} = 0.48$). The coefficient indicated that for every one-unit change in initial status, final status increased by .48 words. The coefficient (Classroom 1, $\beta_{03} = 1.47$) indicated that the students in this classroom were achieving higher spelling scores at final status relative to

students in Classroom 3. No statistically significant differences in the level of spelling achievement for feedback conditions were observed in the sample.

Similar patterns emerged when I considered student growth rate in achievement. Students' initial achievement status was a positive predictor of students' rate of spelling growth. The coefficient relating initial status to growth ($\beta_{11} = 0.09$) indicated that for every one scale-score unit change in students' initial status, students' spelling growth increased on average by 0.09 scale score points per session. The result was that the initial gap between higher and lower achievers widened over the course of the developmental period studied. Similarly, Classroom 1 had students growing one word per session ($\beta_{13} = 0.96$) greater than Classroom 3 students while students of Classroom 2 were growing a quarter of a word ($\beta_{14} = 0.25$) greater than Classroom 3 students. (See Appendix C for ANOVA reporting of Classroom 3.)

A visual examination of the individual growth trajectories supported the widening differences of ability between high and low achievers (see Figure 4 & 5 for unfitted and fitted growth trajectories). The fitted individual growth trajectories display a fantail effect. Children who started out with higher initial status were growing at a faster rate than those who started out with lower initial status.

Figure 4. Unfitted Time Series Data

The bottom of Table 10 under Random Effects presents conditional variance estimates of students' spelling achievement level and growth. Chi-square tests demonstrated that adjustments for students' initial status and classroom differences did not completely explain the difference among students in spelling achievement at the final developmental time point but did explain all the variance in rate of growth. However, even though the remaining variance is not significant for growth rate, the chi-square test may be underpowered by the small sample size. When a comparison of unconditional and conditional variance was made, estimates revealed that Level 2 predictor variables accounted for 28% of the

variance in student growth, and 46% of the variation in students' final achievement levels.

Figure 5. Fitted Trajectories.

Table 10

Two-Level Conditional Model Relating Feedback, Initial Status, and Classroom differences to Spelling Achievement

Fixed Effects	Estimates	SE	t
Mean Accuracy Achievement, β_{00}	3.81	.25	15.51***
Initial Accuracy Status, β_{01}	0.48	.09	5.57***
Feedback w/expert explanation accuracy, β_{02}	0.40	.48	0.83
Classroom 1 accuracy, β_{03}	1.47	.61	2.39*
Classroom 2 accuracy, β_{04}	0.30	.60	0.51
Mean Growth Rate, β_{10}	1.21	.11	10.64***
Initial Accuracy w/ Growth Status, β_{11}	0.09	.03	3.16**
Feedback w/expert explanation growth rate, β_{12}	0.06	.22	0.26
Classroom 1 growth rate, β_{13}	0.96	.28	3.46**
Classroom 2 growth rate, β_{14}	0.25	.27	0.92
Random Effect	Variance Component	df	χ^2
Individual achievement, r_{0i}	1.66	26	94.18***
Individual growth, r_{1i}	0.21	26	33.44

Note. SE = Standard Error, β_0 = accuracy, β_1 = growth rate

* $p < .05$. ** $p < .01$. *** $p < .001$.

Qualitative Analyses: Relationships between Orthographic Features and Spelling Strategies

The third question examined whether spelling stages and elements of the overlapping wave model shared any relationships. Qualitative methodology helped discover salient patterns related to these two major components of spelling development, and provided an approach for describing how these components related. Methodology choice assumed relationships to be fundamentally interpretive and more emergent than tightly prefigured (Marshall & Rossman, 1999; Rossman & Rallis, 1998). The method incorporated a microgenetic perspective of trial-by-trial exploration and was extensive in nature. The fine-grained analysis was necessary to examine each spelling trial for patterns in orthographic features and spelling strategies children used.

Due to the extensive nature of the exploration the qualitative analyses used students from one of the three participating classrooms. Results from the growth curve analysis showed one classroom in particular increasing significantly in accuracy of spelling words and rate of growth over the three sessions. This class represented one third of the original participants (10 out of 31). I hypothesized that: (a) this higher performing classroom would reveal relationships between orthographic features and strategy use because of high growth rate and accuracy, and (b) higher performing spellers who were initially low performing would display a wide range of growth patterns found among first grade classrooms in general. Therefore, I made the decision to limit the analysis data to

these ten students based on the belief that they would reflect the participants as a whole, and first grade students in general.

The analyses took place in three phases. The first phase was an analysis of orthographic feature errors to discover what features children knew and what degree of orthographic understanding children reached. The second phase included observational data from video recordings, children's self-report and children's spellings, and findings organized into two types of data displays. Data displays (Miles & Huberman, 1994) showed the orthographic features and spelling strategies children used for each session and for each spelling trial within a session, and displayed relationship patterns over time. The third phase included a series of componential analysis (Spradley, 1980) conducted to determine relationships between orthographic features and spelling strategies and organized into paradigms (specialized matrices). The paradigms built upon the foundation of the data displays. The following describe these three phases.

Phase 1: Error Feature Analysis

Spelling inventories used orthographic feature errors to analyze children's spelling attempts. Bear et al. (2000) provided error guides and feature guides that placed spelling errors on a continuum of developing spelling ability. An error guide classifies commonly made errors for each specific word and places that error within one of the six spelling stages. For instance, the word *net* was the first word on the Spelling Inventory II. If a child spelled *net* with just an initial and final consonant (i.e., N or NT), then the child performed in the Middle Emergent stage. If the child spelled *net* with an incorrect vowel but one that was phonetically close

(i.e., NAT), then the child performed in the Early Letter Name-Alphabetic stage. If a child spelled the word correctly, then she or he performed in the Middle Letter Name-Alphabetic stage. An overall evaluation of the error guide displayed a general depiction of stage-level performance.

The feature guide used points to determine an overall placement of stage development. The guide gave each letter of each word points according to the spelling features the child accurately represented (i.e., initial and final consonants, short vowels, digraphs and blends, long vowel patterns, other vowel patterns, consonant doubling, prefixes and suffixes, and bases and roots). The fifteen words used on Spelling Inventory I and II represented a range of stages from Late Emergent to Early Syllable Juncture and Easy Suffix. The feature guide determined what orthographic features the students knew, confused, and needed to learn.

Phase 2: The Display Matrices

Data displays used the error feature analysis to explore patterns of relationships between the orthographic feature and the spelling strategies. Miles and Huberman (1994) defined a data display as an “organized compressed assembly of information that permits conclusion drawing” (p.11). A display format summarizes the data and allows the researcher to clearly describe an accounting of the variables under investigation (Bernard, 1988), in this case spelling strategies and orthographic features.

Display formats come in several varieties and have specific purposes. A checklist matrix is a format that organizes major variables. The matrix includes

the components of the variables in a coherent singular fashion. The display encourages comparability and permits simple quantification. In contrast, the time-ordered matrix helps describe information by time. The format arranges the components chronologically into time-ordered events or phases of the developmental process. Both types of display matrices were used in the analysis.

The first display (Table 11) was a series of three comprehensive checklists matrices for each analyzed participant at each period of development (thirty-three total). The checklist matrix assessed relationships between spelling strategies and orthographic features and determined the child's current spelling stage (Schlagal, 1989; Bear et al., 2004).

The checklist matrix organized the first column into the fifteen spelling words, which also headed the rows of the matrix. The second column was entitled Observed Strategy and displayed an abbreviation of spelling strategies the researcher observed. The third column displayed the self-report of the child. The fourth column displayed the spelling strategies that were determined by the spelling itself.

The next seven columns displayed the orthographic features according to Bear et al. (2004) that were possible among the fifteen words. Initial sound, final sound, short vowel sound, digraphs and blends, long vowel patterns, other vowel patterns, syllable juncture and easy suffix were the titles of those seven columns. Displayed in those columns were the letter choices the child made to spell the word. Highlights indicated the incorrect letter choices and black ink indicates the correct letter choices. For *trace*, the seventh row of our example displayed a

Table 11

Checklist Matrix Example Without the Summary Rows and Columns

Time2		Strategies				Features				
Word	Observed	Reported	Student Work	Initi	Fina	Short Vowel	Digra & Blend	Long Vowel	Other Vowel Pattern	Junctu & Suffix
net	CR	I already knew it		n	t	e				
trip	CR	I already knew it			p	i	tr			
then	CR	I already knew it	Consonant Digraph rule		n	e	th			
dump	CR	I already knew it		d		u	mp			
soap	PR	Sounded it out & tried to decide if I needed an "a" or "w".	Incorrect vowel marker	s	p					
chain	SO	I knew it.	Consonant Digraph rule		n		ch			
trace	PR	I was trying to decide if I need an "s" or a "C"					tr			
crime	SO	Sounded it out			m		cr			
fright	PR	I knew it			t					
popping	PR,SO "p" and "o"	I knew it	Chunk	p						
broil	SO	I heard an "oi" and didn't know what letters to put with it and Sounded it out	Vowel diphthong	b	i					
jerking	CR"king" SO "jer"	I thought of it	Chunk	j						ing
brewed	SO	Knew it	Vowel digraph				br			
bunnies	SO	Sounded it out		b		u				
perched	SO	Sounded it out	Consodigraph control r, "ed" suffix				ch			ed
Stage/Strategy	Late Phonetic Stage/ PR predominant, some SO, 4 CR & RU increasing									

Note. CR is Complete Retrieval. PR is Partial Retrieval. SO is Sounding Out.

black *tr* under blends and digraphs, a highlighted ■ under final sound, a highlighted ■ under long vowel patterns. The final column of the matrix was a summary of the combinations found between strategies and correct features.

In addition, the matrix included two final rows. The first row summarized each column's overall findings, and the final row listed all the strategies used by the participant and named the child's spelling stage. The checklist matrices were oversized documents and were not included in the appendix. However, Table 11 displays a reduced example.

The second display (Table 12) was a time-ordered matrix for each analyzed participant (ten total). This matrix organized the results from the checklist matrices over the three developmental sessions to provide an in depth look at the variables over time. The time-ordered matrices revealed patterns of spelling growth, the spelling strategies, and the orthographic features generated. The matrix displayed the sessions in the columns. The rows represented: (a) the stages of development; (b) the ways strategies were observed (i.e., researcher observation, participant self-report, and participants work); and (c) the orthographic features. A final row displayed researcher remarks. (See Table 12 for an example and see Appendix D for all ten time-ordered matrices.)

Table 12

Time-ordered Matrix for One Participant

ID 3	Session 1	Session 2	Session 3
Stage	Late Semiphonetic Stage	Late Phonetic Stage	Late Phonetic Stage
Strategies Used	1 CR + PR + SO + 5 G	2 CR + PR + SO + CH + RU + 1 G	2 CR + PR + SO + CH + RU + 1 G
Strategy Observed	1 PR + 14 SO	1 CR + 1 PR + 13 SO	2 CR + 2 PR + 11 SO
Strategy Reported	PR + SO	1 CR + PR + SO	CR + PR + SO
Strategy Displayed on Student Work	1 CR + G (5 cases)	1 G + CH: ing suffix (once) + RU: (4 cases) consonant digraph	1 CR + 1 G + CH: ing suffix (stable) + RU: (2 cases) consonant digraph
Initial and Final Consonant	Guessing, becoming consistent	Consistently accurate	Guessed (1 case), accurate 94 %
Short Vowels	3 incorrect out of 6	1 incorrect (phonetically close)	Consistently accurate
Blends	No knowledge of digraphs or blends	Unstable, 6 correct cases out of 12	Unstable, 4 correct cases out of 10
Long Vowel Markers	No Knowledge	No Knowledge	No Knowledge, phonetically correct
Other Vowel Patterns	Guessing	No Knowledge	No Knowledge
Junctures and Suffixes	Guessing	Guessing or phonetically correct	Suffix ing consistently accurate, others phonetically correct
Remarks	<i>Sounding out</i> is predominant strategy through all sessions. <i>Guessing</i> decreases but is never eliminated. All words at Session 1 are spelled with three letters. Session 2 & 3 displays digraphs and the easy suffix ing. Consonant digraphs never stabilize but the ing suffix does. CR gradually increases as initial and final sounds stabilize and G decreases. CR, RU & CH are added.		

Note: CR is Complete Retrieval. PR is Partial Retrieval. G is Guessing. SO is Sounding Out. RU is Rule Use. CH is Chunking.

Phase 3: Componential Analyses

Phase 3 included the development of three componential analysis paradigms. Spradley (1980) defined a componential analysis as a way to “organize and represent all the contrasts you have discovered” (p. 130). The organization format is similar to a display matrix that Spradley refers to as a paradigm. The paradigm identifies “components of meaning”. Components of meaning are subsets of information that define the question under investigation. Components of meaning have attributes that help characterize the subsets. Spradley (1980) referred to these attributes as “any element of information regularly associated” with the question under investigation (Spradley, 1980, p. 131). Attributes become dimensions of contrast. The most effective way to describe the paradigm is with a visual sample that I provide in Table 13. The three componential analyses were the final step in exploring patterns between orthographic features and spelling strategies.

Table 13

Sample Componential Analysis Paradigm

Components Of Meaning	Dimensions Of Contrast		
	1	2	3
Subset	Attribute 1	Attribute 2	Attribute 3
Subset	Attribute 1	Attribute 2	Attribute 3
Subset	Attribute 1	Attribute 2	Attribute 3

Table 14 shows the first componential analysis paradigm. The components of meaning analyzed were spelling stages and included four major developmental

Table 14

Paradigm of Participants' Developmental Progress

Spelling Strategies	Developmental Progress Patterns of Ten Participants in Order of Beginning Status									
ID	3	4	5	6	8	1	2	7	9	10
Late Semiphonetic	S1	S1	S1	S1						
Early Phonetic		S2 S3	S2					S1		S1
Middle Phonetic			S3	S2	S1 S2 S3	S1	S1			
Late Phonetic	S2 S3			S3		S2	S2	S2	S1	
Early WWP						S3	S3	S3	S2	
Middle WWP										S2
Late WWP										
Early Syllable Juncture									S3	S3
Emerged Pattern	Pattern 1	Pattern 2		Pattern 3		Pattern 4		Pattern 5		
Definition of Progress Patterns	Initial Status:Late SP. Progress delayed S2	Initial Status:Late SP and progress consistent		Progress delayed at Middle P stage		Progress consistent S2 and S3. Final: Early WWP		Rapid progress. Final: Early SJ		

Note. S = Session. WWP = Within Word Pattern. SP = Semiphonetic. P =

Phonetic. SJ = Syllable Juncture.

stages. These stages were determined from the data found on the checklist and time-ordered matrices and are: Late Semiphonetic; Early, Middle, and Late Phonetic; Early, Middle, and Late Within Word Pattern; and Early Syllable Juncture.

The dimensions of contrast were the ten participants' developmental progression through the stages at Session 1, 2, and 3. Five patterns of developmental progression emerged. Two variables distinguished these patterns, initial or final status, and stage progress (i.e., the amount of stages the participant progressed through over the three sessions). The five patterns are: (1) initial status at Late Semiphonetic stage and a delay in progress at Session 2; (2) initial status at Late Semiphonetic stage and progress consistently developing over the three sessions; (3) a delay in progress at the Middle Phonetic stage over all sessions; (4) consistent progress through the same stages at Session 2 and Session 3 and having a final status at the Early Within Word Pattern; and (5) rapid progress with a final status at the Early Syllable Juncture stage. These patterns represented the orthographic features children displayed in their spellings and provided a means in which to compare spelling strategies.

The second componential analysis displayed the five progression patterns as the dimensions of contrast, and the dimensions of contrast were the eight spelling strategies observed by the participants (see Table 15). This second componential analysis displayed Orthographic Rule Use separately in Table E1 of Appendix E. Orthographic Rule Use's direct dependence on orthographic features created a need for a detailed in depth matrix.

Table 15

Paradigm of Spelling Strategies Used Over the five Patterns of Developmental Progress

Patterns of Development Progress	Session	Strategies Used						
		Complete Retrieval	Partial Retrieval	Sounding Out	Guess	Chunk	Analogy	Visual Check
1 Begin LSP progress delayed S2	1	0 or 1	1-2 cases/ session	11-14 cases/ session	8 cases	et	None	1 case at S3
	2	Increase 1			4 cases	ing		
	3	Increase 0 or 1			1 case	ing		
2 Begin LSP consistent progress	1	0	0-5 cases/ session	10-15 cases/ session	6 cases	0	1 case at S2	1 case at S3
	2	Increase 1			1 case	ing		
	3	Increase 1			1 case	ing		
3 MP MP MP	1	2	1-4 cases/ session	10-15 cases/ session	0 cases	0	None	None
	2	Increase 2			0 cases	ing		
	3	Increase 2			0 cases	ing		
4 S2 & S3 same, final status EWW	1	1 or 2	4-10 cases/ session	0 – 9 cases/ session	1 case	0	4 cases over each session	1 case at S2 & 3
	2	Increase 2			0 cases	ing		
	3	Increase 2			0 cases	ing		
5 Rapid growth, final status ESJ	1	1 or 4	0-5 cases/ session	5-13 cases/ session	4 cases	ing	1 case at S1	1 case at S1 & 2
	2	Increase 1 or 3			1 case	ing		
	3	Increase 4			1 case	ing		3 cases at S3

Note. LSP = Sate semiphonetic. MP = Middle Phonetic. EWW = Early Within

Word. ESJ = Early Syllable Juncture. S = Session.

I determined strategy comparisons by using checklist matrix and/or time-ordered matrix information. Comparisons used individual information for each

strategy. I compared *complete retrieval* by using the rate in which it increased. For *partial retrieval*, *sounding out*, *guessing*, *analogy* and *visual checking* I used the number of incidents in which children used the strategies at each time session. For *chunking* I used letter patterns.

Table E1 (see Appendix E) displays Orthographic Rule Use strategy. The orthographic features of the words defined the attributes of *Rule use*: initial sound, final sound, short vowel sound, digraphs and blends, long vowel patterns, other vowel patterns, and syllable juncture and early suffixes. I compared each feature's attribute by how the participants used the orthographic rules that the features constrained.

A third paradigm looked at the total use of strategies over the five patterns of developmental progress. The analysis' purpose was to reveal any patterns that might emerge between total types of strategies used and the five developmental progression patterns. Comparisons displayed types of strategies used over sessions within the five patterns of developmental progression (see Table 16).

Qualitative Findings

Findings from the qualitative matrices and paradigms demonstrated evidence of spelling strategy commonalities and differences and children's growing use of orthographic features. Common patterns emerged from the findings and summarized important relationships. The quantitative analyses supported many of the qualitative findings. I present findings first by strategy, explaining relationships between the individual spelling strategy and orthographic features;

and then by orthographic features, detailing findings from the error feature analysis. I conclude by presenting common patterns found from the overall data.

Table 16

Paradigm of Total Strategies Used

Total Strategies Used					
Patterns of Stage Development	Session	Range	Common Strategies Used		Strategy Used Different from Group
1Begin LSP progress delayed S2	1	4-5	PR + SO + G		CR RU
	2	5-6	PR + SO + G + CR + RU		CH
	3	6	PR + SO + G + CR + RU		CH VC
2 Begin LSP consistent progress	1	3-4	PR + SO + G		RU, PR G
	2	3-6	SO +	CR + RU	A
	3	3-7	SO +	CR + RU	PR G CH VC
MP	1	5	PR + SO + G + CR + RU		
MP	2	7	PR + SO + CR + RU + CH + VC + A		
MP	3	7	PR + SO + CR + RU + CH + VC + A		
4 S2 & S3 same, final status EWW	1	4-6	PR + SO + G + CR + RU		A
	2	5	PR + SO + CR + RU + CH		A
	3	4	SO +	CR + RU + CH + VC	PR
5 Rapid growth, final status ESJ	1	5-7	PR + SO +	CR + RU	G CH VC A
	2	5-6	PR + SO +	CR + RU	G CH VC
	3	6-7	PR + SO +	CR + RU + CH + VC	G

Note. CR = Complete Retrieval. PR = Partial Retrieval. G = guessing. SO =

sounding out. RU = rule use. A = analogy. VC = visual checking. CH = chunking.

LSP = Late Semiphonetic. S = Session. MP = Middle Phonetic. EWW = Early

Within Word. ESJ = Early Syllable Juncture.

Findings by Strategy

Complete retrieval showed a steady and consistent increase over the three sessions (Session 1: $M = 1.2$ words correct, Session 2: $M = 2.8$ words correct, and Session 3: $M = 4.5$ words correct).

Children used *complete retrieval* with individual words more frequently as their knowledge of orthographic features improved. For instance, in Session 1 students were inconsistently accurate when using 4 to 7 feature types (short vowel sounds, digraphs and blends, long vowel patterns, other vowel patterns, and syllable junctures) and *complete retrieval* ranged 0–4 words ($M = 1.2$). By Session 3 students were inconsistently accurate when using 3 to 4 feature types (digraphs and blends, long vowel patterns, other vowel patterns, and syllable junctures) and *complete retrieval* increased 2–9 words ($M = 4.5$).

Complete retrieval seldom occurred without *rule use*. If children accessed *ship* from memory accurately, the consonant digraph rule was also used. When children spelled *soap* without any observable behaviors and the child reported just knowing it, also children used the *oa* vowel pattern rule.

Qualitative results of both *complete retrieval* and *rule use* demonstrated the Matthew effect (Stanovich, 1986). Students that started at a higher level of orthographic feature understanding were increasing the use of *complete retrieval* and *rule use* at a faster rate than those who started out with less feature understanding. Higher performing students who began at the Phonetic stage progressed between five and seven stage levels, increasing *complete retrieval* one to four words per session. Lower performing students who began at the

Semiphonetic stage progressed between two to three stage levels, increasing *complete retrieval* zero to one word per session.

I compared one lower performing student's increase of *complete retrieval* and *rule use* with a higher performing student's increase. The lower student increased 1 *complete retrieval* per session and 2 *rule use* per session, while the higher student increased 4 *complete retrieval* per session and 6 *rule use* per session. These results were consistent with the findings from the growth curve analysis where accuracy between high and low students was increasing at a different rate of growth and the findings from the efficiency correlations. These analyses included all 31 participants.

Complete retrieval and *rule use* were the most common strategy combination followed by the combination of *complete retrieval*, *rule use*, and *sounding out*.

Rule use demonstrated that the more consistently and accurately the strategy was used, the faster the growth rate. For instance, participants who consistently and accurately used initial, final and short vowel sound features at Session 1 were attempting long vowel sound, other vowel patterns and syllable junctures by Session 2 and beginning to be consistently accurate with those features by Session 3. However, those who were unstable in initial, final, and short vowel sounds at Session 1 only increased their proficiency in those three features by Session 3.

Findings showed *rule use* directly related to the orthographic features that individuals understood and employed. Knowledge of vowel patterns allowed the implementation of vowel pattern rules. In other words, the child had to know the

orthographic pattern in order to apply the rule. Higher performing students demonstrated orthographic rule use sooner and were more consistently accurate sooner. For instance, participants falling under the fastest progression pattern “Rapid growth, final status ESJ” were consistently accurate over three types of orthographic features at Session 1. Participants falling under the slowest progression pattern “Begin LSP progress delayed Session 2” took till Session 3 to become consistently accurate over three types of orthographic features.

Interestingly, if children stated rules during self-report there was a higher degree of use of that rule among the trials. For instance, a lower performing student spelled *float*, FLOT, reported sounding it out at Session 1. Not until Session 3 was the word *boat*, spelled BOAT, and reported, “I used a rule, but I’m not sure what.” Over the three sessions this child’s spelling attempts of long vowel patterns went from no attempts to one attempt and one incident of accuracy. Compare that performance with a higher performing participant who spelled the word *serving* at Session 1 SRUVEN, and reported, “some letters I already knew and some I spelled out.” At Session 2, he spelled *jerking*, JERCKING, and reported, “I knew it but I kept messing up.” By Session 3, he spelled *perching*, PERCHING, and reported, “Sounded out, has an *rrr* so it’s *er*.” Over the three sessions this child’s spelling attempts of the *r*-control vowel went from no attempts to five attempts and three incidents of accuracy. As the awareness of rules emerged within the self-reports, there were higher incidents of that rule being used.

Sounding out and *partial retrieval* participants used through all patterns of developmental progression consistently. *Sounding out* was the most used strategy with a range of 5 to 15 cases at each session ($M = 11.1$). *Partial retrieval* had a range of 1 to 10 cases per session ($M = 3.9$). These findings were consistent with quantitative measures and were demonstrated in the frequency counts and statistical analysis used to determine variability of strategy use for the general sample.

Guessing revealed participants using the strategy less as time passed with some of them eliminating *guessing* all together. I coded as high as 19 cases at Session 1 and no more than three cases coded at Session 3. *Guessing* was the only strategy dropped (six of the ten participants were no longer using *guessing* by Session 3). Lower performing students employed *guessing* more often (8 cases at Session 1) than higher performing students (4 cases at Session 1). Congruently, children used the strategy far more frequently at the earlier spelling stages of development (14 cases at Late Semiphonetic stage) than at the later spelling stages (1 case at Early Syllable Juncture stage). These findings were consistent with statistical results of the variability analysis.

Chunking was sparse and primarily associated with spelling the *ing* suffix. The *ing* pattern children consistently spelled accurately once the chunk appeared in the student's writing. *Chunking* was the most commonly added strategy (all ten participants were using it by Session 2, but isolated to *ing*).

Analogy and *visual checking* were the least used strategies. *Analogy* had six reported cases. *Visual checking* had nine coded cases. The componential

analyses showed these strategies employed more by the higher performing students (5 cases of *analogy* and 6 cases of *visual checking*) than the lower (no cases of *analogy* and 2 cases of *visual checking*), and that they were added to a child's repertoire of spelling strategies only after reaching the Phonetic Stage.

I created a componential analysis to look at efficiency in order to further investigate *analogy*, *visual checking*, and *chunking* (see Table 17). The

Table 17

Strategies Added as Features Mature

Added Strategies	Session 1	Session 2	Session 3
Chunking	2 cases 100 % correct	15 cases 100% correct	18 cases 100% correct
Analogy	2 cases 50% correct	2 cases 0% correct	2 cases 50% correct
Visual Checking	1 case 100% correct	3 cases 67% correct	5 cases 80% correct

evidence showed incidents of these strategies increasing in use and accuracy.

Children effectively used *Analogy* in 50% of the cases in Session 1 and 3, but in Session 2 it was not effective. *Analogy* was used twice at each session. Children effectively used *visual checking* in most cases (80% accurate by Session 3).

Visual checking increased steadily over sessions (one, three, and five incidents respectively). *Chunking* did not show up until the Middle Phonetic Stage and then only occurred with the *ing* suffix. Once children employed the pattern, it stabilized

quickly (100% accuracy over all sessions). Incidents increased with one at Session 1, fifteen at Session 2, and eighteen at Session 3. Only qualitative analysis was possible for *analogy*, *visual checking*, and *chunking* due to the low number of incidents.

Evidence from the matrices and paradigms suggested that orthographic feature understanding influenced six of the eight strategies. They also provided support for the quantitative analysis on most findings.

Findings by Orthographic Features

Feature error analysis showed children progressing gradually through levels of orthographic understanding by adding a feature a few incidents at a time. Blends and digraphs often started out with only one or two correct incidents and then progressed until all possible incidents were consistently accurate. For instance, one participant got one blend right at Session 1. By Session 2 he produced five correct blends. At Session 3 he produced all but three blends correctly. Features were added inaccurately often before they became accurate. Many of the short vowels (win for when), the *r*-controlled vowel (porched for perched), and the silent *e* rule (frite for fright) are examples.

Findings provided evidence for general phases as children added types of features only after other features were consistent. Initial and final features became consistently accurate before short vowel features. Short vowel features became consistent before long vowel patterns. Blends and digraphs became consistent before long vowel patterns. Other vowel patterns and syllable junctures did not start to emerge until children added some incidents of long

vowel patterns. Children over generalized the silent e rule for all long vowel patterns before other long vowel patterns appeared. Children used initial, final features, short vowels, and blends consistently before long vowel, other vowel patterns and easy suffixes were demonstrated. These last three types of features had incidents added across them, sometimes concurrently, but none of them reached consistency.

Fuzzy lines between levels indicate phases rather than stages. For instance, children demonstrated the accurate use of the easy suffix *ing* (Syllable Juncture stage) before long vowel patterns were consistent (the Within Word stage). Also, other vowel patterns (i.e., vowel diphthong or *ew*) were slower to emerge than the *ing* or the *ed* suffixes.

The error feature analysis provided evidence that orthographic understanding was a gradual progression acquired in phases rather than stages.

Common Patterns Across Results

Evidence from the orthographic feature analysis and evidence of strategy use from the matrices and paradigms showed four common patterns: (a) Some spelling strategies were not affected by orthographic features, (b) some spelling strategies were tethered to orthographic features, (c) the appearance of some strategies were related to orthographic knowledge, and (d) development of strategies and features progressed in diverse ways.

The first common pattern showed orthographic features did not affect some spelling strategies. *Sounding out* and *partial retrieval* remained constant in spite of orthographic feature knowledge, with *sounding out* being the most

predominant strategy among all the strategies. They appeared stable over time as children used them in a persistent and frequent manner. The descriptive statistics associated with the general linear model comparing strategy use over the three sessions for all participants corroborated this finding. (Refer to Table 6.)

The second common pattern that emerged from the qualitative matrices revealed that in five ways orthographic features were tethered to three spelling strategies, *complete retrieval*, *rule use*, and *guessing*. One way showed that children used *rule use* in tandem with the feature even though some rules were more tacit than explicit. *Rule use* existed only in the presence of the feature. If a child spelled *oi*, she or he used the diphthong rule.

The second way orthographic features influenced spelling strategies was that *complete retrieval* is impossible to achieve without the accurate use of orthographic features. If a child spelled the word *marched* correctly that child also used four orthographic features correctly (i.e., initial feature, *r*-control vowel feature, consonant digraph feature, and easy suffix feature).

The third relationship demonstrated that *guessing* was void of any evidence of orthographic feature knowledge, and the more knowledge about orthographic features the individual obtained the less the students used *guessing*. Also, *guessing* decreased as *rule use* and *complete retrieval* increased. Four participants eliminated *guessing*, but at least one participant used it at each level of orthographic development.

Another influencing factor was as *rule use* increased so did *complete retrieval*. However, *complete retrieval* lagged behind *rule use*. For instance, the

use of *complete retrieval* increased in frequency 1 to 3 spelling trials per session where the use of *rule use* increased in frequency 2 to 6 spelling trials per session. The final relating factor showed both *rule use* and *complete retrieval* affected by the Matthew effect.

The third common pattern showed the appearance of certain strategies affected by orthographic knowledge. *Chunking, analogy* and *visual checking* appeared related to orthographic feature knowledge at least in the timing they appeared within a child's repertoire. One indication of this was that students did not employ *chunking, analogy* or *visual checking* until they mastered the early phonetic stage and were at least consistent with their initial and final sounds.

Finally, the fourth common pattern pointed to diverse development paths for strategies and features. Spelling strategy use and orthographic feature understanding developed in dissimilar ways. Strategies overlapped one another while orthographic feature understanding developed in orderly phases. There was no evidence that supported a lock step, discrete movement. I observed orthographic features changing systematically and in an orderly phase-like fashion as children became more sophisticated in their knowledge of orthography. The analysis found children making overgeneralizations as spelling words introduced more complex features (i.e., *r-control* vowel used in blends; *fr* spelled FER), but children remained "stuck" until the overgeneralization cleared up. One participant remained at the Middle Phonetic stage the entire 19 weeks due to the overgeneralization of *r-control* vowel rule. Also, less sophisticated knowledge faded rather than ending abruptly (e.g., Children overcame incorrect

short vowel usage gradually). In contrast, a range of strategies appeared early in the development of orthographic understanding and persisted over time. Just as the overlapping wave model suggested, there were strategies that started early and persisted, those that started early and faded, those that increased in use and efficiency and those that appeared as spelling development progressed.

Figure 6 illustrates how the qualitative exploratory findings mapped strategy use unto orthographic feature understanding. Abbreviations along the X-axis refer to the different stages of spelling development.

The results for the qualitative analysis described four common patterns, which supported the results of the quantitative analysis. Those patterns showed that spelling strategies and orthographic features influence one another and that they developed together in synchrony, yet on diverse paths of progression.

Note. LSP = Late Semiphonetic, EP = Early Phonetic, MP = Middle Phonetic, EWW = Early Within Word, MWW = Middle Within Word, LWW = Late Within Word, and ESJ = Early Syllable Juncture.

Figure 6. *Mapping Strategy Development to Orthographic Feature Development*

CHAPTER V

DISCUSSION

This chapter's organization begins with a brief review of the findings related to each research question followed by a discussion that highlights key points. The chapter concludes with implications for theory, spelling instruction, and research methodology.

Does Overlapping Wave Theory Provide A Viable Explanation of Spelling Development?

Review of Findings

The current study examined orthographic development in the light of Siegler's (1995) overlapping wave theory. The investigation attempted to replicate and extend Rittle-Johnson and Siegler's (1999) study on children's use of strategies to generate spellings. I hypothesized that if the study found evidence of variation, gradual growth, and adaptiveness within the spelling behaviors of children, then orthographic development could be described as progressing in overlapping wave-like progression. The findings showed evidence of the overlapping wave theory in some aspects of spelling development, specifically with spelling strategies children used.

Evidence was based on findings from my observations and children's immediate retrospective self-report. Since self-report has often been found suspect (Reynolds, Brown, Niederhauser, & Trathen, 2006), a preliminary analysis to discern the accuracy of the self-report of the children was important. Four analysis conditions defined the consistency of the children's self-report with experimenter observation using accuracy and solution response times. Preliminary findings showed children's self-report to be consistent with researcher's observation in three of the four analysis conditions, which was 92% of the spelling trials. Only one of the four condition produced questionable results. This analysis condition was when children reported not using a strategy but the researcher observed one being used (8% of the trials). Rittle-Johnson and Siegler's (1999) original study found this analysis condition, but they were able to resolve the inconsistencies in favor of student self-report. The current study did not. In the current study evidence showed that children preferred accessing memory to sounding out. Researcher's observations alone were used for these spelling trials. Also, the four spelling conditions helped identify spelling strategies. Additionally, an automaticity baseline measure distinguished two ways children accessed their memories: strategically and automatically.

I conducted a test for variability once preliminary findings substantiated the methods and identified strategies. The results supported the existence of variability by producing nine different strategies used among the 31 participants: *sounding out*, *partial retrieval*, *rule use*, *complete retrieval*, *analogy*, *visual checking*, *chunking*, and *copying*. Children used two or more of those strategies

during each session and within each spelling trial. Also, the degree children used the strategies changed over sessions.

I characterized growth rate in terms of strategy frequency and efficiency and found that generally strategies were increasing in use and children were becoming more accurate and fast. However, individual strategies impacted efficiency differently and while the overall affect was positive, progress was slow. Less sophisticated strategies like *sounding out* and *partial retrieval* remained dominant, yet were not efficient. Interestingly, *sounding out*, while having no apparent affect on efficiency at first, hindered feature accuracy by the third session. More sophisticated strategies like *rule use* and *complete retrieval* increased in frequency and accuracy but did not improve in speed. *Rule use* actually slowed down production while improving accuracy. *Guessing*, as it was eliminated, was related to an improvement in accuracy and speed.

Finally, I found no adaptive choice among these spellers. A low negative correlation between word difficulty and strategy use showed low performing spellers using more strategies on words spelled correctly than on words not spelled correctly. As participants' spelling accuracy improved the number of strategies they used to help spell words increased. This is the opposite trend predicted if adaptive choice is present.

Evidence of Overlapping Waves

Preliminary Findings Discussed

I begin with the discrepancies between the two studies found in the preliminary results to discuss the first question's findings. Then I discuss the

results of the variability and gradual growth findings and conclude with the adaptability discrepancies.

I established rater reliability of analysis conditions showing consistency of children's self-report with experimenter observation. However, two inconsistencies with the Rittle-Johnson and Siegler (1999) study were found. The first discrepancy related to differences found in verification of children's self-report within one of the four analysis conditions. The condition in question was an ambiguous classification where the researcher observed the use of a strategy but the children reported accessing their memories. In Rittle-Johnson and Siegler's (1999) study children's self-report was verified by higher accuracy rates and faster solution times demonstrating accessing memory. Also, the researchers discovered when examining the video tapings children began with a strategy but finished the word by rote. However, in the current study accuracy rates and solution times did not substantiate the children's reports, and examining video tapings produced evidence that children favored accessing their memories over using a spelling strategy.

The inconsistency of findings between Rittle-Johnson and Siegler's and the current study can be explained by the differences in children's spelling ability coupled with their disposition towards accessing memory. Rittle-Johnson and Siegler's participants were high performing students (B. Rittle-Johnson, personal communication, May 23, 2005). The current study's sample consisted of low ability, at-risk students. High performing students accurately access their memory sooner and more often. In contrast, at-risk students accurately access their

memory less frequently and at a higher cost of effort. They tend to worry more whether they are accessing their memory than a higher performing child. Therefore, lower performing children appear to try to mask their difficulties.

The second discrepancy between Rittle-Johnson and Siegler's study and the current study pertains to when children accessed their memory to spell words. Rittle-Johnson and Siegler coded accessing memory as retrieval. Rittle-Johnson and Siegler (1999) described retrieval (or accessing memory) as a state of instantaneous and subconscious recognition, yet they also classified accessing memory as an alternative strategy to those they considered backups. This was a perplexing stretch of how a strategy was usually defined.

Strategies are considered goal-directed cognitive operations. They are flexible, conscious processes agreeable to personal changes (Paris, Wasik, & Turner, 1991; Pressley, El-Dinary, Gaskins, et al, 1992; Pressley, Harris & Marks, 1992). In spelling, if children produced a word often enough (i.e., an individual's name or many high frequency words) the spelling lost all necessity for strategic behavior and became an unconscious act that was quick, accurate, and effortless (Plaut, McClelland, Seidenberg, & Patterson, 1996; Treiman, 1993). When spelling words reached this level of proficiency they were no longer strategic. Retrieval as a heuristic in these incidents was not very helpful.

I found determining differences between automaticity and strategic behavior important assuming that first grade struggling readers would probably not be proficient. I classified accessing memory into two strategies, *complete retrieval*, and *partial retrieval*. Accessing memory trials that produced inaccurate spellings

fell into the classification of *partial retrieval*. They were not automatic by virtue of their incorrectness, but also their spelling solution times were slow. Accessing memory trials that produced accurate spellings were classified as *complete retrieval*. I then revisited the spelling trials coded *complete retrieval* and compared spelling solution response times with the automaticity baseline measure. Automaticity accounted for a moderate percentage of words spelled. In these incidents *complete retrieval* was questionably a true strategy. The automaticity baseline measure provided evidence that *complete retrieval* was strategic or automatic depending on the word. Rittle-Johnson and Siegler and this study code *complete retrieval* as a strategy. This study's decision to do so was based on the above information.

Variability, Gradual Growth and Adaptability

It is apparent after examining the data that variability in spelling strategies used among the participants did exhibit the pattern of overlapping waves. One of the major tenets of the overlapping wave model is based on the notion that strategies used in the development of a cognitive skill are multiple, and this study observed nine spelling strategies. Also, a second tenet is that strategies are to be varied, meaning that less sophisticated strategies are used more at first and then are eliminated, while at the same time more sophisticated strategies are introduced and eventually become dominant. Such patterns were evident and demonstrate the ebb and flow of growing ability. Additionally, some strategies increased at a slower rate, while others remained dominant throughout all sessions. These examples point to both multiple and varied characteristics of

spelling behavior as children used strategies to spell words. Further, the use of a variety of strategies occurred not only along the developmental continuum but was found within individual trials.

Gradual growth was clearly evident as strategies slowly changed. The shared affiliations between strategy change and efficiency measures reflected not only gradual growth rate but also inherent characteristics of the strategies themselves. *Sounding out* slowed performance and created more and more inaccuracy over time. *Rule use* slowed down production as children became more accurate at using them. Moreover, students who verbalized the orthographic rule they were using, tended to stabilize the rule they were describing faster.

These results were not surprising since the behavior of *sounding out* begins with one-on-one correspondences between sounds and letters. As orthographic features become more complex and adhere more to morphological knowledge, they require a less strict application of phoneme/grapheme matching and more effort in processing (Venezky, 1999). However, the overt characteristics of *sounding out* can be deceiving. *Sounding out* appeared more useful for straightforward sound-letter constituents. Yet, we know from the reading literature that *sounding out* facilitates mastery of the alphabetic code and phonological configurations are retained in memory. This lays a foundation that improves availability for accessing all orthographic patterns regardless of how straightforward they are (Perfetti, 1992). *Sounding out* conceived from this standpoint is a foundational strategy required at each level of orthographic understanding. The scope of this study does not provide evidence of this;

however, research on phonological processes and their importance to literacy skills do (Stanovich, 2000). As progressive refinements are made increased use of *rule use* becomes more important and reliance on the knowledge of the orthographic system more critical.

Gradual patterns of growth are seen in many areas of literacy development. Children learning to read become more competent over time with exposure and practice. Examples can be found in decoding and vocabulary enrichment. For instance, decoding develops over time as children become phonemically aware, are exposed to word work, and have practice reading connected text (Beck & Juel, 1995). Vocabulary knowledge is enhanced over time as children have more opportunities to read and discuss books (Stanovich 1993; Beck, McKeown, & Kucan, 2002).

The final element for the overlapping wave model is adaptability, and the current evidence yielded unexpected findings. Previous studies demonstrated children using more strategies to help spell the most difficult words in different populations, particularly first grade spellers (Rittle-Johnson & Siegler, 1999), and children with or without learning disabilities (Greary & Brown, 1991). This sense of adaptiveness seemed appropriate, since the sampling consisted of at-risk first graders. However, in the current study children actually increased strategy use on less difficult words.

How can this inconsistency be explained? Perhaps, the problem arises from the ability level of these low performing spellers. They began with few strategies in their repertoire (a range of 2-4). Adaptiveness of strategy choice depends on

the choices available to the individual. If a struggling speller only has access to less effective strategies or cannot execute strategies effectively, this paucity does not translate into a lack of adaptiveness. Siegler (1995) suggests that if children are too low in their level of development, they probably are not capable of making use of strategies.

Conversely, these participants found most spelling trials difficult. If we looked at the children's growing orthographic knowledge and compared that growth to their increase in strategy use, then children's spelling behavior took on aspects consistent with adaptiveness. This is because in the present study an increased use of strategies was directly tied to a growing knowledge of orthographic features. I reasoned that this growing knowledge facilitated decision-making, and their goal oriented need to be accurate. The evidence showed that the more orthographic knowledge children possessed the more accurate were the spellings, which in turn increased the use of strategies. So perhaps in this sense, these students did succeed at demonstrating adaptiveness.

Also, adaptiveness related children's short-term and long-term goals. These goals often conflicted as children tried to be both fast and accurate. For instance, children used *rule use* at the expense of speed in order to be more accurate, but when trying to hurry they relied on sounding out or random placement holder selection. In order to meet short and long-term goals adaptively children must be able to meet the requirements of adequate knowledge and a moderate repertoire of strategies. These struggling spellers were deficient in both, but definitely

improving. Improvement in knowledge and in use of multiple strategies could account in part for the low correlation.

Siegler (1996) proposed a hypothesis that explained in part the discrepancy in adaptiveness seen in the present study. In his moderate experience hypothesis, he suggested that the greatest variability in children was not at the low or high end of cognitive skill development but in the middle. The more experience with spelling tasks the more strategic a child became. As skills became more and more efficient variability waned. The diversity of variability was greatest when spellers had moderate amounts of experience in spelling words. The participants of the current study were performing at the low end of the cognitive development continuum and thus showed less variability that affected adaptability.

I conclude that this study replicated and extended Rittle-Johnson and Siegler's (1999) basic findings. Children were highly variable in the amount and use of spelling strategies. They were progressing gradually, and their low ability status likely explained their lack of adaptiveness. Also, I think that even though children were low performing, their improvement in *rule use* in tandem with orthographic knowledge and coupled with the overall increase in strategy use accounted for the process. Therefore, the overlapping wave theory is a viable approach to understanding spelling development from the aspects of spelling strategies.

Is Feedback With Expert Explanation

A Source of Development?

The second question asked if feedback was a source of development. This question approached the evidence of growth by manipulating achievement through differential feedback. I assumed that the influence of feedback would facilitate spelling growth through increased accuracy rates and faster spelling solution times. If differential feedback failed, then growth trajectories estimated by HLM provided a promising backup of actual growth.

Statistical findings from HLM showed student initial status and Classroom influence predicting student's final status. Also, growth trajectories showed participants growing in ability and growth rate differently. Higher performing students were growing at a faster rate than their lower performing peers providing evidence of the Matthew effect (Stanovich, 1986). Feedback had no effect on children's growth in spelling ability.

Sources of Spelling Development

Feedback Effects

Since feedback showed no impact on spelling development, I looked for a possible explanation by comparing Siegler's (1995) number conservation study where feedback positively affected growth with the current study. In Siegler's study, time between feedback sessions was a matter of a few days but in the current study time between feedback sessions was over weeks. It may be that too much time between outcome variables may have contributed to less learning.

Another explanation comes from the performance level of participants to explain an expert's reasoning. In Siegler's (1995) number conservation study, one of the significant factors contributing to learning was the number of explanations a child was able to advance during the pretest situation and the sessions. The children in the current study struggled with any kind of explanations. Often when asked, "How do you think I knew the word was correct." The response was, "because you're older" or "because you have it on that paper" or "I don't know". The experimenter often had to model the type of explanation desired using examples from the assessment to demonstrate, and then ask the question again. Participants' explanations became more substantial after this direct teaching approach, but never multiple.

Initial status and classroom differences predicted spelling growth and confirmed growth despite feedback's lack of influence. Other important findings came from the growth curve analysis. Most notable were findings concerning individual differences.

Individual Differences

Growth curve analysis revealed a Matthew effect (Stanovich, 1986) among the participants with initial status predicting growth rate and accuracy. Low performing students made steady progress; however, their rate of growth was slower than the higher performing students, causing an overall increasing gap between the high and low students. Other academic endeavors have found evidence of the Matthew effect. Walberg (1983) found the phenomenon occurring in educational achievements in general. He noticed that early gains in

educational pursuits generated faster rates of future achievement. Stanovich (1986) demonstrated its affect specifically in reading development. He found that children who began school with little phonological awareness had trouble acquiring basic level decoding skills. Struggling to identify words generated a downward spiral in slower rates of future reading ability.

There is strong evidence that reading and spelling achievement are highly related to phonological awareness (Bradley and Bryant, 1985; Ehri, 1989, 1991; Henderson, 1981; Morris & Perney, 1984; Orton, 1999; Perfetti, Rieben & Fayol, 1997). Reading and spelling depends on phonemic awareness (a sublevel of phonological awareness) for accuracy. Phonemic awareness is the number one predictor of reading failure. Therefore, finding evidence of the Matthew effect in spelling development does not come as a surprise. Evidence of the Matthew effect in spelling achievement was subsequently another connection to the reading-spelling link, and placed spelling among the subsidiary skills that require serious attention. Evidence of the Matthew effect supports early spelling instruction and word work. Literacy scholars already recognize word work as a critical component of a balanced literacy program (NICHD, 2000). Spelling instruction that focuses on developmental orthographic feature study is a high priority when faced with the phenomenon's negative consequences. Children who struggle do not have a minute to waste (Adam, 1990)!

Classroom Difference

Classroom differences are difficult to interpret. This is because the purview of the current study did not examine known factors that contribute to classroom

success. For instance, data was not collected to determine spelling pedagogy, the degree of family support, or number of English language learners within each classroom. Reasons for classroom differences are impossible to trace without an investigation of these influential factors. However, the differential growth of students by classroom does support the broad notion that classroom differences influence developmental growth of children's spelling skills (Huges & Searle, 1997; Schlagal & Trathen, 1998; Venezky, 1999). In conclusion, the results for the second question reveal that although feedback is not a source of spelling development, students' initial performance and the classroom they attend are.

Do Features and Strategies Relate?

My third question explored the relationships between spelling strategies and orthographic features as sources of evidence for developmental growth. These diverse data sources represented opposing arguments in the description of how spelling development occurred: (a) spelling strategies supporting the overlapping wave theory and (b) orthographic features providing foundational evidence to stage-like progression. A qualitative investigation looked for interactive patterns that might emerge between the two data sources. The hope was to uncover potential relationships between the two alternative descriptions of spelling development that would lead to a clearer explanation of how children acquire spelling ability.

Orthographic feature analysis provided evidence for spelling development progressing in general phases. Qualitative matrices provided evidence of

detailed strategy use where children achieved, dropped, and added strategies in direct relationship to the amount of orthographic understanding they achieved. Some strategies remained in constant use in spite of improvement in orthographic feature knowledge.

The literature supports the notion that the appearance of strategies such as *analogy*, *visual checking*, and *chunking* in a child's growing repertoire of spelling strategies are related to the degree of orthographic feature knowledge understood (Ehri, 1991; Gaskins, et al., 1996), and their higher performance ranking (Ehri, 1997; Gombert, Bryant, & Warrick, 1997). This could explain why the current study's at-risk population so seldom used these strategies. Other comparisons between children showed a tendency for higher performing students to use uncommon strategies more often than the lower performing students and to use more of a range of strategies throughout all sessions. In addition, qualitative matrices showed two strategies, *rule use*, and *complete retrieval*, demonstrating the Matthew effect (Stanovich, 1986).

Finally, findings placed strategy use and orthographic feature understanding on a continuum, mapping them together to illuminate their relationships. These predominant patterns exposed spelling strategies and orthographic features as having interactive relationships, but progressing in qualitatively different ways. Orthographic understanding measured by orthographic features produced general phases of development, but not lock step, discrete jumps from one stage to the next. Alternately, just as the overlapping wave model suggested, strategies

started early and persisted, others started early and faded, still others increased in use and efficiency.

Notably, the evidence from the qualitative methods provided support for the findings of the statistical analyses. Collaboration of findings boosted the strength of the results by providing converging evidence.

Discussion of Feature and Strategy Relationships

The results of the present study concurred with the notion of phase-like development of orthographic awareness. Children appeared to be learning orthographic features in a series of invariant levels of orthographic complexity. However, this maturing knowledge did not occur abruptly or in a lock step fashion. Transitional periods were seen when children experimented with the next level of feature knowledge before they became consistently accurate with the previous level. They often began with one or two correct incidents, gradually advancing to consistent and accurate renditions.

Whether or not leaps of understanding occurred seemed to depend on the ability of children. There were some participants that demonstrated almost instantaneous understanding of some higher levels of orthographic knowledge. However, these cases were rare. Predominantly movement was a gradual steady improvement towards higher and higher levels of orthographic feature knowledge. I observed overlap when some features like long vowel patterns were slow to solidify while at the same time children attempted suffixes. A participant spanning several orthographic levels at once was observed.

Do not confuse overlap in this sense with the overlapping wave progression seen with strategy use. Children were experimenting with higher levels of understanding while still predominantly performing on a lower level. However, one level invariantly preceded another, which led to another. There was a gradual ebbing and flowing of the frequencies of more complex feature knowledge, but constrained to transitional attempts (i.e., overgeneralizations, etc.) to the next higher level of knowledge. Children became consistently accurate with more complex orthographic features; higher feature knowledge did not begin early and then improve. Lower levels of understanding did not fade with time and experience, but became foundational to further understanding.

Literacy scholars did not assume that spelling development appeared in an abrupt leap from one distinct set of characteristics to another (R. Schlagal, personal communication, December 19, 2004). Yet the word *stage*, in the classical sense, meant just that. As Ehri (1992) and Rieben and Saada-Roberts (1997) suggested, the word *phases* was far more appropriate term for the phenomenon observed in the present study. Flavell (1971) argued that development did not progress in kind or degree but incrementally with practice. The orthographic feature attempted by participants of this study complimented Flavell's depiction.

Though findings from the feature error analysis opposed development as overlapping waves, spelling strategy use embraced the theory. Spelling strategies developed and improved in overlapping waves at the same time

children' orthographic understanding was developing and improving in phases. This study provided evidence that they happened concomitantly.

Orthographic feature knowledge highly influenced strategy development. Levels of orthographic understanding supported an increase in more sophisticated strategies and more sophisticated strategies allowed feature knowledge to become more efficient. Greater precision and accuracy of one seemed to lead to more proficiency of the other. Strategy use and orthographic feature knowledge appeared to interact with one another as they supported the general development of spelling acquisition. The point of interaction appeared to be mediated by orthographic knowledge. Understanding the orthographic system drove the strategies children used.

The overall results yielded a description of spelling development more as overlapping strategies overlaid onto gradually expanding levels of orthographic feature knowledge. However, strategy use and orthographic knowledge did more than co-exist. They interacted with one another boosting and supporting the overall development of spelling.

Theoretical Implications

One of my goals was to provide a more theoretically precise description of spelling development that moved beyond the current theoretical understanding of the three approaches: stages versus continuous movement versus overlapping waves. Instead what I found was not three distinct theoretical approaches to understanding spelling development, but suggestions for combinations of

interactive processes producing viable changes in spelling development. Some aspects like orthographic feature understanding moved in an almost stage like fashion. However, within the broad stage-like movement, incremental feature understanding appeared to move very much as Perfetti (1992) suggested in a continuous fashion. Still another aspect like spelling strategies progressed in overlapping waves.

More specifically, stage-like progression was supported when orthographic understanding progressed within general classifications defined by the feature errors children made when spelling. Development represented a qualitatively different way of thinking as children progressed from one phase of feature understanding to the next. Long vowel patterns did not show up until short vowel patterns were stable. Syllable juncture patterns and easy suffixes did not appear until initial and final consonant patterns were stable. Feature types progressed only under the right circumstances, including an increase of orthographic feature knowledge and the flexible use of strategies. Although no lock step or abrupt changes were evident, this progression was more in type than in degree, a Piagetian point of view but not tied to maturation.

Although the scope of my study was narrowed to spelling stages and the overlapping wave model, there was support for a continuous path when looking at orthographic feature knowledge. For instance, findings from children's spellings supported Perfetti's (1992) accumulative specificity and redundancy theory. I found evidence of word representations increasing as children's sensitivity to letter sequences and spelling features accumulated. It appeared

that sensitivity to spelling patterns aided the quality of words represented in memory until words were spelled conventionally. Letters that specifically represented correct features increased in precision and accuracy. Also, a redundancy of orthographic feature knowledge occurred with the *rule use* strategy. The orthographic feature and the *rule use* strategy provided a redundant presentation that aided in higher-quality word representations. This evidence supported the notion that children moved from spelling words inaccurately and slowly to increased accuracy and speed as precision and redundancy increased the quality of word representations. Improvement came over time with practice. These findings supported Vygotsky's notion that development was mediated by experience and learning.

The third alternative view was supported through the aspect of spelling strategies and supports Siegler's perspective of overlapping waves. Findings supported large variability and gradual growth, and witnessed a high amount of influence over strategies from orthographic understanding. More sophisticated strategies appeared only after children achieved certain foundational orthographic knowledge. Other strategies progressed in tandem with the degree of orthographic understanding achieved while still others were unaffected. This perspective extends and contributes to spelling development theory and provides a fresh look at orthographic feature hierarchy, demonstrating the important influence feature knowledge has on the development of spelling strategies.

Additionally, I suggest that incremental knowledge improvement of the type suggested by Perfetti (1992) mediates eventual qualitative changes. The degree

of specificity and redundancy of the child's feature knowledge determines not only the sophistication of the spelling strategies used as suggested by the time sensitive appearance of *analogy*, *visual checking*, and *chunking*, but dictates the appearance of future phases as suggested by initial patterns foreshadowing blends and digraphs. Orthographic knowledge gains not only mediated the types of strategies used and the sophistication of the spelling patterns, but influenced the quality of adaptive behavior children performed as suggested by the degree of adaptive behavior these low performing students were capable of demonstrating. From these findings spelling development appeared to be mediated by the degree of orthographic knowledge the child accumulated. These findings support the notion that learning precedes development and is influenced by experience.

This study found orthographic achievement as a cognitive ability developing in phases, continuously, and with overlapping waves. All three proceeded evenly and sequentially through a developmental orchestration of both spelling strategy and orthographic feature interactions. These results bring into question the historical debates about kind, degree, and overlapping waves and advocates instead for a mixed description of its developmental path where different aspects of the spelling task dynamically interact with one another.

In conclusion, traditional views of spelling development do not provide precise enough descriptions of what children actually appear to be doing. The current study suggests that no single theory accounts for all results. If this is true for spelling development, perhaps it is also true for larger areas of cognitive

development and worth investigating. Also, different aspects of the spelling task focus on different paths of development. However, when each aspect is viewed specifically and concurrently a more complicated process is seen. Cognitive development may benefit from further research where other cognitive tasks are broken down into component parts, which may develop in different ways. In order to accomplish this research, we might refine research methods to incorporate a trial-by-trial microgenetic approach with both quantitative and qualitative methods.

Instructional Implications

Instructional implications from the current study strongly supported the use of orthographic features in advancing spelling achievement. Orthographic knowledge mediated development with practice and continual application of feature knowledge to the words. The implications suggest a need for teachers to approach spelling instruction founded on developmental orthographic feature knowledge. Instructional significance of orthographic features is not new (Templeton and Morris, 2000; Bear, Invernizzi, Templeton, & Johnson, 2004). The added insights received from the current study emphasized its importance. Knowledge of shared affiliations between features and strategies provided strong support for explicit, systematic word study that focuses on the spelling patterns and the sounds the patterns make. The fundamental principles for word study should be the developmental phases or orthographic understanding and should show how *rule use* and other strategies are tethered to this knowledge.

Incorporated into a word study program could be an instructional approach focused on the production of words where children learn more sophisticated strategies such as *analogy*, *chunking*, and *visual checking*.

At-risk spellers in particular need a program that will advance their skills and allow them to avoid the devastating Matthew effect. Instruction needs to start early and target the orthographic features that are developmentally appropriate. Instruction should provide opportunities for children to arrive more quickly at the necessary phonetic phase where they are capable of learning the more sophisticated strategies that can facilitate further advancement.

More effective pedagogical practices are all ready in existence (Bear et al., 2004; Schlagal, 2001). Previous educators taught *analogy* and *chunking* successfully with results supporting orthographic development (Gaskins, et. al, 1996). Literacy scholars provided theoretical and empirical encouragement to educators for the use of *analogy*, *visual checking*, and *chunking* and their more sophisticated effects (Gombert, Bryant, and Warrick, 1997). This study supports these literacy scholars and educators for the advancement of effective word study programs and instruction in effective use of spelling strategies.

In summary, knowledge of the interrelationships of the strategies with orthographic knowledge underscores the need for pedagogical practices to focus on orthography and its developmental nature. The Matthew effect dominates the necessity for effective pedagogical practices that will curb its distressing outcomes. The results forecast the importance of early instruction in word study and provide valuable insights for teacher practitioners.

Methodological Implications

Converging evidence derived from the microgenetic mixed design of qualitative and quantitative methodologies attributed to the strength of the current microgenetic study. The choice to combine design components in a trial-by-trial analysis optimized the answers to my questions. The present study was a positive example of how cross-validation increased insights and enhanced research findings. The study alerted researchers to the possibilities of a mix-and-match paradigm. Also, the study provided evidence of the microgenetic designs' potential to inform both theory and practice, in this case the theory of orthographic development and the practice of teaching spelling; and demonstrated its potential for garnering more complete knowledge,

The microgenetic mixed approach was a natural compliment to the traditional quantitative and qualitative paradigms. One of the goals of mixed methods was not to replace either quantitative or qualitative but to provide a workable third alternative. The two dominant methods advocated for either deep, rich observational data or for hard, generalizable data (Sieber, 1973). Mixed methods advocated for both, drawing from their strengths and minimizing their weaknesses (Greene, Caracelli & Graham, 1989).

I conducted the qualitative and quantitative phases of the study concurrently with equal emphasis. The phases were similar to conducting two mini-studies, one quantitative and one qualitative (Johnson & Onwuegbuzie, 2004). Strengths of the quantitative methods provided precise numerical data. The quantitative approach allowed results to be relatively bias-free of the researcher (e.g.

statistical significance), and allowed testing of hypothesis that I constructed before I collected the data (in the case of the current study, the first two questions), and allowed generalizations. Statistical significance provided evidence of (a) verification of strategy conditions, (b) frequency of changes in strategy use, (c) strategy accuracy and speed, (d) growth trajectories, (e) the source of developmental success, and (f) the sessions when change occurred.

The qualitative methods provided a means by which the researcher studied in-depth a limited number of cases. The microgenetic approach augmented qualitative methods by encouraging a high concentration of observations over as long a time span as possible. The intent was to witness changes in the children's competencies as they occurred. The intense trial-by-trial analysis added insights about: (a) Interaction between spelling strategy and orthographic feature development, (b) appearance and effectiveness of lesser-used strategies, and (c) the prevailing influence orthographic features hold on strategy use.

At one point the process integrated findings from both methods. That point serendipitously occurred when analytical findings from the quantitative results converged with findings from the qualitative analysis unexpectedly. These integrated findings strengthened the results as corroborating evidence and increased the validity of those results. Examples are: (a) variability of strategies, (b) range of strategies, (c) percentage of use and effectiveness of specific strategies, and (d) the Matthew effect.

The current study represented the microgenetic approach as a powerful tool. Corroborated conclusions increased the generalizability of the results when

converging evidence from both approaches uncovered similar outcomes. Combined methods added insights and understanding missed under only one approach and created important opportunities for answering complex questions. The findings exemplified the approach's ability to explain and answer research questions in depth. In conclusion, the methodological importance of a microgenetic mixed design came from insights gained from its dual nature and its trial-by-trial analysis. These advantages highlighted the choice of a mixed microgenetic approach. Not just as something researchers do on occasion but as a viable third method of research.

APPENDIX A

SPELLING WORD LISTS

Automaticity Baseline Measure

Pretest Measure to Establish

Baseline Performance

Teacher Suggested

Primary Spelling Inventory

(Bear et al., 2004, 3rd edition, p.301)

first name my

fan stick

at to

pet shine

the see

dig dream

he can

rob blade

cat mom

hope coach

wait fright

gum chewing

sled

Outcome Variables for Session 1, 2, and 3

Spelling Inventory I	Spelling Inventory II*	Spelling Inventory III
(Bear et al., 2000, 2nd edition, pp. 288 & 292)		(Created by researcher)
bed	net	red
ship	trip	drip
when	then	bend
lump	dump	hump
float	soap	boat
train	chain	brain
place	trace	grace
drive	crime	shine
bright	fright	slight
shopping	popping	stopping
spoil	broil	foil
serving	jerking	perching
chewed	brewed	threw
carries	bunnies	worries
marched	parched	charmed

*List has been modified to more precisely duplicate Inventory I.

Spelling Lists for Adaptability Analysis

Rittle-Johnson and Siegler, 1999, p. 346

List 1	List 2
hat	bat
bug	rug
dog	pop
red	bed
kite	dime
stop	drop
fish	dish
candy	baby
boat	goat
moon	soon
chair	stair
girl	bird
letter	better
frown	clown
feet	leaf

APPENDIX B

DATA COLLECTION SCHEDULE WITH ADJUSTMENTS

Week	Date	School	Activity	Adjusted Time Schedule
1	Jan 3 – 7 M/W/ F T/W/Th	A B	Pre tests: Elementary Spelling Inventory Grade Level Spelling Inventory	Initial Status Assessment
2 NoSchoolFri	Jan 10–12 M / W	C	Pre tests: Elementary Spelling Inventory Grade Level Spelling Inventory	Elementary Spelling Inventory only.
3 MLKing Day Monday	Jan. 19 / 21 Wed / Fri	A	1st Spelling Inventory I with self-report and Individual feedback sessions	Session 1 Counter Balance Administration to accommodate for restricted condition.
2 NoSchoolFri	Jan. 11 / 13 Tues / Thurs	B	1st Spelling Inventory I with self-report and Individual feedback sessions	
3 MLKing Day Monday	Jan. 18 / 20 Tues/Thurs	C	1st Spelling Inventory I with self-report and Individual feedback sessions	
4	Jan 24/ 26 Mon / Wed	A	2nd Spelling inventories II with self-report and Individual feedback sessions	
4	Jan. 25 / 27 Tues / Thurs	B	2nd Spelling inventories II with self-report and Individual feedback sessions	
5	Feb. 1 / 3 Tues / Thurs	C	2nd Spelling inventories II with self-report and Individual feedback sessions	
6	Feb. 7 / 9 Mon / Wed	A	3rd Spelling List 1 with self-report and Individual feedback sessions	Session 2 Eliminated from Growth Curve Analysis Also counter balanced to accommodate for restricted
6	Feb 8 / 10 Tues / Thurs	B	3rd Spelling List 1 with self-report and Individual feedback sessions	
7 Valentines Mon.	Feb. 15 / 17 Tues / Thurs	C	3rd Spelling List 1 with self-report and Individual feedback sessions	

8	President Day & NoSchool Tu	Feb 23 / 25 Wed / Fri	A	4th Spelling List 2 with self-report and Individual feedback sessions	condition.
9		March 1 / 3 Tues / Thurs	B	4th Spelling List 2 with self-report and Individual feedback sessions	Session 3 Elementary Spelling Inventory posttest. Results dropped.
9		Feb. 28/ M 2 Mon / Wed	C	4th Spelling List 2 with self-report and Individual feedback sessions	
10		March 7 / 9 & March 8 / 10	A B	Posttests: Elementary Spelling Inventory Grade Level Spelling Test	
11		Mar 15/ 16 Tues / Wed	C	Posttests: Elementary Spelling Inventory Grade Level Spelling Test	
Adjusted Time Schedule					
12	Spring Break				
13-14	March 28 – April 8	Investigation of inconsistent results.			
15	AERA Conf.	April 11-15			
16-17	April 18-29	A, B & C	Spelling Inventory I or II		Session 4 <u>Reported as 2</u> Counter balance because of Session 1.
18-19	May 2-13	A, B & C	Spelling Inventory (Researcher created)		Session 5 <u>Reported as 3</u>

APPENDIX C

ANOVA REPORTING OF CLASSROOM DIFFERENCES

The HLM growth curve analysis left two unanswered questions in regards to the effects found among the classrooms. Since Classroom 3 was set as a reference, Classroom 1 and Classroom 2 were compared only to Classroom 3 and not to each other. We know that Classroom 1's students are achieving significantly higher than Classroom 3 at final status, and that Classroom 2 and 3 have no significant differences among their students at final status. A remaining question would be what differences were there between Classroom 1 and 2. Also, since initial status and classroom differences accounted for all the variance in growth rate, it was wondered just what actual initial status differences there were among the three classrooms. An additional analysis of variance (ANOVA) was run to see if those questions could be resolved.

First, did Classroom 2 have statistically significant differences from Classroom 1 at the final developmental point? An analysis of variance showed no differences of final status between these two classrooms (see Table C1).

Second, initial status differences between the three classrooms were not significant. Even though the descriptive statistics reveals Classroom 3 beginning with the lowest mean correct, there were no significant statistical differences. (See Table C2 for descriptive statistics.)

Table C1

Differences in final status between classrooms

(I) classroom	(J) classroom	Mean	Standard	<i>p</i>
		Differences	Error	
1	2	0.95	0.93	0.57
1	3 ^a	2.01	0.82	0.05
2	3 ^a	1.06	0.88	0.46
No Effect		$F(2,28) = 3.025, p = .516$		

^a*Relationships already established by HLM.*

Table C2

Differences in initial status among classrooms

Classroom	N	Mean	SD
1	10	4.20	1.97
2	8	4.58	2.05
3	13	3.85	2.90
No Effect		$F(2,28) = 2.22, p = .803$	

APPENDIX D

TIME ORDERED MATRICES

ID 1	Session 1	Session 2	Session 3
Stage	Middle Phonetic Stage	Late Phonetic Stage	Early Within Word Pattern
Strategies Used	SO + RU + G Guessing Inaccurate And Accurate Consonant Digraphs Vowel Digraphs	PR + SO + RU + CH Chunking Accurate Consonant Digraphs Inaccurate Vowel Marking 1 attempt Inaccurate Vowel Digraphs	SO + RU + CH Accurate Consonant Digraphs Inaccurate Vowel Digraphs 1 inaccurate attempt 1 Accurate Attempt 3 non attempts at Vowel Markings
Strategy Observed	Nothing or sounding out	Nothing or Sounding out	Nothing or Sounding out
Strategy Reported	Sounding out (once) I don't know	Sounding out (once) I knew it	Sounding out (once) Used a rule
Strategy Displayed on Student Work	Consonant digraphs being attempted but inaccurate. (once) Random Placement Holders	Consonant digraphs are now Accurate. Vowel digraphs attempted but inaccurate. One vowel marking but inaccurate. The <i>ing</i> suffix now Accurate.	Consonant digraphs consistently Accurate. Vowel digraphs consistent but not Accurate. Two vowel markings, one Accurate one not. The <i>ing</i> suffix consistently Accurate.
Initial and Final Consonant	Consistently Accurate.	Consistently Accurate.	Consistently Accurate.
Short Vowels	Being used but inconsistent Accuracy.	Consistently Accurate.	Consistently Accurate.
Blends	Consistently Accurate.	Consistently Accurate.	Consistently Accurate.
Long Vowel Markers	No vowel markings.	One attempt at vowel markings.	Two attempts at vowel markings, one Accurate.
Other Vowel Patterns	Vowel digraph used inconsistently and inaccurately.	Vowel digraphs used inconsistently and inaccurately.	Vowel digraphs consistent but inaccurate.
Junctures and Suffixes	Suffix <i>ing</i> attempted but incorrect. Suffix <i>ed</i> not attempted. No attempt at junctures.	Suffix <i>ing</i> consistent and Accurate. Suffix <i>ed</i> not attempted. No attempt at junctures.	Suffix <i>ing</i> consistent and Accurate. Suffix <i>ed</i> not attempted. No attempt at junctures.
Remarks	Sounding out is predominant strategy used in all three stages. Initial and final consonants are first to become consistently Accurate, next are blends and short vowels. Consonant digraphs and the <i>ing</i> suffix came next. Vowel digraphs and vowel markings slow to emerge. Vowel markings became more Accurate at time they were self-reported as a rule-use strategy.		

ID 2	Session 1	Session 2	Session 3
Stage	Middle Phonetic Stage	Late Phonetic Stage	Early Within Word Pattern
Strategies Used	CR + PR + SO + RU 1 inaccurate digraph	CR + PR + SO + A + RU Consonant digraphs 1 inaccurate vowel marker easy suffixes	CR + PR + SO + RU Consonant digraphs 1 Accurate vowel marker easy suffixes r-control vowel syllable juncture doubling
Strategy Observed	2CR + 7PR + 5SO	4CR + 4PR + 8SO	6CR + 4PR + 9SO
Strategy Reported	8CR + PR + SO	8CR + PR + A ("I knew king." Word was jerking.) + SO + RU ("tried to decide if o needed a or w" and "tried to decide if trace ended with S or C")	2CR + SO + PR + RU ("I knew oa makes the o says its name"; "I put 2 p's because it had an ing"; "e before r because r has a vowel to go with it"; "double h because of ing" and "oo has more than one spelling")
Strategy Displayed on Student Work	RU: (6 cases) consonant digraphs	CH: ing & ed suffix RU: (7 cases) consonant digraphs, vowel markers	CH ing suffix, RU: (12 cases) consonant digraphs, doubling of syllable juncture, r-control vowel, vowel marker
Initial and Final Consonant	Consistently Accurate	Consistently Accurate but incorrect when RU are over generalized	Consistently Accurate
Short Vowels	Mostly Accurate	Mostly Accurate	Consistently Accurate
Blends	Becoming consistent	Digraphs now consistent, blends mostly consistent	Consistently Accurate
Long Vowel Markers	No knowledge	One attempt at vowel marker	1 correct vowel marking, no knowledge of silent e rule
Other Vowel Patterns	Phonetically obtained	3 attempts at vowel patterns	r-control vowel Accurate
Junctures and Suffixes	No knowledge	3 out of 4 Easy suffixes	2 out of 4 Easy suffixes. Doubling of ending suffix but over generalized.
Remarks	Complete retrieval is increasing as awareness of orthographic rules increase. More features are becoming consistently Accurate as orthographic rules increase. Interestingly, syllable juncture doubling came before the silent e rule. Evidence of over generalization as RU rules are emerging. Analogy is used only once, but successfully (ie. King for jer-king). Uses the same four strategies but at different ratios over the 3 time periods. PR decreased at Session 2 as CR & RU increased, but PR leveled off at Session 3 even though CR & RU continue to increase. SO is often coupled with another strategy, slightly increasing, mostly stable. Direct positive relationship between CR, RU and features. Rule use became stable when child self-reports it.		

ID 3	Session 1	Session 2	Session 3
Stage	Late Semiphonetic Stage	Late Phonetic Stage	Late Phonetic Stage
Strategies Used	1 CR + PR + SO + 5 G	2 CR + PR + SO + G + RU + 1 CH	2 CR + PR + SO + G + RU + 1 CH
Strategy Observed	1 PR + 14 SO	1 CR + 1 PR + 13 SO	2 CR + 2 PR + 11 SO
Strategy Reported	PR + SO	1 CR + PR + SO	CR + PR + SO
Strategy Displayed on Student Work	1 CR + G (5 cases)	1 G + CH: ing suffix (once) + RU: (4 cases) consonant digraph	1 CR + 1 G + CH: ing suffix (stable) + RU: (2 cases) consonant digraph
Initial and Final Consonant	Guessing, becoming consistent	Consistently Accurate	Guessed (1 case), Accurate 94 %
Short Vowels	3 incorrect out of 6	1 incorrect (phonetically close)	Consistently Accurate
Blends	No knowledge of digraphs or blends	Unstable, 6 correct cases out of 12	Unstable, 4 correct cases out of 10
Long Vowel Markers	No knowledge	No knowledge	No knowledge, phonetically correct
Other Vowel Patterns	Guessing	No knowledge	No knowledge
Junctures and Suffixes	Guessing	Guessing or phonetically correct	Suffix ing consistently Accurate, others phonetically correct
Remarks	Sounding out is predominant strategy through all time periods. Guessing decreases but is never eliminated. All words at Session 1 are spelled with three letters. Session 2 & 3 displays digraphs and the easy suffix ing. Consonant digraphs never stabilize but the ing suffix does. CR gradually increases as initial and final sounds stabilize and G decreases. CR, RU & CH are added.		

ID 4	Session 1	Session 2	Session 3
Stage	Late Semiphonetic Stage	Early Phonetic Stage	Early Phonetic Stage
Strategies Used	PR + SO + G + OR + 8 CH Consonant digraph	1 CR + PR + SO + RU + 4 CH ├── Consonant digraph └── Incorrect vowel marker	2 CR + PR + SO + RU + 1 G + VC ├── Inconsistent consonant digraph ├── Incorrect vowel digraph ├── Incorrect vowel marking └── Incorrect r-control vowel
Strategy Observed	2 PR + 13 SO	1 PR + 13 SO	1 CR + 2 VC (i.e, visually checked final sound and correctly changed it.) + 2 PR + 12 SO
Strategy Reported	PR + SO + CH (et chunk) + G	SO + G	SO + G
Strategy Displayed on Student Work	8 G + RU: (1 case) consonant digraph	CR + 4 G + RU: consonant digraph (2 cases) and incorrect vowel marker	1 C + 1 G + RU: consonant digraph (1 right, 1 wrong), incorrect vowel digraph, incorrect vowel marking, incorrect r-control vowel
Initial and Final Consonant	Inconsistent, guessing	Consistently Accurate	Consistently Accurate
Short Vowels	Inconsistent	Consistently Accurate	Consistently Accurate
Blends	1 correct attempt at consonant digraph, 2 attempts at blends	2 out of 5 consonant digraphs, 3 out of 7 blends, guessing	1 out of 4 consonant digraphs, 3 out of 7 blends
Long Vowel Markers	No vowel markers, phonetically correct	No vowel markers, phonetically correct	1 attempt at vowel marker, guessing
Other Vowel Patterns	No knowledge, guessing	Attempt at vowel digraphs	Attempts at vowel digraphs and r-control vowels
Junctures and Suffixes	No knowledge	No knowledge, guessing	Attempt at ing suffix
Remarks	CR is increasing slightly, G is decreasing substantially but not eliminated, Dropped chunking, added Visual Checking, SO predominant, RU slow to emerge. Initial, final and short vowel sounds are only consistent features. Is starting to attempt vowel markers, vowel digraphs and the ing suffix at Session 3.		

ID 5	Session 1	Session 2	Session 3
Stage	Late Semiphonetic Stage	Early Phonetic Stage	Middle Phonetic Stage
Strategies Used	PR + SO + RU + 3 G + non-strategic explanations Incorrect Vowel marker attempt at suffix	1 CR + PR + SO + RU + A + 1 G incorrect vowel marker Incorrect r-control vowel attempt at suffix	2 CR + PR + SO + RU + VC + CH + 1 G Incorrect Vowel Marker Consonant digraph Incorrect r-control vowel
Strategy Observed	5 PR + 10 SO	4 PR + 12 SO	1 CR + 10 SO + 4 PR + 1 VC (did not change anything)
Strategy Reported	PR + SO + non-strategic explanations (My nanny wrote it for me.)	PR + SO + A (incorrectly applied: If you know how to spell brewed you know how to spell red.)	CR + PR + SO + CH (ing) (I knew the ing)
Strategy Displayed on Student Work	3 G + RU: incorrect vowel marker, attempt at suffix	1 CR + 1 G + RU: incorrect vowel markers, incorrect r-control vowel	RU: incorrect vowel marker, consonant digraph, r-control vowel + 1 G + 2 CH (ing)
Initial and Final Consonant	Consistently Accurate	Consistently Accurate	Consistently Accurate
Short Vowels	Inaccurate	Showing improvement: 3 out of 6 correct	3 out of five, but two are phonetically close
Blends	Non-existent or inaccurate	Accurate with most r-blends, no use of consonant digraphs	8 out of 10 Accurate, one digraph Accurate
Long Vowel Markers	Not phonetically correct, 1 attempt at vowel marker,	1 attempt at vowel marker, becoming more phonetically correct	2 attempts at vowel marking, phonetically correct
Other Vowel Patterns	No knowledge	Attempt at r-control vowel and vowel digraph	Attempts at r-control vowel and vowel digraphs
Junctures and Suffixes	Attempt at suffix ing	Attempt at suffix ing	Consistently Accurate at suffix ing (chunks it)
Remarks	CR and RU are slowly emerging as are the features that require orthographic knowledge. Learned the suffix ing by using chunking strategy. Initial and final sounds are consistent but short and long vowel sounds are slowly emerging, first becoming phonetically correct. Blends took a leap in Accuracy by Session 3 but consonant digraphs are slow to emerge. SO is predominant strategy. VC (at Session 3) and A (at Session 2) were both used. Analogy was incorrectly applied and VC did not result in a Complete retrieval. G decreased but was not eliminated.		

ID 6	Session 1	Session 2	Session 3
Stage	Late Semiphonetic Stage	Middle Phonetic Stage	Late Phonetic Stage
Strategies Used	PR + SO + 6 G	2 CR + SO + RU <div style="display: flex; justify-content: space-around; margin-top: 5px;"> Consonant Digraphs Incorrect vowel digraph </div>	3 CR + SO + RU <div style="display: flex; justify-content: space-around; margin-top: 5px;"> Consonant Digraphs Incorrect vowel digraph </div>
Strategy Observed	3 PR + 12 SO	15 SO	2 PR + 14 SO
Strategy Reported	PR + SO	SO	SO
Strategy Displayed on Student Work	6 G	2 CR + RU: consonant digraphs, incorrect vowel digraph	1 CR + RU: consonant digraphs, incorrect vowel digraph
Initial and Final Consonant	Consistently Accurate	Consistently Accurate	Consistently Accurate
Short Vowels	Inconsistent, 3 out of 6 Accurate	Consistent, one inaccurate but it is phonetically close	Consistent, one inaccurate (i.e., confusing short u with short o in all 3 time periods)
Blends	Mostly inaccurate, 1 out of 10 correct, no digraphs, guessing	Digraphs consistently Accurate, most blends Accurate one is phonetically close	Consistently Accurate
Long Vowel Markers	No knowledge, phonetically Accurate	No knowledge, phonetically Accurate	No knowledge, phonetically Accurate
Other Vowel Patterns	No knowledge, guessing	Attempt at vowel digraph	Attempt at vowel digraphs
Junctures and Suffixes	No knowledge, guessing	Suffix ing is represented partially (ieg)	Suffix ing reduced to eg
Remarks	Predominantly SO. G is eliminated and CR & RU are added by Session 2 and consistent at Session 3. Develops dramatically (over two stages) in feature Accuracy between Session 1 and Session 2 (i.e., consonant digraphs become consistently Accurate when at Session 1 there were none. Short vowels and blends are consistent but not completely Accurate. There is an attempt at vowel digraphs and the suffix ing.) Features improving from Session 2 to Session 3 but no changes in strategy use.		

ID 7	Session 1	Session 2	Session 3
Stage	Early Phonetic Stage	Late Phonetic Stage	Early Within Word Pattern Stage
Strategies Used	1 CR + PR + SO + A + OR + 3 G Attempt at suffix	3 CR + PR + SO + RU + CH + C consonant digraph vowel marker r-control vowel	5 CR + SO + RU + CH r-control vowel consonant digraph vowel marker incorrect vowel digraph
Strategy Observed	15 SO	1 CR + 10 SO + 4 PR + 1 C	1 CR + 14 SO
Strategy Reported	1 CR + PR + SO + A (its just like play = place) + non strategy (I went on a train. That helped me)	3 CR + SO + CH(pop and ing) + C (but not correctly) + RU ("studied the ir")	3 CR + SO + CH (stop and ing) + RU (consonant digraphs, "I have sh in my classroom" and "I have studied ch"; oa vowel marking, "I knew it had an a"; and r-control vowels, "I knew er" and I've studied ar")
Strategy Displayed on Student Work	3 G + RU: attempt at suffix	RU: consonant digraph, vowel marking, r-control vowel	RU: vowel marking, consonant digraph, r-control vowel, incorrect vowel digraph + CH (ing)
Initial and Final Consonant	Consistently Accurate	Consistently Accurate	Consistently Accurate
Short Vowels	Confusing short i sound with letter e	Confusing short a sound with letter e	Consistently Accurate
Blends	No digraphs but most blends are Accurate (5 out of 7)	Consonant digraphs (2 out of 3) and blends (4 out of 6) mostly Accurate.	Blends and digraphs consistently Accurate except final nasal blend
Long Vowel Markers	No knowledge	One successful vowel marker (oa)	One successful vowel marker (oa)
Other Vowel Patterns	No knowledge	Inaccurate r-control vowels	Consistently Accurate r-control vowel, attempt at vowel digraph
Junctures and Suffixes	Attempting ing with en	Suffix ing is being chunked.	Suffix ing is consistently Accurate
Remarks	CR steadily increasing, RU use developing Accurately and quickly over all features (i.e., when a rule is used it is Accurate more than it is not), CH is used for suffix ing, G dropped and PR not used at Session 3. A and C only used once. Sounding out is predominant. Rules that are verbalized during self-report indicate solidification.		

ID 8	Session 1	Session 2	Session 3
Stage	Middle Phonetic Stage	Middle Phonetic Stage	Middle Phonetic Stage
Strategies Used	2 CR + PR + SO + RU + 1 G <div style="display: flex; justify-content: space-around; align-items: center;"> <div>consonant digraph</div> <div>attempt at suffix</div> <div>incorrect r-control vowel</div> <div>incorrect vowel digraph</div> </div>	3 CR + PR + SO + RU + A + VC + CH <div style="display: flex; justify-content: space-around; align-items: center;"> <div>consonant digraph</div> <div>incorrect & correct r-control vowel</div> <div>incorrect vowel digraph</div> </div>	5 CR + PR + SO + RU + A + VC + CH <div style="display: flex; justify-content: space-around; align-items: center;"> <div>consonant digraph</div> <div>incorrect & correct r-control vowel</div> <div>incorrect vowel digraph</div> </div>
Strategy Observed	2 CR + 1 PR + 12 SO	1 CR + 6 PR + 9 SO + 2 VC (1 word spelled conventionally and 1 word not) + 1 CH (ing)	4 CR + 8 PR + 4 SO + 1 VC (spelled conventionally)
Strategy Reported	2 CR + PR + SO	3 CR + PR + SO + A (like boy)	5 CR + PR + SO + A (I used bump to spell hump) + RU (r-control vowel, "sounded out the rrr so it's er"; and vowel marker, "think it is a double e, so it says eee")
Strategy Displayed on Student Work	1 G + RU: Consonant digraph, attempt at suffix, incorrect r-control vowel, incorrect vowel digraph	RU: consonant digraph, incorrect and correct r-control vowel, incorrect vowel digraph + CH (suffix ing)	RU: incorrect and correct r-control vowel, consonant digraph, incorrect vowel digraph + CH (Ing)
Initial and Final Consonant	Consistently Accurate	Initial consistently Accurate Final has overgeneralization of ck ending	Consistently Accurate
Short Vowels	Confusing short e with letter i	Consistently Accurate	Consistently Accurate
Blends	All blends represented but not always Accurate. Consonant digraph "ch" consistent.	Using r-control "er" for all r blends	Digraphs consistently Accurate Blends contaminated with overgeneralization of "er" r-control vowel
Long Vowel Markers	No knowledge	No knowledge	No knowledge
Other Vowel Patterns	Attempted vowel digraph and r-control vowel	Attempted vowel digraph r-control vowel (2 out of 2)	Attempt at vowel digraph r-control vowel (1 out of 2)
Junctures and Suffixes	Attempted suffix ing = en	Suffix ing has been learned as a chunk	Suffix ing consistently Accurate Incorrect use of vowel marker
Remarks	CR increases over time. G dropped, A and VC added to both Session 2 and Session 3 and are effective. CH effectively used for suffix. SO diminishing over time. RU knowledge and features remains stable(i.e. long vowel patterns, blends stymied because of over generalization of r-control vowel, attempts at vowel digraphs) and only slight increases (digraphs become consistently Accurate, suffix ing becomes consistent). RU and features have a direct relationship. Explanation of rules validates what child understands.		

ID 9	Session 1	Session 2	Session 3
Stage	Late Phonetic Stage	Early Within Word Pattern Stage	Early Syllable Juncture Stage
Strategies Used	4 CR + PR + SO + Ru + VC + A + C + CH consonant digraph	5 CR + PR + SO + RU + C + CH + 1G consonant vowel incorrect incorrect ed digraph markers vowel r-control suffix digraph vowel	9 CR + PR + SO + RU + VC + CH Consonant vowel incorrect r-control ed /s/ spelled c Digraph markers vowel vowel suffix when follow digraph by e
Strategy Observed	3 CR + 3 PR + 9 SO + 1 VC (Complete retrieval)	1 CR + 2 PR + 12 SO + 1 C	6 CR + 5 PR + 5 SO + 1 VC (changed final p to t)
Strategy Reported	CR+ SO + A ("had an ing like popping") + C	CR + PR + SO + RU ("I knew the rule.") + C	CR + SO + RU ("I knew there was a silent e"; "c was like an s"; "e is silent because e, u, and i help r"; I knew a was needed for /ar/") + CH ("I knew ing.")
Strategy Displayed on Student Work	RU: consonant digraphs CH: suffix ing	RU: consonant digraphs, vowel marking, silent e rule, incorrect vowel digraph, incorrect r- control vowel, ed suffix CH: ing suffix + G: vowel digraph	RU: vowel markers (oa and silent e); /s/ followed by an e is spelled with a c; consonant digraph, incorrect vowel digraph, r-control vowel, ed suffix CH: suffix ing
Initial and Final Consonant	Consistently Accurate	Consistently Accurate	Consistently Accurate
Short Vowels	Consistently Accurate	Consistently Accurate	Consistently Accurate
Blends	Blends consistently Accurate Digraphs (1 our or 2)	Missed one blend Middle position digraph incorrect	Missed one blend Consonant digraphs consistently Accurate
Long Vowel Markers	No knowledge	oa and silent e rule used	Consistent but over generalization of silent e rule
Other Vowel Patterns	No knowledge	Vowel digraph attempt but used random placement holder selection. Attempt at r-control vowel	r-control vowel consistently Accurate attempt at vowel digraph, over generalization of silent e rule
Junctures and Suffixes	Suffix ing consistently Accurate	Easy suffix ing and ed used consistently and Accurate	Easy suffixes consistently Accurate No knowledge of syllable junctures
Remarks	Uses many types of strategies from the beginning. Goes from 8 types to 6 types over the developmental time period. RU burgeoning at Session 2 remains solid and increases in amount and Accuracy by Session 3. Explanations at self-report shows understanding of rules used. SO Actually decreases substantially from Session 1 to Session 3. CR also increases as RU increases but not at same rate. VC occurred over time and was used successfully. A used successfully. Fewer strategies are used as CR increases. Guessed at vowel digraph during Session 2.		

ID 10	Session 1	Session 2	Session 3
Stage	Early Phonetic Stage	Middle Within Word Pattern Stage	Early Syllable Juncture Stage
Strategies Used	<p>1 CR + PR + SO + RU + 4 G</p>	<p>4 CR + PR + SO + RU + VC</p>	<p>8 CR + PR + SO + RU + VC + CH + 1 G</p>
Strategy Observed	1 CR + 1 PR + 13 SO	2 CR + 2 PR + 12 SO + 1 VC (checked and added silent e)	5 CR + 11 SO + 1 VC (added an a in boat)
Strategy Reported	CR + PR + SO + G	CR + PR + SO + RU ("Used silent e"; and "used to o's so it would sau /oo/")	CR + PR + SO + RU: ("Put an "a" so it wouldn't say bot."; "put a silent e"; "has to have two p's"; "put ed because /d/ at the end"; and "put silent e so it would say /ar/ instead of rrr.")
Strategy Displayed on Student Work	Letter name + 4 G + RU: attempt at suffix, incorrect consonant digraph	RU: consonant digraphs, incorrect and correct vowel markers, ing suffix, incorrect vowel digraph, r-control vowel	RU: Correct and incorrect vowel marking, consonant digraph, consonant doubling, incorrect vowel digraph, r-control vowel, suffix ed + CH (suffix ing) + G (vowel digraph)
Initial and Final Consonant	Initial consistently Accurate Final guessed once	Consistently Accurate	Consistently Accurate
Short Vowels	Used a letter name "n", guessed once	Consistently Accurate	Consistently Accurate
Blends	Guessing 1 attempt at consonant digraph	4 out of 7 blends digraphs consistently Accurate	7 out of 8 blends digraphs consistently Accurate
Long Vowel Markers	No knowledge	Vowel markers (2 out of 5 correct)	Vowel markers consistent (3 out of 5 Accurate)
Other Vowel Patterns	Guessing	r-control vowels Accurate (2 out of 2) attempt at vowel digraphs, overgeneralization of silent e rule	r-control vowel (1 right, 1 wrong) Guessing at vowel digraphs
Junctures and Suffixes	No knowledge	Suffix ing consistently Accurate	Overgeneralizing of silent e rule Doubling consonant Accurate Suffix ing consistently Accurate, ed Accurate
Remarks	CR increases over time as does RU. RU burgeoning at Session 2 and solidifying at Session 3. SO remains predominant strategy. Many types of strategies used. G eliminated at Session 2 and used once at Session 3. Adds VC at Session 2 and 3. Adds CH at Session 3. CR and Features improve as RU increases.		

APPENDIX E

TABLE E1

Componential Analysis of Rule Use

Table E1

Componential Analysis of Orthographic Rule Use Over the 5 Developmental Spelling Stage Patterns

Patterns of Stage development	Orthographic Rule Use							
	Session	Initial	Final	Short Vowel	Digraphs & Blends	Long Vowel Patterns	Other Vowel Patterns	Syllable Juncture & Easy Suffixes
1 Begin LSP progress delayed S2	1	Inconsistent Guessing	Inconsistent Guessing	Inconsistent Confusing vowels	No knowledge of digraphs, 2 attempts at blends	No knowledge	No knowledge, guessing	Guessing
	2	Consistently accurate	Consistently accurate	1 incorrect, phonetically close	Accurate half The cases.	No knowledge, phonetically correct	Attempt at vowel digraph	No knowledge, phonetically correct
	3	Consistently accurate	Consistently accurate	Consistently accurate	Digraphs becoming consistent. Blends accurate half the cases.	1 attempt at vowel marker	Attempt at vowel digraph and r-control vowels.	ing suffix consistently accurate

2 Begin LSP consistent progress	1	Consistently accurate	Consistently accurate	Inaccurate	No digraphs. Blends inaccurate.	No knowledge, phonetically accurate.	No knowledge	No knowledge, guessing
	2	Consistently accurate	Consistently accurate	Improving, half correct	Accurate with most r-blends, no use of consonant digraphs	1 attempt at vowel marker	Attempt at vowel digraph and r- control vowel	Attempt at ing suffix
	3	Consistently accurate	Consistently accurate	Consistent, 1 inaccurate	One digraph accurate. Blends consistently accurate.	2 attempts at vowel marker	Attempt at vowel digraph and r- control vowel	Consistently accurate at suffix ing

3	MP MP MP	1	Consistently accurate	Consistently accurate	Confusing short e with letter i	Consonant digraph "ch" consistent. All blends represented but not always accurate.	No knowledge	Attempt at vowel digraph and r- control vowel	Attempt at ing suffix
		2	Consistently accurate	Consistently accurate	Consistently accurate	Overgeneralization of "er" r-control vowel for all r blends.	No knowledge	Attempt at vowel digraph and r- control vowel	Suffix ing learned as a chunk.
		3	Consistently accurate	Consistently accurate	Consistently accurate	Digraphs consistently accurate. Blends contaminated with overgeneralization of "er" r-control vowel.	No knowledge	Attempt at vowel digraph and 1 correct r-control vowel	Suffix ing consistently accurate

4 S2 & S3 same, final status EWW	1	Consistently accurate	Consistently Accurate	Inconsistent	Inconsistent	No knowledge	No knowledge	No knowledge
	2	Consistently accurate	Consistently accurate	Confusing one sound	Digraphs consistent, blends mostly consistent	One attempt at vowel markings	Inaccurate r- control vowel	Suffix ing
	3	Consistently accurate	Consistently accurate	Consistently accurate	Consistently accurate	Two attempts at vowel markings, one accurate	Consistently accurate r- control vowel, attempt at vowel digraph	Suffix ing, doubling of ending suffix but over generalized
5 Rapid growth, final status ESJ	1	Consistently accurate	Consistently accurate	Consistently accurate	Blends inconsistent Digraphs 1 attempt	No knowledge	No knowledge	No knowledge
	2	Consistently accurate	Consistently accurate	Consistently accurate	Missed one blend Middle position digraph incorrect	Vowel markers (2 out of 5 correct)	Attempt at vowel digraphs and r- control vowel	Easy suffix ing and ed consistently accurate
	3	Consistently accurate	Consistently accurate	Consistently accurate	Blends or digraphs consistently accurate	Vowel markers (3 out of 5 correct)	r-control vowel consistently accurate	Easy suffix ing and ed consistently accurate, juncture doubling accurate

Conclusions Explanations demonstrate orthographic understanding. Higher functioning students demonstrate *Rule use* sooner and are more consistently accurate sooner (Matthew effect). *Rule use* strategy reflects developmental spelling stages. *Rule use* strategy is directly related to orthographic understanding. Rate of growth is dependent on what degree of consistency *RU* is used. The more consistently accurate features are the faster the growth rate. Also, If rules are stated during self-report there is a higher degree of use of that rule among the trials (Evidence is found in Time-Ordered Matrices).

APPENDIX F

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