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**DEVELOPMENT OF STRESS-RULES
IN ENGLISH DERIVATIONAL MORPHOLOGY**

by

Linda D. Jarmulowicz

A dissertation submitted to the Graduate Faculty in Speech and Hearing
Sciences in partial fulfillment of the requirements for the degree of Doctor of
Philosophy, The City University of New York.

2000

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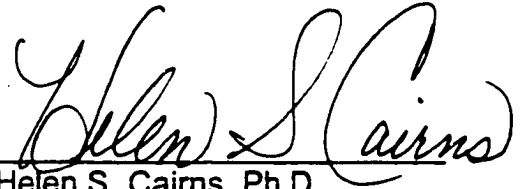
LINDA D. JARMULOWICZ

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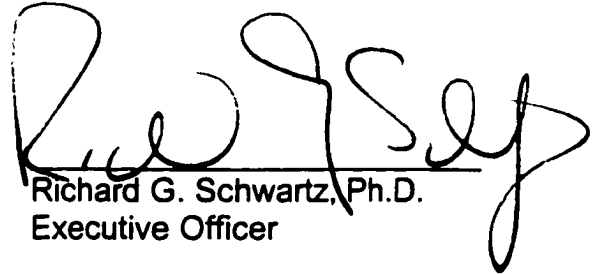
Date



Helen S. Cairns, Ph.D.
Chair of Examining Committee

4/28/00

Date



Richard G. Schwartz, Ph.D.
Executive Officer

Charles Cairns, Ph.D.

Richard G. Schwartz, Ph.D.

Virginia V. Valian, Ph.D.

Supervisory Committee

THE CITY UNIVERSITY OF NEW YORK

ABSTRACT

DEVELOPMENT OF STRESS-RULES IN ENGLISH DERIVATIONAL MORPHOLOGY

by

Linda D. Jarmulowicz

Advisor: Helen S. Cairns

The English language has two types of derivational suffixes: those that affect stem stress ('rhythmic suffixes'), and those that do not ('neutral suffixes'). Rhythmic suffixes (e.g., *-ic*) are attached to a stem after main stress is assigned by the stress rules, following which the entire derived word is cycled back through the stress assignment rules, yielding pairs like *artist/artis'tic*. Conversely, neutral suffixes are those that are attached after main stress is assigned to a stem word; but the derived word is not recycled through stress rules, yielding pairs such as *ar'gue/ar'gument*. From a metrical phonology perspective, the distinction between these two types of suffixes reflects the cyclic application of the English stress rules in rhythmic derivations, but not in neutral derivations (Hayes, 1995.)

Although the development of derivational morphology has been studied from various perspectives, none of these have specifically addressed the phonological stress rules. English speaking children must learn that words

derived with rhythmic suffixes feed back to the metrical stress rules, which reassign stress to the entire new word, whereas neutral suffixes have no effect on stem stress.

The present study was designed to answer the following questions: 1) Is there a developmental progression as children master the two types of morphophonemic rules associated with rhythmic and neutral suffixes? 2) Are there differences between the two types of suffixes? 3) Are more frequent suffixes mastered first? 4) Is stress assigned by rule or is word stress lexicalized?

Perception and production tasks were designed, which included rhythmic and neutral suffixes on real and nonsense word stems. Participants included 19 seven-year old children, 18 eight-year old children, and 15 nine-year old children. Several conclusions can be made from the resulting data: 1) The morphophonological rules for neutral suffixes are mastered before those for rhythmic suffixes; 2) There is a developmental progression as school-aged children learn the rhythmic stress rules; 3) Some of the differences between individual rhythmic suffixes can be attributed to suffix frequency; 4) Stress assignment by children appears to be rule based, however access to the lexical representation of a word does not always rely on morphological decomposition.

ACKNOWLEDGMENTS

Writing a paper of this length and detail is often a solitary endeavor. Despite my irrational hopes that sometime during the night the paper would magically write itself, I was left to make friends with my capricious companions: the computer, the keyboard and Determination. I am reminded of a quote from Calvin Coolidge, who said,

“Nothing in the world can take the place of persistence. Talent will not; nothing is more common than unsuccessful men [and women] with talent. Genius will not; unrewarded genius is almost a proverb. Education will not; the world is full of educated derelicts. Persistence and determination alone are omnipotent.”

I make no claim of expansive omnipotence, nor do I aspire to dominate more than my own little sphere of comprehension. However, I do believe that I have reached a plateau for a moment, which may only be a foothold in a very long climb. Ultimately, determination may come from within, but it is strengthened and bolstered from without. I could not have completed this project without the kindness and support of numerous people.

First, I would like to thank the members of my supervisory committee: Richard Schwartz, Chuck Cairns, and Helen Smith Cairns. Ten years ago, before taking the jump into the Speech and Hearing Sciences program, I was told that it would be difficult to keep a foot in linguistics – not that it would be impossible, but that I would have to work very hard to make it happen. Although I do not profess to being on the cutting edge of linguistic theory, I believe I managed to keep a foot, or at least a toe planted. In large part, this is due to the people I encountered, their interests, and their ability to foster my own interests.

I thank Chuck for his patience and assistance as I struggled to understand the subtleties of metrical theory and lexical phonology. After several years of plodding through various theories of stress assignment, I finally understand it. Chuck was also kind enough not to point out that now that I understand it, it's probably outdated.

I am grateful for the guidance and support provided by Richard, who has been instrumental in shaping my research, writing, and professional skills. One of the many things I did not know upon entering graduate school was that I would be interested in language development, and by extension, working with children. Walking in the door I expected to study adults, but instead I found myself in a lab with a bunch of two-year olds, Richard, and several students who became some of my closest friends. What I also found was that phonology was more than tracing historical connections between languages; the development of phonology

was dynamic and the examination of this development was fascinating. Above all, I thank Richard for challenging and encouraging me.

My unbounded appreciation and admiration are given to Helen Cairns, for seeing me through every step and misstep of this project, helping me to backtrack gracefully, lending a hand or a shoulder when I stumbled, and gently pushing me along when I feared the next step. Her guidance was inspiring, her enthusiasm was infectious, and her respect for me, and for all her students, was empowering. It was a pleasure to work with her and bring this project to fruition under her guidance.

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My family deserves my sincerest thanks for always believing in me and trusting that, one day, I would finally finish school (and for willingly subjecting themselves to numerous pilot studies). Thank you Mom, Dad, Peter, Ania, Mateusz, and Stella. I would also like to recognize the support and sagacious advice I received from Charles and Susanne Doty. Finally, I owe my husband, Brett Doty, my deepest gratitude and appreciation for never doubting my ability to finish (in spite of my own doubts), for his pride in my accomplishments, for his superior proofreading skills, for his cooking skills, for reminding me that life is more than words (even polymorphemic ones), and for his patience and love when I needed it most. Thank you Brett, this is dedicated to you.

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CHAPTER 1: INTRODUCTION

Recent inquiries into phonological development have focused on the acquisition of suprasegmental components of language, specifically prosody and stress. Most of these studies have explored perception and production in very young children to find evidence of prosodic structure development (Gerken, 1994; Jusczyk, Cutler & Redanz, 1993; Schwartz & Goffman, 1995). Relatively little developmental research has examined lexical stress beyond bisyllabic words, and still less has examined lexical stress in polymorphemic words.

Studies of English morphological development have also been focused primarily on the early processes of inflectional morphology and compound formation. By the time English speaking children are acquiring the derivational processes, they have mastered the basic prosodic system (i.e., the syllable, foot, and phrase structure characteristic of metrical stress rules). However, the English derivational system has stress and phoneme alternations that are morphologically conditioned.

The English language has two types of derivational suffixes: those that affect stem stress and those that do not. For example, when the suffix *-ic* attaches to a stem word, such as "magnet", primary stress moves one syllable to the right: **MAG**net/mag**NE**tic¹. In contrast, attaching the suffix *-ness* to a stem

¹ Throughout this paper, I will indicate primary stress on a word by capitalizing the syllable receiving primary stress.

word does not alter primary stress on the stem: HAppy/HAppiness. These morphophonological rules are assumed to be part of the lexicon in linguistic theories of lexical phonology, yet they have received relatively little attention by developmental researchers. Nevertheless, children mastering English must learn where and when these rules apply.

This study reports two experiments designed to investigate the development of morphologically conditioned stress alternations in seven-, eight-, and nine-year old children. Specifically, it uncovers the developmental sequence with which children acquire the stress rules for words with suffixes that do and do not affect the stress of the stem word. Prior to presentation of the experiments, the pertinent linguistic theory and developmental literature will be reviewed, followed by a synopsis and critique of the literature, and a discussion of the hypotheses and predictions of the study in Chapter 2. Chapter 3 presents a preliminary experiment determining suffix frequency, which was needed for stimuli selection. Both experiments were administered in the same session; however, to avoid confusion I will discuss each task independently. The production results are reported first, in Chapter 4, and the perception results follow in Chapter 5. A subsequent comparison of the two experiments and the general discussion continue in Chapters 6 and 7. A summary of the data collected from parent questionnaires and test of print exposure can be found in Appendices N and O.

Theoretical Background

To understand the difference between suffixes that affect stem stress and suffixes that do not, two areas of linguistic theory must be reviewed. First, we must understand how phonology and morphology are linked in the lexicon, and second, we must understand how stress is assigned to English words. The purpose of this section is to provide a coherent framework, grounded in linguistic theory, which will satisfy these two requirements. Although other theories exist, I have chosen to present a combination of lexical phonology and metrical theory. These theories are well established in the linguistic literature, and sufficiently meet the needs of this study.

Phonologists recognize a fundamental distinction between post-lexical and lexical effects on words in English. Post-lexical processes apply without exception, and they can cross word boundaries. One example of a post-lexical rule is flapping, which changes “intervocalic dental stops to a sonorant [D]” in certain environments (Kenstowicz, 1994). This rule is phonetically motivated, and produces an allophone of /t/. Flapping occurs within words (e.g., a[D]om for “atom”), across morpheme boundaries (e.g. ea[D]ing for “eating”), and across word boundaries (e.g., wha[D] is it? for “what is it”). The rules above the word level that assign phrase and sentence stress (i.e., prosodic phonology) also apply post-lexically.

Lexical rules, in contrast, are grammatically sensitive to syntactic category (e.g., affixes are sensitive to the syntactic category of the stem word: the prefix

re- and the suffix *-tion* only attach to verbs), semantic characteristics (e.g., affixation is usually blocked when a word already exists in the lexicon with the same meaning: *intend/intention* but *defend/defense/*defension* or *accuse/accusation* but *refuse/refusal/*refusation*), morphological composition (e.g., some suffixes prefer to attach to certain stem forms: stems ending in *-able* or *-ible* often can be suffixed with *-ity*, as in “*capability*” or “*deconstructability*”), and they account for lexical exceptions (e.g., irregular past tense forms such as *run/ran*, *swim/swam*). Furthermore, although lexical rules generally do not produce allophones, they must account for lexical alternations such as vowel quality alternations (e.g., *s[e]ne/s[æ]nity*), consonant alternations (e.g., *electri[k]/eletri[s]ity*), and stress alternations (e.g., *ACtive/acTIvity*).

Thus, words in English and many other languages are subject to both lexical and post-lexical phonological rules. English stress alternations in morphologically complex words, the topic of this paper, constitute a lexical process. Therefore, I will focus the following discussion on the principle tenets of lexical phonology and metrical stress theory as they pertain to English.

Lexical Phonology

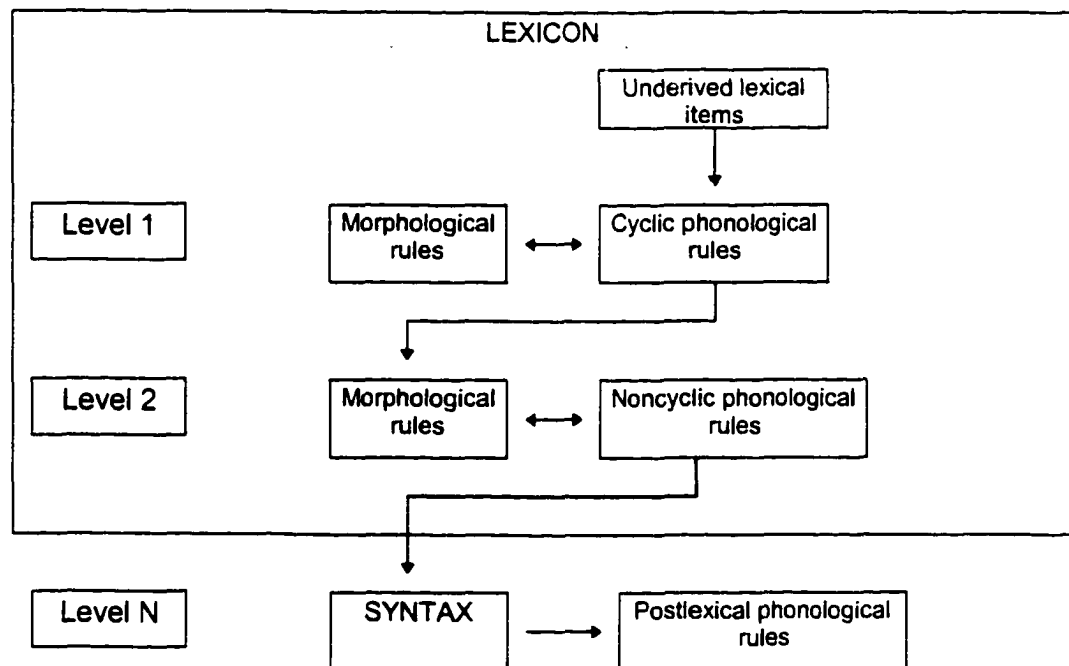
In the Sound Pattern of English (SPE), Chomsky & Halle (1968) established linear rules for lexical phenomena such as stress, vowel and consonant alternations. The SPE framework differentiated between affixes that attach at word boundaries (with "#"), as in #sane#ly#, or morpheme boundaries (with "+"), as in #san+ity#. In this way, two types of derivational word-formation processes were identified: those that did not affect the stem stress, consonant, or vowel quality, and those that did. In this model, lexical items were static representations and rules acted upon them. Exceptions to rules were believed to be stored as lexical entries (e.g., "ran" the irregular past of "run" would be stored as a separate lexical item).

The SPE schematization was superseded by Lexical Phonology (LP) models which attempted to capture some of the nuances and interactions between English morphology and phonology. Kiparsky (1982), following Siegel (1979), noted that affixes attached at "+" or "#" boundaries shared certain characteristics, and he renamed them Level 1 and Level 2 respectively. Some of the characteristics of the affixes connected at a "#" boundary (the Level 2 type) were that they often applied to new words in the language or in novel ways (e.g., workaholism or toddlerhood). They also had semantically transparent meanings, unlike some of their Level 1 counterparts. For example, both *-ness* (a Level 2 suffix) and *-ity* (a Level 1 suffix) may be appended to an adjective to form an abstract noun, however, the meaning of *-ness* is consistently something like "the

state of being (stem)" whereas the meaning of *-ity* is less predictable, as in the following derived word pairs: oddness/oddity; realness/reality; spiritualness/spirituality. Furthermore, Level 1 type suffixes have been noted to affect word internal phonology (i.e., vowel, consonant, and stress alternations). Level 2 suffixes never alter the phonological form of a word or stem.

Kiparsky proposed to replace the SPE model with his theory of Lexical Phonology. In this model, lexical as well as postlexical rules are represented. In LP models, morphological rules, such as those that append affixes, are linked with phonological rules at different levels or strata, as seen in Figure 1.

Figure 1. Model of Lexical Phonology



Some cyclic rules, like those that assign stress, apply at Level 1 and apply to monomorphemic forms. Other Level 1 cyclic rules must apply in only morphologically complex environments. The output of the first cycle (Level 1 phonology) may acquire a Level 1 affix, in which case the derived word loops back through the Level 1 phonological rules. On this cycle, the stress rules apply again, as do those that apply only in morphologically complex environments, including the rules for consonant and vowel alternations. Thus, for a word like “defensiveness”, the underived lexical item “defend” is first fed through the Level 1 stress rules. The Level 1 suffix *-ive* is attached to “defend” and the new word cycles through the Level 1 phonological rules to yield “defensive” (following application of a consonant alternation rule). The output of the Level 1 phonological rules becomes the input to Level 2 morphology, which adds the suffix *-ness*, and feeds the new word through the Level 2 phonology, where no rules apply to this word. The complete word is then sent to the syntax module and post-lexical rules.

Let us examine another example in which stress changes. For the purpose of illustration, I take the liberty to invent the word “nationalityless”, a plausible word describing the condition of having no nationality. First, the stem “nation” is fed through the Level 1, cyclic phonological rules and is assigned main stress to the first syllable. Then, the Level 1 suffix *-al* is attached, and the new word is fed back through the Level 1 phonological rules. At this point, stress is reassigned, although no stress shift results, and the vowel changes from /e/ to /æ/, producing the word “national”. Another Level 1 suffix, *-ity*, is appended to

produce “nationality”, and again the new word is fed through the Level 1 phonological rules that move main stress to the presuffixal position. With no other Level 1 processes, the word moves to Level 2, where the suffix *-less* is attached, and the whole word “nationalityless” is given phonological form. Since stress is applied at Level 1, the affix applied at Level 2 has no effect on stress. Thus, it adds morphological complexity but does not affect stress redistribution.

Early LP models adhered to strict level ordering which do not permit words formed at a later level to return to an earlier level. The type of model in Figure 1 captures many nuances of the interaction between morphology and phonology; however, it is controversial. Since the inception of LP models, there have been bracketing paradoxes that the LP model is unable to explain gracefully (Aronoff, 1976). An example is the problem of a word like “ungrammaticality”, with the following bracketing: [[un: [[grammatic]al]]ity]. The prefix *un-* is a Level 2 affix which attaches to an adjective, the Level 1 suffix *-al* forms an adjective, and *-ity* is also a Level 1 affix that forms a noun. Following strict level ordering, the Level 1 suffix *-al* is attached first, then the Level 2 prefix *un-*, yielding “ungrammatical”. Then *-ity*, a Level 1 affix, must be attached, but strict level ordering prohibits looping back to a previous level. The prefix *un-* cannot be attached after *-ity* because it does not attach to noun stems, only adjectives². Furthermore, Aronoff (1976) identified suffix sequences that could not be generated by Kiparsky’s LP model. For example, the suffixes *-able* and *-ment* are both Level 2 suffixes that

² In this case, *un-* is an adjective prefix with the meaning of “not”. There is another *un-* prefix in English that attaches to verb stems, as in “undo” or “untangle”, which roughly means “the reverse of the stem action”.

don't affect stem stress, however they can be attached before Level 1 suffixes such as *-ity* or *-al* (e.g., *representability*, *developmental*). Again we see that level ordering or affix ordering models do not efficiently capture acceptable patterns in English (also see Cole, 1995).

Subsequent LP models captured some of the subtlety inherent in Kiparsky's model while eliminating the bulkiness (and errors) of strict level ordering (Booij & Rubach, 1987; Halle & Kenstowicz, 1991; Halle & Vergnaud, 1987). Most of the later models highlight the difference between cyclic rules and postcyclic or noncyclic rules. Essentially, cyclic rules apply on Level 1 and noncyclic rules apply on Level 2, as illustrated in Figure 1. However, Halle and Kenstowicz (1991) suggest that ordering can be eliminated completely if suffixes are marked +/- cyclic. This last suggestion has interesting repercussions for learning the English morphophonological system, and will be discussed later in Chapter 2.

Contemporary phonological theory envisages stress as an aspect of the hierarchical structure of phonological representations. Stress is defined in terms of syllable position in prosodic structure. Within this approach, metrical theory offers an account of word stress, which is key to this study. I will turn now to discuss the basic metrical framework and how Halle and Idsardi's (1995) metrical stress rules fit into a lexical phonology model.

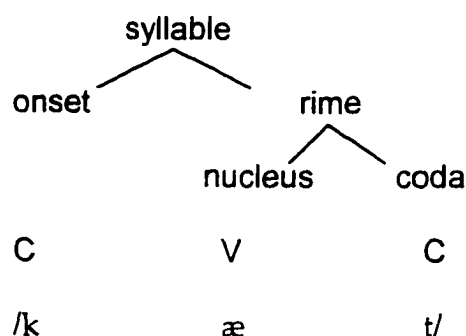
Metrical Theory and Word Stress

Metrical Fundamentals

Metrical models have addressed stress assignment at both the word and phrasal level. Metrical theory is concerned with syllabification and rhythmic organization, both of which influence and define stress assignment. Word stress assignment has been a major focus in the development of metrical theory. However, before we review word stress assignment, a brief discussion of syllable structure and metrical framework is in order.

Syllables are a central unit in metrical theory; they are the stress bearing units of a word. The internal structure of a syllable consists of an optional consonant as an onset and a rime. The rime minimally contains a nucleus, usually a vowel (V), and may optionally have a consonant coda after the vowel (VC or CVC). Syllable structure is depicted in Figure 2.

Figure 2. Syllable Structure

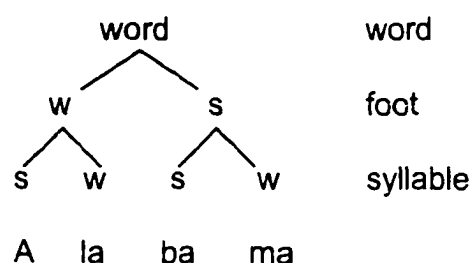


A syllable without a coda, or final consonant, is an open syllable, whereas a syllable with a final consonant is a closed syllable. In many languages, including English, syllables are said to have “weight”, and can be heavy or light. A light syllable is an open syllable, whereby the rime consists of a single vowel. A heavy syllable has a branching rime, which means that either the syllable is closed, CVC, or contains a diphthong or long vowel, CVV. The stress-bearing phoneme of a syllable is called the nucleus, or head of the syllable. Thus, in the example in Figure 2, the head of the syllable would be the vowel /æ/. Only the rime is relevant to determining weight; onsets play no role. Thus, in a polysyllabic word like “Alabama”, which contains all open syllables, the syllabic structure would be V CV CV CV.

In the phonological literature there are two primary approaches to metrical organization: trees and grids. Metrical trees mark syllables as having strong (s) or weak (w) stress, relative to each other, as seen in Figure 3. In this type of structure, “stress is represented as a hierarchy of binary branching structures” (Kager, 1995). Foot structure (i.e., the level between the individual syllables and

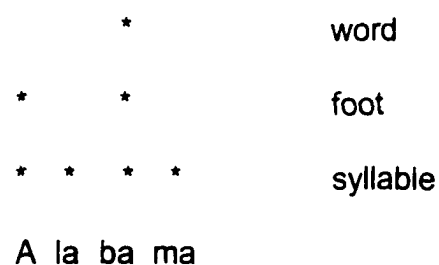
the word) is easily identifiable in trees. Syllables are combined into feet (usually two syllables per foot), and feet into words.

Figure 3. Metrical Tree (from Kager, 1995)



Metrical grids highlight the relative prominence of syllable stress at different levels, and provide a hierarchical representation of rhythmic structure (Hayes, 1995; Kager, 1995; Kenstowicz, 1994). An example of grid structure is seen in Figure 4. In this framework the second level also corresponds to feet. At this level, only the heads of feet (i.e., the strong syllable of a pair) are marked.

Figure 4. Metrical Grid (from Kager, 1995)



Although both of these structures are employed in the linguistic literature, I will restrict further discussion of word stress to grids. Grid theory is capable of expressing stress rules with relative simplicity and economy. Halle and Idsardi (1995) propose a theory of stress assignment that relies heavily on the rhythmic

representation of grids and also incorporates bracketing, which captures some of the constituent-sensitive aspects of trees (without actually using trees). In this theory, the metrical grid is built up from the syllable level (on Line 0), foot constituents are marked and the prominent member of a foot is elevated to the next level (on Line 1). Finally, the syllable receiving the most prominence, or stress, in the word is elevated to the highest level (on Line 2). Thus, unlike the syllable, foot, word hierarchy in the Alabama diagram in Figure 4, Halle and Idsardi call these “Lines” of representation at which different rules apply.

Metrical Stress Rules

We turn now to the specifics of stress assignment using metrical grids. For simplicity, I will review the theory only as it pertains to English.³ In their elaboration of the rules and constraints for stress assignment, Halle and Idsardi (1995) state that:

“A formal account of stress phenomena will require at least the following three devices: a device for designating the elements in the sequence that are capable of bearing stress; a means for delimiting the groupings of the elements; and a marker to distinguish in each grouping or constituent the prominent head-element from the rest.” (p., 404)

The head-element is equivalent to the syllable nucleus, which is the stress bearing unit. Stress assignment becomes a process of assigning marks to levels of the grid by identifying the stress-bearing elements, marking those elements into constituents, and linking certain elements with another higher in the structure. Table 1 depicts the metrical stress assignment of several words. For

example, syllable heads are projected onto the first line, or plane, of representation, labeled Line 0. In a weight sensitive language, like English, syllable boundaries (indicated by parentheses) are projected to the left of a syllable if it is heavy, except for closed word-final syllables in nouns, which are exempt from the syllable boundary projection. This rule is called Project: L, and can be seen in Table 1a. Note that in the word "geranium" a constituent boundary, indicated by a left parenthesis, is projected for the heavy syllable (i.e., long vowel /e:/), while Project: L results in no boundary marking in the examples "parameter" and "monosyllable" because there is no heavy syllable in these words.

³ Further elaboration of stress assignment parameters can be found in Kager (1995), Hayes (1995), Halle & Idsardi (1995), and references there.

Table 1. Metrical Stress Assignment Rules.

a.	Project: L	x (x x x dʒərə: niʒəm geranium	x x x x parameter	x x x x x monosyllable	Line 0
b.	Edge: RLR	x (x x) x geranium	x x x) x parameter	x x x x) x monosyllable	Line 0
c.	ICC: L	x (x x) x geranium	x (x x) x parameter	(x x (x x) x monosyllable	Line 0
d.	Head: L	x x (x x) x geranium	x x (x x) x parameter	x x (x x (x x) x monosyllable	Line 1 Line 0
e.	Edge: RRR	x) x (x x) x geranium	x) x (x x) x parameter	x x) (x x (x x) x monosyllable	Line 1 Line 0
f.	Head: R	x x) x (x x) x geranium	x x) x (x x) x parameter	x x x) (x x (x x) x monosyllable	Line 2 Line 1 Line 0

The next step is edge-marking, which is equivalent to identifying the elements that are extrametrical, meaning that they are excluded from further consideration in stress assignment. For English nouns, a right parenthesis is placed to the left of the rightmost syllable (Edge: RLR), and is illustrated in Table 1b. In effect, the rightmost syllable is rendered invisible to further rules.

The following rule is called Iterative Constituent Construction (ICC). This rule groups the syllables into units (i.e., metrical feet) by placing a parenthesis to the left of every two syllables, starting from the rightmost constituent boundary marked by the Edge rule. This is most clearly illustrated for the word “monosyllable” in Table 1c.

At this point, the syllables are grouped into constituents and now the head elements of those constituents must be marked on the next level. The Head Rule is employed to elevate certain elements to both Line 1 and Line 2, although at the lowest level the head is the leftmost member of a constituent, or foot, and at the higher level it is the rightmost member. Thus, after application of the ICC rule, the heads of the feet, which are the leftmost members of a constituent (marked by left parenthesis), are identified and projected to Line 1 by the Head: L rule, as seen in Table 1d. Once elements have been projected to Line 1, another Edge rule marks a right parenthesis to the right of the rightmost element (Edge:RRR), as seen in 1e. As illustrated in Table 1f, the head projected from Line 1 to Line 2 is the rightmost member of the constituent (Head:R).

The stress rules for English Main Stress (for nouns) can be stated as follows:

1. All syllables (i.e., stress-bearing units) are projected to Line 0, and heavy syllables are marked with a left constituent boundary (indicated by a left parenthesis): Project:L
2. Word-final syllables are extrametrical: Edge: RLR
3. On line 0, construct binary, left-headed constituents (feet) from right to left, and project heads to line 1: ICC:L, Head:L
4. On line 1, construct unbounded right-headed constituents, and project heads to line 2: Edge: RRR, Head: R

Metrical Stress and Lexical Phonology

Recall that in the LP framework, the stress assignment rules apply at Level 1 for all words (i.e., monomorphemic and polymorphemic words). The stress assignment rules reviewed in the previous section are the rules that apply at Level 1 for monomorphemic and polymorphemic words. They are cyclical rules in the sense that after application of a Level 1 affix the newly formed word is sent back through the stress assignment rules.

The distinction between the two types of English affixation, either stem-stress changing or stem-stress retaining, is maintained in metrical models (Hayes, 1995). For clarity and consistency, throughout this paper I will refer to the stress-affecting suffixes as 'rhythmic suffixes'. These suffixes are subject to the cyclic, Level 1 phonological rules and are included in the rhythmic reassignment of main stress. The noncyclic suffixes I will refer to as 'neutral suffixes' because they are not subject to cyclic rules and cannot affect stem stress. The crucial theoretical difference between classical LP approaches and the metrical approach adopted here, is that the rhythmic suffixes trigger reapplication of cyclic phonological rules instead of being grouped on levels reliant on level ordering. Thus, if individual suffixes are marked in the lexicon for cyclicity or not, they are free to apply to stem words without being applied at a predefined level (Halle & Kenstowicz, 1991). This eliminates some of the bracketing paradoxes mentioned earlier.

The rhythmic stress assignment rules are cyclic and rely on phonological factors, like syllable weight, and grouping of stress bearing units into metrical constituents, as illustrated above. These are the rules that assign main stress to words, as seen previously in Table 1. Both stem words and Level 1 derivations create word-internal cyclic domains in which the stress assignment rules apply (Cole, 1995; Halle & Kenstowicz, 1991). Underived words are their own cyclic domain. Suffixes subject to the rhythmic stress rules are often those associated with Level 1 morphology (e.g., *-ity*, *-ous*, *-al*, etc). When rhythmic suffixes are attached to a stem the entire newly formed derived word constitutes a new cyclic domain. A derivation formed with a rhythmic suffix is erased of any previous stem stress, and stress is assigned anew. This process is illustrated in Table 2. The lexical item "curious" is sent through the stress assignment rules, yielding the rhythmic form in Table 2f. The rhythmic suffix *-ity* is attached after stress is assigned to the stem, but because *-ity* is a rhythmic suffix, the stress rules are reapplied to the derivation "curiosity". In this way, the suffix triggers another cycle through the phonological rules.

Table 2. Cyclic Stress Assignment to a Stem and a Rhythmic (Level 1)**Derivation.**

		1st Cycle curious	2nd Cycle curious + ity	
a.	Project: L	x x x curious	x x x x curiosity	Line 0
b.	Edge: RLR	x x) x curious	x x x x) x curiosity	Line 0
c.	ICC: L	(x x) x curious	(x x (x x) x curiosity	Line 0
d.	Head: L	x (x x) x curious	x x (x x (x x) x curiosity	Line 1 Line 0
e.	Edge: RRR	x) (x x) x curious	x x) (x x (x x) x curiosity	Line 1 Line 0
f.	Head: R	x x) (x x) x curious	x x x) (x x (x x) x curiosity	Line 2 Line 1 Line 0

The rules for neutral suffixes are noncyclic and correspond to Level 2 morphological and phonological processes. Metrically, these suffixes are weakly stressed or unstressed. In English, attachment of neutral or noncyclic suffixes (e.g., *-ment*, *-ness*, *-ist*) does not affect the primary stress assigned to the stem because they do not define a cyclical domain (Cole, 1995). These suffixes are attached after main stress is assigned; the subsequent derivations respect the previously assigned metrical structure, and are not subject to stress re-assignment (Hayes, 1995; Halle & Kenstowicz, 1991). Thus, for a word like

“preposterousness” the stem “preposterous” is metrified (i.e., assigned primary stress) with the cyclic, Level 1 phonological rules, which then becomes the stem for the neutral suffix *-ness*, as seen in Table 3. Importantly, the attachment of *-ness* does not trigger the cyclic stress assignment rules.

Table 3. Neutral (Level 2), Noncyclic Suffixation on output of Cyclic Metrification of a Stem word.

	Stem (output of 1 st Cycle)	Neutral Suffix	Derivation
Line 2	x		x
Line 1	x)		x)
Line 0	x (x x) x	x	x (x x) x x
	preposterous	+ ness	preposterousness

In sum, phonological theory provides a coherent framework with which morphophonological stress alternations can be examined. Lexical phonology describes the interface between morphological and phonological processes that take place in word formation, and explains the phonological difference between rhythmic and neutral suffixes as a difference in terms of access to the cyclic phonological rules after affixation. Metrical phonology explains what the cyclic stress rules are, and how they apply in morphologically simple and complex words. A theory of acquisition should include how children learn these rules.

Developmental Background

The literature examining the acquisition of English morphology is vast. However, the bulk of this work has focused on inflectional morphology, and secondarily on compounding. Derivational morphology has received the least attention. Developmentally, most English inflections are mastered before age four (Berko, 1958; Brown, 1973). Evidence of novel compound formation can be found in children as young as two and continues to develop through the early elementary school years (Atkinson-King, 1973; Becker, 1994; Berko, 1958; Derwing & Baker, 1986; Clark & Hecht, 1982). Derived words, on the other hand, only begin to contribute to vocabulary expansion in the middle of elementary school, and may continue throughout adulthood (Anglin, 1993; Carlisle, 1988; Corson, 1996).

Developmental studies have examined derivational morphology from several perspectives. These different approaches fall roughly into three categories: lexical and semantic development (Anglin, 1993; Clark & Hecht, 1982; Derwing & Baker, 1979, 1986; Freyd & Baron, 1982; Wysocki & Jenkins, 1987), phonological and phonetic development (Gordon, 1985, 1989; Jaeger, 1984; Moskowitz, 1973; Stotko, 1992; Windsor & Hwang, 1999a, 1999b), and reading and spelling development (Carlisle, 1988, 1995; Carlisle & Nomanbhoy, 1993; Templeton & Scarborough-Franks, 1985; Tyler & Nagy, 1989). The discussion that follows will address each of these separately, although in some cases significant overlap exists.

Lexical and Semantic development

Rapid vocabulary expansion has been documented in young children around two years of age (Markman, 1994). During this time, children add words to their lexicon at a rate of approximately 30 words per week. Interest in this word spurt has fueled significant research in language acquisition. In addition, there appears to be a second period of vocabulary expansion which has received less attention. This "second spurt" occurs between ages eight and twelve (Wysocki & Jenkins, 1987) and predominantly involves morphologically complex words.

Anglin (1993) conducted an extensive study of vocabulary development in first, third and fifth grade children. In this study, children defined a list of 196 randomly selected words from a dictionary. The list was broken down into root words, inflected words, derived words, literal compounds, and idioms. Word knowledge, as measured by the ability to define, to put into a sentence, or to choose from multiple definitions, was shown to increase for all word types across grades. The largest increase in word knowledge occurred for polymorphemic derived words between grades three and five. The mean estimated number of derived words jumped from 1,794 to 5,577 to 16,088 in the lexicons of children in grades one, three and five respectively. The overall number of words in children's vocabularies across all word types was estimated as 10,398, 19,412, and 39,994 for first, third and fifth graders respectively. In terms of proportions, derived words represent 17.25% of the first graders', 28.73% of third graders',

and 40.23% of fifth graders' vocabularies. This is a tremendous leap in the knowledge of derivations and presumably the word formation rules governing derivations.

One contributing factor to lexicon growth is semantic development. The ability to semantically decompose derived words is influenced by developmental and individual processes. Morphological relationships between words are most easily identified by children and adults when the semantic relationship between the stem and derived word are transparent (Derwing & Baker, 1979; 1986). This falls under the developmental principle of semantic transparency, whereby combinations of familiar forms are preferred, and in this case recognized, over unfamiliar forms (Clark & Hecht, 1982). For example, the relationship between *dirty* and *dirt*, or *teacher* and *teach*, is more recognizable than between *appliance* and *apply*. Furthermore, the ability to recognize morphological relationships, transparent and opaque, increases with age throughout adolescence and adulthood (Derwing & Baker, 1986; Corson, 1997). Productive use of derivational suffixes also continues to develop through adolescence (Corson, 1997; Selby, 1972).

In a study examining use of sentence context and morphological generalization, Wysocki & Jenkins (1987) found that children in fourth, sixth, and eighth grades were able to determine the meanings of words based on previously learned related forms. The authors taught children the definitions of infrequent stimulus words (e.g., *repudiate*, *abatement*, *sapient*, *stipulation*) then tested them on derivationally related transfer words (e.g., *repudiation*, *abate*,

sapience, stipulate). Transfer words were presented in either a semantically “strong” or “weak” sentence context. For example, if the stimulus word was “melancholic”, the target word in an unbiased (weak) context would be “Her melancholia lasted seven days”. Conversely, the same target word in a strong context would be “After Jack’s puppy died, his melancholia was so bad that he didn’t want to play with his friends”. Control words were also presented in strong and weak contexts, the difference being that there was no training on a related stimulus word.

Children of all ages were better at defining the transfer words when compared to control words, and better at defining words presented in strong sentence contexts than in weak contexts. However, the older two groups demonstrated greater ability to use sentence context, and greater morphological generalization as measured by their acceptable definitions for both the transfer and morphologically complex control words. The authors suggest that vocabulary growth during the elementary school years is in part attributable to morphological generalization with suffixes.

Knowledge of morphological relationships assists in word learning as well as in determining morphologically complex word meanings. Freyd and Baron (1982) demonstrated that fifth grade children with greater skill at decomposing derived words (i.e., separating a stem from an affix) were able to learn the meanings of new derived words faster than eighth graders who were not as skilled at morphological analysis. Children were administered a vocabulary test on simple and derived English words, and a paired-associate learning test

composed of simple and derived non-words. For the vocabulary test, children were asked to write definitions of orally presented real English words (e.g., movement, imaginative). In the paired-associate learning test, children were taught the meanings of novel stems and derivatives, half of which shared the same stem (e.g., "flur", "flurment" associated with the meanings "play" and "game" respectively) and half of which had different stems (e.g., "jeve", "kruttist" with the meanings "study" and "pupil").

The most common error children made when defining derived words involved lexical category. Children tended to disregard the lexical category change produced by the suffix and attended to the lexical category of the root word. For example, an error for the word "responsive" would be the definition "to respond" or "to take action". This type of lexical category error was also found by Wysocki & Jenkins (1987). The academically advanced fifth graders outperformed the average eighth graders most markedly on morphologically complex words (mean correct definition on derived words for 8th grade = 8.8, and for 5th grade = 14.1). The fifth graders also were able to learn novel stems and derivations that shared a common root better than those that did not. In contrast, the eighth graders showed very little difference in their ability to recall related and unrelated stems and derivatives. Overall, the results suggest semantic and morphological development are linked because children skilled at morphological analysis use that skill to learn new words by generalizing the meanings of bound derivational morphemes.

In a series of experiments with fourth, sixth, and eighth grade children, Tyler and Nagy (1989) examined derivational suffixes with respect to three types of knowledge acquisition: relational, syntactic, and distributional. All measurements were off-line, paper-and-pencil tasks. Relational knowledge, defined as the ability to recognize morphological relationships (i.e., between stems and affixed words), was found to be acquired by fourth grade. All children were able to differentiate stem morphemes from unfamiliar derived forms at above chance levels on a multiple choice definition task (e.g., they were able to recognize the stem in a derived form like "odorous"). Recognition of the syntactic category of a suffix was measured using a multiple choice sentence completion task in which children had to select the appropriate derived form. Fourth-graders performed at chance, but syntactic category knowledge began improving by sixth-grade, and was mastered by eighth-grade.

Distributional knowledge concerns the combinatory constraints on stems and suffixes. For example, agentive *-er* attaches to verbs, and the verb-forming *-ize* attaches to nouns. Also included is knowledge that words with phonetically similar roots prefer one suffix over another (e.g., *receive/reception/*receival/*receiveness*, *deceive/deception/*deceiveness*; *infer/inference/*inferal*, *prefer/preference/*preferal/*preferation*). Tyler and Nagy presented children with a list of well-formed and ill-formed derivations with "neutral" (i.e., those that do not affect stem stress) and "non-neutral" suffixes (i.e., those that alter stem stress), on high and low frequency stems. For example, children read well-formed derivations like "tameness" and "explosivity" and ill-formed derivations

like “snapness” and “alertity”. Children were asked if they knew what each word on the list meant. Distributional knowledge was the last to be acquired, although even fourth-graders showed some constraint awareness. Furthermore, children appeared to overgeneralize neutral suffixes, but not non-neutral suffixes. That is, children made more false positives on words with neutral suffixes than with non-neutral suffixes. The authors argued that neutral derivatives are formed by combinatory rules, and therefore are overgeneralized in a similar way that the regular past tense can be ungrammatically attached to an irregular verb (e.g., *drinked*) before its distribution is fully learned. In contrast, non-neutral derivatives must be analyzed via “analogical processes that refer to the phonological form of the root” because there are more distributional constraints (e.g., phonological in addition to lexical) on the types of stems a non-neutral suffix can attach to.

Phonological and Phonetic Development

The segmental and suprasegmental aspects of allomorphy and stress are another facet of derivational morphology. Developmental research has addressed vowel shift in morphologically complex words (Moskowitz, 1973; Jaeger, 1984), level ordering (Gordon, 1985, 1989), and the processing of stress shifting suffixes (Stotko, 1992; Windsor & Hwang, 1999b). The bulk of this research is inextricably intertwined with semantic and reading development, mostly due to methodological issues.

Derived word pairs such as *serene-serenity*, *divine-divinity*, and *profane-profanity* exemplify the vowel alternations typical of Vowel Shift Rules (VSR), codified by Chomsky and Halle (1968). Long, tense vowels become shorter and more lax in different morphological conditions. This type of morphologically induced vowel shift was assumed to be productive.

Initial examination of these vowel alternations from a developmental perspective was conducted by Moskowitz (1973). She elicited productions from children, who were aged 5, 7, 9 to 12 years old, by giving them a nonsense stem word and asking them to add *-ity* to it. Children were given instructions with modeled stems and derivations reflecting one of three conditions: vowel shift, vowel laxing, and incorrect vowel shift. After a period of training with front vowel alternations, different front and back vowel alternations were tested to see if children would transfer the learned alternation. Moskowitz found poor performance with both the vowel laxing and incorrect vowel shift conditions. In fact, no children met the learning criteria for the lax vowel alternations, and only a few learned the incorrect vowel shift. For the vowel shift condition, in which the vowel alternation was reflected in English, children younger than age nine did not shift front vowels in derived nonsense words ending in *-ity*, whereas most 9 to 12 year old children did. None of the children, in any of the conditions, shifted back-vowels reliably.

Moskowitz suggested that the vowel alternations associated with derivations, what she labeled internal morphophonemic rules, are the result of

increased familiarity with orthographic rules. Children's mastery of vowel shift is gradual, and appears to coincide with reading instruction (cf. Jaeger, 1984). Furthermore, the strategies children employed to produce morphologically induced vowel changes (e.g., overtly mentioning long and short vowels) were a result of formal learning not rule deduction. Children learn there are different pronunciations for the same written symbol; for example, the "a" in *fat/fate* or the "i" in *kit/kite* are also reflected in derivational pairs *profane/profanity* and *divine/divinity*. Moskowitz concluded that unlike external morphophonemic (i.e., inflectional endings), allophonic, and phonotactic rules which are learned early in development, VSR are learned later and by a different process.

Critics of Moskowitz's study were not persuaded by her arguments (Kiparsky & Menn, 1977). Recall that the children in Moskowitz's study were much better at shifting front vowels than back vowels. If children were relying solely on a spelling strategy, then why would they use it for /naim, nɪmlti/ but not /spowb,spablti/ when alternate pronunciations of the grapheme "o" exist as well as for "i" (e.g., robe/rob and dime/dim)? Kiparsky & Menn suggested that this is because they have internalized the basic patterns of English vowel shift in which front vowels have vowel alternates (e.g., hide/hid; keep/kept) but back vowels do not. They argued that Moskowitz's conclusions of orthographic dependence are "obscure". Moreover, her results indicate that learning morphologically conditioned vowel alternations is not much different from learning other phonological patterns.

More recently, lexical phonology has received attention from a developmental perspective. Gordon (1985) found evidence that children as young as age three formed compound words following the constraints of Kiparsky's (1982) three-tiered model. Specifically, children produced compounds of the form "X-eater" where "X" was plural if pluralization was irregular, but singular if it followed the regular rule (e.g., "mice-eater" in contrast to "rat-eater"). In Kiparsky's model, irregular plurals, characterized by word-internal vowel changes (e.g., mice) are generated at Level 1, but regular plurals are attached at the postlexical Level 3. Compounds are formed at Level 2. Following strict level ordering, a regular plural would not be available for compounding whereas an irregular plural would be. In fact, children who used regular plurals (e.g., rats) predominately formed compounds from the singular (e.g., rat-eater), but used the irregular plural in parallel constructions (e.g., mice-eater, not mouse-eater). Therefore, if a word is generated at Level 1, it is available for word formation at Level 2 or 3. For example, "mice" is generated at Level 1, and evidence from children suggests it is available for the Level 2 process of compounding, as in "mice-eater", or a Level 3 process which may yield "mice-eaters" or an over-regularized plural such as "mices". However, a strict level ordering model is linear. The output of a Level 3 process cannot loop back as the input to Level 2; it cannot be subject to further word formation processes. Children did not produce a compound with a regular plural (e.g., rats-eater), which Gordon considers supporting evidence of the lexical phonology model.

Other studies have examined differences in how children acquire Level 1 (rhythmic) and Level 2 (neutral) derivations (Gordon, 1989, Stotko, 1992). Gordon (1989) was interested in issues of productivity and lexicalization. He claimed that words with productive suffixes (which he assumed to be the Level 2 type) would be more recognizable to children than lexicalized derivations (which he connected with Level 1 suffixes) because the suffix is easily stripped off, leaving a familiar stem. In a series of untimed, auditory, lexical decision tasks with five-, seven-, and nine-year old children, Gordon tested his claims. Children judged lists of words containing low frequency derived words with Level 1 affixes (e.g., *-ous*, *-tion*, *-ity*), Level 2 affixes (*-ness*, *-able*, *-er*), and Level 3 affixes (i.e., inflections such as *-ed*, *-s*, *-ing*), as well as distracters consisting of suffixed nonsense words and suffixed function words. Acceptance rates for Level 3 suffixes (e.g., *freezes*, *typed*, *repairing*) were highest, followed by Level 2 derivations (e.g., *thinness*, *answerable*, *grower*), and then Level 1 derivations (e.g., *sensuous*, *coloration*, *evidential*) for all ages. Word acceptability, across all levels, increased with age. In addition, high stem frequency facilitated recognition of low-frequency derived words.

Although these results generally support Gordon's claims of productivity and lexicalization, even his youngest subjects accepted Level 1 derivations far more than derived nonsense and ungrammatical control words (e.g., *more+ous*, *become+al*, *glanation*), which suggests that even five-year olds have some knowledge of derivations with Level 1 (rhythmic) suffixes. Furthermore, his method and stimuli may have biased his subjects. The metalinguistic task

required subjects to recognize real versus nonwords, but to do this they must strip off suffixes to determine the viability of the stem. Use of this strategy with Level 2 and 3 suffixes would reliably yield a stem that could be analyzed and judged. For example, removing the suffixes from “freezes” or “thinness” yields the stems “freeze” and “thin” with no further phonological manipulation. However, with some Level 1 derivations children would have to employ further phonological rules in reverse to yield 'sense' from /sɛnʃ/, the base left from stripping the suffix off 'sensuous'. Hence, stripping off Level 1 (or rhythmic) suffixes does not infallibly yield a real-word English stem. The interpretability of Gordon's (1989) study is clouded by the phonological inequity of his stimuli.

In a series of timed lexical decision task experiments with third graders, Stotko (1992) examined reaction time differences to neutral (Level 2) and non-neutral (Level 1) suffixed words presented on a computer screen. Her results complement those of Gordon. Reaction times to monomorphemic words were shortest, followed by words with neutral suffixes, followed in turn by words with non-neutral suffixes. For example, response time to “beetle” was less than “peaceful” which was less than “magician”. Error rates were higher and response times slower for nonsense words with neutral suffixes than those with non-neutral suffixes (e.g., slagment v. blarity). Children were more likely to say that a neutrally suffixed non-word was a real word than they were on rhythmic non-words. There was no evidence of spelling influence or interference. Stotko concludes that children appear to be analyzing morphologically complex words with non-neutral suffixes differently than those with neutral suffixes; specifically,

phonological and semantic decomposition of non-neutral suffixes lags behind that of neutral suffixes. Despite this conclusion, the phonological rules were not tested directly, but rather through a reading task.

Very recently, a study of auditory word recognition was conducted by Windsor and Hwang (1999b) which included neutral and rhythmic derivations (what they term phonologically transparent and phonologically opaque derivatives, respectively). This study included children with and without language disabilities and used a timed auditory lexical decision task. Much like Stotko's results, they found more errors (and longer reaction times) on words with nonsense stems and neutral suffixes than on rhythmic nonsense derivations, and they found more errors (and longer reaction times) on real rhythmic derivations than on real neutral derivations. Together, these results indicate that children were more likely to consider neutral derivations as real English words, in contrast to rhythmic derivations which were more often considered to be nonwords than real words. Furthermore, the pattern of results across conditions for the language impaired (LI) group was similar to that of the language age matched (LA) group and the chronological age matched (CA) group, however the CA group was generally faster and more accurate than the other two groups. Also, the performance of the LI group was affected more by phonological opacity (i.e., words with rhythmic suffixes) than the other two groups, especially for real word recognition. Windsor and Hwang suggest that LI children were affected more than children without LI by an increased processing demand produced by phonological opacity.

In sum, we see some support for the lexical phonology framework in Gordon's studies (1985, 1989), and evidence that morphophonological stress plays a role in lexical decision tasks (Stotko, 1992; Windsor & Hwang, 1999b). Furthermore, according to LP models, vowel alternations are also cyclically applied after Level 1 suffixation, like the stress rules. However, (front) vowel alternations do not appear to be mastered by children until age nine or more (Moskowitz, 1973). Possibly, the cyclic stress rules are acquired around the same time as the vowel alternation rules, because both are Level 1 processes.

Reading and Orthographic Development

Another perspective from which to view the development of derivational morphology is reading and spelling. Some of this work has already been mentioned in the previous section. Research in this area generally falls into one of two categories: evidence that morphological awareness affects reading development or evidence that reading development influences morphological analysis. Regardless of the question, the resounding reply is that the development of derivational morphology is linked in some way to reading development, and in turn to vocabulary development.

In an effort to quantify the frequencies and types of words in print to which children are exposed, Nagy & Anderson (1984) undertook an analysis of 7,260 randomly sampled words from a larger corpus collected from school-based materials (Carroll, Davies & Richman, 1971). They estimated that roughly half of

the population of words children see are suffixed (also noted by Freyd & Baron, 1982), from which they concluded that "knowledge of word-formation processes opens up vast amounts of vocabulary to the reader" (p.314).

Children with better phonological awareness show greater comprehension of morphological structure, and just as phonological awareness contributes to reading ability, morphological awareness is also strongly linked to reading (Carlisle & Nomanbhoy, 1993; Fowler & Liberman, 1995). Older elementary-school children (4th, 6th & 8th graders) gradually improve in their ability to spell derived words, and production of the same words precedes orthographic mastery at all ages. However, there is some influence of morphological knowledge on spelling; children were better at spelling derived words when they could accurately spell the stem word, suggesting they had performed some morphological decomposition (Carlisle, 1988).

In contrast to the findings by Carlisle (1988), others have found spelling to facilitate the development, or at least the manipulation of morphologically complex words. Production of novel derived words (nonsense stems and English suffixes which alter vowel quality) by sixth and tenth graders was more accurate when the stem was presented orthographically (i.e., printed on cards that they read) than auditorily (Templeton & Scarborough-Franks, 1985). They concluded that derivational morphology rules are accessed better via an orthographic than a phonetic route.

Jaeger (1984) revisited the orthography-vowel shift issue with adults (18 to 36 years old). She conducted a perceptual category-formation study in which subjects listened to word pairs that exhibited vowel shift and orthographic similarity (e.g., profane/profanity) and other pairs that were morphologically related but orthographically different (e.g., retain/retention). Subjects were first trained to identify and categorize the vowel shifting pairs only. Then subjects either accepted or rejected as part of the vowel-shift category test items that included vowel-laxing pairs that shared a common spelling, and vowel shift pairs that did not (e.g., reduce/reduction and abound/abundance respectively). Subjects overwhelmingly included the pair with similar spelling and rejected the vowel shifting pair. Jaeger interpreted these data as evidence of a psychologically real rule; one based not on vowel shift rules (as proposed by Chomsky & Halle, 1968), but on spelling-related alternations.

Finally, reading proficiency has also been found to be associated with morphological knowledge (Fowler & Liberman, 1995). More proficient readers (aged 7 to 9) were better at extracting stem words from derived forms than poor readers, especially for those that exhibited some phonological alternation (e.g., stress or allophonic alternations). Spelling skill correlated more with the ability to generate derived forms from a base form than with extracting a stem from a derivation. Additionally, vocabulary knowledge also correlated highly with performance on morphological tasks, suggesting that better readers have more expansive vocabularies and are gaining morphologically complex information from reading. The flipside is that "...morphological decomposition and problem-

solving provide one way to understand and learn the large number of derived words used in the books they (children) read" (Carlisle, 1995).

CHAPTER 2: MOTIVATION FOR THE STUDY

Critical Review

Previous developmental examinations of derivational morphology have focused on semantic decomposition, reading and orthographic skills, or specific segmental alternations. The insight we gain from these studies is that children can use derivational information to comprehend, learn, produce, read and spell new words, and that this skill develops most dramatically during the early to mid school-age years. Furthermore, derived words contribute greatly to the expansion of school-aged children's vocabularies. Thus, knowledge of derivational relationships is important to academic success. Nevertheless, the bulk of work examining developmental morphology has been on inflections or morphosyntax. Derivational morphology, and in particular morphophonology, remains to be explored further.

The tasks employed in prior studies represent a range of methods, many of which may add confounding variables or underestimate children's knowledge, and many of which are inappropriate for examining stress shift. Overt teaching (e.g., teaching children derived words then testing them on stems or related derivations), reading, or spelling tasks are indirect and rather cumbersome ways of tapping into language knowledge. These methods rely on specific learning skills or reading behavior, and although they provide information on the semantic relationships between stems and derivations, as well as awareness of

phonological and spelling conventions, they cannot effectively isolate children's knowledge of phonological rules.

Timed and untimed lexical decision tasks are more direct methods of tapping into word recognition and evaluating lexical processing; however, these tasks are less useful when evaluating phonological rule learning. The results from lexical decision tasks allow for inferences about how words are stored and accessed in the lexicon. However, even if we conclude that neutral derivations are easier to process than rhythmic derivations, which seems to be true for children (Stotko, 1992; Windsor & Hwang, 1999b), we still cannot determine exactly why rhythmic derivations require more processing. It may be due to less semantic transparency or phonological opacity or both, but these studies cannot easily separate the two.

Very few studies have employed production tasks to examine differences between neutral and rhythmic suffixes. Windsor & Hwang (1999a) were able to elicit novel derivations from children between the ages of 7;6 (year;month) to 12;8. However, this study was examining suffix choice and productivity, not stress rule acquisition.

In terms of stimuli, many of the studies that included neutral and rhythmic suffixes did not adequately control for stress. For example, some of the rhythmic derivations exhibited a stress shift whereas others did not, as with **MAgnet/magNEtic** but **atTRACT/atTRACtion** or **preVENT/preVENTion** (Stotko, 1992), **FAMily/faMILial** but **reLAtion/reLAtional** (Gordon, 1989). Some of the stems required reversal of phonological rules such as vowel or consonant

alternations to arrive at a free standing word, as in explode/explosion or decide/decision (Stotko, 1992) and sense/sensuous (Gordon, 1989). Although Windsor & Hwang (1999b) did not report all their stimuli, they did note a nonsense rhythmic stimulus item *dividic, from the word 'divide'. They may confuse their subjects because in a rhythmic derivation, there is a consonant alternation in the stem 'divide' when it is in a derived form which was violated in their example (e.g., divide/division/divisive and *divisic not *dividic). In any case, none of these studies sufficiently isolated phonology, nor did they employ phonological theory as a way to explain stress alternations, and, by extension, to explain what phonological rules children are learning.

From the few developmental studies that used neutral and rhythmic suffixes as variables, the general conclusion is that these two suffix types are processed differently (Gordon, 1989; Stotko, 1992; Windsor & Hwang, 1999a, 1999b). Neutral suffixes are more easily recognized, more easily processed, and more likely to be used in novel derivations than rhythmic suffixes. The arguments used to explain these results have frequently conflated phonological with semantic factors. The basic argument is that neutral suffixes are more transparent, both semantically and phonologically, and are used more productively to form new words, whereas rhythmic derivations are often phonologically and/or semantically opaque. Thus, children acquire neutral suffixes first because they are easier to identify and analyze. The question that remains to be answered is: What are children learning? More specifically, what

are the phonological rules that children are learning and can we observe this learning?

Learnability Issues

From a learnability perspective, children must do the following when acquiring suffixes: 1) isolate the suffix; 2) identify the meaning of the suffix; 3) determine the syntactic constraints (i.e., on what lexical category can an affix attach); 4) formulate a phonological rule for that suffix. The majority of prior studies on derivational morphology have examined the first three points. However, there is evidence from other areas of language acquisition that may shed some light on what children do when learning morphophonological rules.

A large part of language acquisition involves finding patterns in the ambient language and forming rules for those patterns. Inflectional morphology has provided fertile ground for exploration into rule acquisition. For example, once a child isolates and understands the meaning of plural -s, he/she forms a rule for the application and generalization of plural -s in novel environments. Berko (1958) established that children between the ages of four and seven are developing rules for the allomorphic variations of plural -s (with the variations /s/, /z/, and /əz/) and the past tense -ed (with variations /t/, /d/, and /əd/). This study was replicated and expanded by Selby (1972) and Derwing and Baker (1977). To illustrate, children were found to generalize the regular plural rule to novel words, and more specifically they were found to be using the /s/ and /z/

allomorphs productively (i.e., in the appropriate phonetic environments) before the /əz/ allomorph. Thus, children would pluralize /wʌg/ as /wʌgz/, but they were not reliably providing /gʌtʃəz/ for /gʌtʃ/. The important contribution of these studies was that children were not learning isolated forms, instead they were learning the rules for morphologically conditioned sound alternations, in this case allomorphs. In the wug-wugs type studies, children were shown to generalize a rule, however children also make errors by overgeneralizing a rule.

The English past tense has both a regular form (-ed) and irregular forms (e.g., run/ran; sing/sang/sung; drink/drank). The regular past marker is applied by rule, whereas the irregular forms are presumably stored separately in the lexicon. Evidence for this comes from two sources: Recently introduced lexical items into the language, and observations from children (Kim, Marcus, Pinker, Hollander & Coppola, 1994; Pinker, 1994). New lexical items, like "to fly out" in baseball, or "to nose-dive" result in regular past tense forms, "flew out" or "nose-dived". These examples provide evidence for regular past rule generalization.⁴ Even though they may contain items that have irregular past forms, they do not result in "flew out" or "nose-dove".

Children learning English have been found to go through several stages as they acquire the past tense forms. Children may be observed to produce correct irregular past forms, until they have identified and formulated a rule for

⁴ Another example is that infrequently used irregular verbs often become regular (e.g., strive/strove?/strived? or dive/dove?/dived? or swell/swoll?/swelled) through overgeneralization of the past tense rule.

the regular past form. Then, a child who once correctly said "I drank some juice" would say "I dranked some juice". The irregular form may not be recovered for some time (Pinker, 1994). Researchers have suggested that overregularizations in acquisition present a learnability problem because children must somehow backtrack from their erroneous productions without explicit negative evidence (e.g., adults often do not correct them when they make overgeneralizations). Children must learn that there is only one form.

Overgeneralizations are universal (Cairns, 1996), and there must be universal principles to overcome them. There are several related theories accounting for children's recovery from overgeneralizations: the uniqueness principle (Pinker, 1984; 1989), and the principles of conventionality and contrast (Clark, 1993). From a generative morphology perspective, Aronoff (1976) has suggested a blocking principle that operates in the lexicon, and which blocks production of **runned* when the lexical *ran* exists. In all of these accounts, the fundamental assertion is that children must come to the task of language learning knowing that one form has only one meaning. Therefore, children who make overgeneralizations will adhere to this constraint and eventually use only the correct adult form because a concept cannot be represented by two distinct forms; forms must be unique, and they must have different, contrastive meanings. Thus, in the adult grammar a form such as *teached* is blocked because there is already a lexically stored form *taught*. Once children have learned the conventional, adult form, they will stop overgeneralizing the regular past rule. They stop overgeneralizing because at some point they must notice

that they have two possible past tense forms for the same verb, and this conflicts with the uniqueness principle. Children then adopt the conventional form, which is also a lexically stored form, not one produced by a rule. Clark (1993) suggested that children who may have used correct irregular past forms prior to overgeneralizing the rule for regular past (e.g., the developmental sequence of go-went-goed-went) did not in fact have a fully analyzed representation of "went" in the first place. The children may have known that it had some motion-related meaning, but they did not know that it also encoded the past tense meaning. Following this hypothesis, the true developmental sequence of irregular past would be go-goed-went, whereby the conventional form, once it is learned, supercedes the erroneous form.

What do these principles have to say about acquisition of the stress alternations characteristic of rhythmic suffixes? These principles have yet to be applied to this aspect of morphophonological acquisition, (cf. Clark, 1994 for analysis of allomorphy). From a phonological perspective, English has two basic types of suffixes: neutral and rhythmic. The phonological rules underlying these suffixes are mutually exclusive; either a suffix is [+cyclic], like the rhythmic suffixes, or it's not, like the neutral suffixes. Children have to sort out which are which in much the same way that they must find systematicity in other areas of language.

We can assume that children have essentially mastered the stress rules for monomorphemic words and that they reliably assign primary stress by the time they are learning the derivational system. We can deduce this for several

reasons. First, there is ample evidence that infants are sensitive to prosody and word stress information in the speech stream (e.g., Jusczyk, 1997; Jusczyk & Aslin, 1995), that they are using this information in their early words (e.g., Echols & Newport, 1992; Wijnen, Krikhaar & den Os, 1994), and that they are acquiring stress and prosodic rules throughout the preschool years (Demuth, 1996; Gerken, 1994, 1996; Kehoe, 1997). Second, although there is evidence of spontaneous stress errors in children as young as 21 months old (Klein, 1984), by the time children are nearing their third birthday, stress errors on spontaneous and elicited words has significantly decreased (Kehoe, 1997). Finally, judgments of primary stress in children's productions dramatically improves through age four, as children become better at controlling the acoustic parameters (i.e., duration, frequency, and intensity) of stress (Pollock, Brammer & Hageman, 1993; Schwartz, Petinou, Goffman, Lazowski & Cartusciello, 1996). Thus, the cyclic rules for main stress assignment are in children's grammars by the time they enter school. These are the same rules used to assign stress in rhythmic derivations. However, what children must still learn is which suffixes trigger reapplication of the cyclic stress rules and which suffixes do not.

Children are exposed to noncyclic phonological rules in morphologically complex words, such as those for inflections, compounding, and some neutral suffixes (e.g., the agentive *-er*), earlier than they are to the cyclic rules characteristic of rhythmic suffixes. In addition, neutral suffixes and inflectional suffixes are semantically coherent and transparent; they have the same meaning in all contexts and the meaning of the whole is essentially the sum of the parts.

As such, noncyclic suffixes are easier to find and analyze than rhythmic suffixes. They are distributionally accessible both phonologically and semantically. Prior studies have shown that school-aged children are able to identify and to find stem words more easily in words with inflectional or neutral suffixes than with words with rhythmic suffixes (Gordon, 1989; Stotko, 1992; Tyler & Nagy, 1989; Windsor & Hwang, 1999), they also have been noted to accept (as correct) more overgeneralizations with neutral than with rhythmic suffixes (Stotko, 1992; Tyler & Nagy, 1989).

We now have two pieces of the puzzle in place. Children know the cyclic (rhythmic) stress assignment rules of their language but the preponderance of morphologically complex words that children hear are noncyclic, and consequently are not reassigned stress. Halle and Kenstowicz (1991) suggest that suffixes are marked [+/- cyclic] in the lexicon. Cyclicity is the distinguishing phonological feature differentiating the rhythmic and neutral suffixes. Suffixes marked [+cyclic], which includes all stress changing, rhythmic suffixes, establish a domain in which the cyclic rules may apply, or more accurately, re-apply. Thus, rhythmic suffixes that apply at Level 1, are marked [+cyclic] and neutral suffixes that apply at Level 2 (and inflectional suffixes that apply at a subsequent level) would be [-cyclic].

Considering that the bulk of suffixes young children are exposed to all have the same noncyclic [-cyclic] feature, I hypothesize that initially children assume that all suffixes share this feature. Essentially, children would overgeneralize the phonological rules for neutral suffixes to rhythmic suffixes.

Goldsmith (1990) suggests that because noncyclic, Level 2 type, phonological rules are less complex, they should be considered the default assumption. He argues that in

“...a cyclic and word-based approach to English stress assignment...what is crucial is the kind of juncture that is found between a base and a suffix; the default case is open juncture (*i.e.*, *Level 2, noncyclic rules*), since English adheres to a word-based morphology. Such a juncture does not cause restructuring of the metrical grid.” (p. 273, italics added).

Therefore, if [-cyclic] is the initial setting for all suffixes, then children will initially treat all suffixes as if they were [-cyclic] or stress neutral. However, as children learn the rhythmic suffixes that change stem stress, they must mark those suffixes as [+cyclic]. Furthermore, we could expect to see a course of development in which children gradually make fewer and fewer overgeneralizations as they learn which suffixes are [+cyclic].

Variables and Hypotheses

The purpose of this section is to isolate the variables and theoretically motivated predictions of the present study. The first question is whether or not there are differences in the phonological acquisition of suffixes that affect stem stress (i.e., rhythmic suffixes) and those that do not (i.e., neutral suffixes). The Lexical Phonology model presented in Figure 1 (p. 6) assumes that stems and suffixes have some degree of autonomy, and that derived words are composed within the lexicon. A derivation of a word involving a suffix that changes stem stress is more complex than a derivation of a word involving a suffix that does not. This is because the derived word must be identified as a cyclic domain (i.e., the suffix must be marked [+cyclic]), reanalyzed, then assigned stress in its entirety. In fact, developmental morphology studies show that children first acquire regular inflections (a post Level 2 process), then compound-formation and stress-neutral suffixes (e.g., agentive *-er*), which are noncyclical (or Level 2) processes (Becker, 1994; Selby, 1972). The cyclical, Level 1 derivational processes emerge last (Clark, Hecht & Mulford, 1986; Corson, 1997). Thus, it appears that children are working their way up the complexity ladder – from noncyclic to cyclic. In effect, children are starting with a noncyclic [-cyclic] assumption, and then learning that some suffixes create cyclic [+cyclic] domains. Therefore, the hypothesis is that children will acquire the noncyclic derivational rules before the cyclic derivational rules. Specifically, if children assume [-cyclic] for all derivations, then we should see fewer stress errors with neutral than with

rhythmic derivations. Furthermore, the types of stress errors on rhythmic derivations are predictable. If all suffixes are treated as noncyclic, then children will retain the original stem stress in the derivation.

The second question addresses whether there is an observable progression of mastery of the rhythmic and neutral suffixes. This could be exhibited by improvement as a function of age or overall language and cognitive development. Younger children may not have distinguished between the two types of suffixes as well as older children, and they may make more errors. We would expect to see a gradual progression of mastery in either perception or production or both as children not only learn that some suffixes are cyclic and change stem stress, but also which suffixes in the language are cyclic.

By examining real words and nonsense words with English suffixes, the difference between primary stress assigned by a productive rule and stress stored with a lexical entry can be determined. If children know that rhythmic suffixes require stress reassignment to the whole unit, then no differences should be observed between real and nonsense words. Conversely, if English words and their derived forms are stored in the lexicon independently, then more stress errors should be seen with the derived nonsense words than with the real words. Thus, on this hypothesis "activity" would be stored separately from "active" and produced with stress correctly on the pre-suffixal syllable, whereas a nonsense derived word, like "lulufity", may be produced with primary stress somewhere other than on the presuffixal syllable (e.g., LUlufity) because it has no lexical entry.

Another factor to consider is suffix frequency. Children have been found to be sensitive to the amount of evidence they receive. For example, Tardif, Shatz and Naigles (1997) found that caregiver speech to young children learning English included more nouns (types and tokens) than verbs, whereas the Mandarin speaking children heard more verbs than nouns from their caregivers. This corresponds to the vocabularies of the children. English speaking children had a noun bias, while Mandarin speaking children had a verb bias. Thus, there was a correspondence between the input the children received and their word learning.

In a similar way, suffix frequency may affect children's familiarity with a given suffix, and by extension, their ability to make a derivation with that suffix. Less frequent suffixes may not exhibit the same regularity in children's performance as more frequent ones. Mastery of suffixation, and the related phonological rules associated with suffixes, may not occur all at once, but rather may reflect the amount of input that the child receives. Potentially, this may be true for both rhythmic and neutral suffixes. However, if the prediction that all suffixes are initially [-cyclic] is correct, then children may do equally well with all the neutral suffixes, leaving the rhythmic suffixes to be influenced by distributional properties. In this study, rhythmic and neutral suffixes were matched for frequency across suffix type (i.e., rhythmic and neutral) as much as possible. The frequency of suffixes within each suffix type were not varied; therefore, within each suffix type we may see suffix frequency effects. Thus,

according to this hypothesis, children should make fewer errors on items with the more frequent and familiar suffixes than with the least frequent suffixes.

Unlike much of the previous developmental work on derivational morphology, this study aims to isolate the phonological stress rules at the intersection of morphology and phonology within the lexicon. Four predictions were made in this chapter. First, if children assume that all suffixes are [-cyclic], then words with neutral suffixes will be more accurate than words with rhythmic suffixes. Furthermore, the errors children make on words with rhythmic suffixes will be that they do not reapply the stress assignment rules, which change the stem stress. The second prediction was that children's performance will improve with age, indicating that they are learning the stress rules associated with rhythmic suffixes. Third, if children are learning a rule, then there should be no difference between stress assignment on real derivations and nonsense derivations. Conversely, if children are storing stress with a lexical entry, then we can expect to see a lexical effect whereby children would perform better on real derivations than on nonsense derivations. The last prediction concerned the frequency of individual suffixes in child-directed English. This prediction has less to do with the acquisition of phonological rules than with which, and in what order, suffixes are marked as [+cyclic].

To investigate these questions, a cross-sectional study with seven-, eight-, and nine-year old children was designed using both perception and production tasks. Both tasks included rhythmic and neutral suffixes on real and nonsense words. I will return to the production and perception experiments in

more detail, but first the issue of suffix frequency must be addressed. In order to control for suffix frequency, a preliminary study was conducted to ascertain relative suffix frequencies in children's literature.

CHAPTER 3: PRELIMINARY STUDY

DISTRIBUTION OF SUFFIXES IN CHILDREN'S LITERATURE

To examine derivational suffixes, the relative familiarity of the suffixes needed to be determined. Children may be more familiar with certain suffixes, and hence certain stress pattern alternations, because those suffixes occur with greater frequency in English. In a lexical decision task with adults, Cole, Beauvillain & Segui (1989) found a facilitation effect of suffix frequency in French. Reaction times were faster for a stem plus a frequent suffix than for the same stem plus a less frequent suffix. Thus, it is plausible that suffix frequency in English may affect children's processing and productions as well. Furthermore, the suffixes that children hear more frequently would also be more familiar to children. This may also affect the rate at which suffixes and their rules are learned.

Despite the availability of English word frequency analyses (e.g., Francis & Kucera, 1982; Carroll, Davies & Richman, 1971), there is no published analysis of the frequency of bound morphemes in English. Although frequencies for monomorphemic stem words and derived forms of the same stem are available in Francis & Kucera, the frequency listings are not suffix specific. We cannot easily determine the distribution with which derivational suffixes occur relative to each other. Furthermore, there are no frequency data for morphemes that children would be exposed to.

As part of her dissertation, Mathews (1998) examined a corpus of 13,527 words from adult literature consisting of newspapers, books, and magazines. She then counted derivational suffixes, regardless of the stem word, and rank ordered them according to proportional representation within her sample corpus. Although this was a step in the right direction, Mathew's data may not reflect the appropriate frequency distribution of the suffixes to which children are exposed. To determine the rank order frequency of derivational suffixes that children could be expected to know, a corpus of children's literature was examined.

Methods and Results

Four children's books, appropriate for children ages 7-12, were included in the analysis. Two of the books were non-fiction and two were fiction. The total words in the corpus were estimated by counting the number of words in the first five lines of text, then averaging those five lines to get the average words per line. The number of lines contained in each book were counted then multiplied by the average words per line. Of the estimated 24,680 total words in the corpus, 13,513 were from non-fiction and 11,167 were from fiction. The literature was culled for words with suffixes. The derived words were then sorted and tallied by suffix.

The results are illustrated in Table 4. Following Mathews, the suffix *-ly* was not included in the distribution because it is controversial whether this is a derivational or inflectional suffix (Bybee, 1985). Bybee argued that inflections are

obligatory and unique (i.e., no possible substitutions). In fact, *-ly* is the only adverbial ending on adjectives, and it applies obligatorily. If it were included in the frequency analysis, the *-ly* suffix would have easily outranked all other suffixes (N=178).

The total number of derivations was 898: 691 from non-fiction and 207 from fiction. For words containing more than one derivational ending, all were counted individually with the rationale that they all would have to be processed by children. Therefore, in a word like "gratefulness" both "-ful" and "-ness" would be counted separately. Words with multiple derivational morphemes (including *-ly*) accounted for 13.25% (total: 119) of all suffixed words (non-fiction: N=92; fiction: N=27).

Table 4. Rank order of suffixes from corpus of children's literature (ages 7-12)

total words in corpus (estimate): 24,680

total derivations (suffixes): 898

percentage of suffixed words: 3.64%

Rank	Suffix	Non-Fiction	Fiction	All Total	%
1	-TION + all variations	104	18	122	13.59
2	-AL -IAL	79	12	91	10.13
3	-ER agent + instrum.	64	21	85	9.47
4	-Y	45	30	75	8.35
5	MENT	49	10	59	6.57
6	-OUS -IOUS	35	16	51	5.68
7	-ANT -ENT	36	14	50	5.57
8	-AN -IAN	47	1	48	5.35
9	-AR -OR	28	15	43	4.79
10	-ANCE -ENCE	23	7	30	3.34
11	-ITY	25	3	28	3.12
12	-ABLE -IBLE	19	5	24	2.67
13	-ATE	21	1	22	2.45
13	-FUL	9	13	22	2.45
14	-IVE	17	0	17	1.89
15	-ICE -ISE	10	6	16	1.78

Rank	Suffix	Non-Fiction	Fiction	All Total	%
16	-IC	11	2	13	1.45
16	-EN	9	4	13	1.45
17	-SHIP	9	2	11	1.22
17	-URE	4	7	11	1.22
18	-NESS	5	5	10	1.11
19	-ERN	8	0	8	.89
19	-AGE	8	0	8	.89
19	-IZE	5	3	8	.89
21	-LESS	3	3	6	.67
22	-ISM	5	0	5	.56
22	-ARY	2	3	5	.56
23	-TH	2	2	4	.45
24	-ITE	0	3	3	.33
24	-IST	3	0	3	.33
25	-ISH	1	1	2	.22
25	-CRACY	2	0	2	.22
26	-IDE	1	0	1	.11
26	-HOOD	1	0	1	.11
26	-IFY	1	0	1	.11
		77.03	22.97		99.99
		691	207	898	

Table 5 contrasts the first 15 suffixes ranked in the adults' (from Mathews, 1998) and children's corpora, and the percentage of each suffix among all suffixes. The first three suffixes are identical. All but three suffixes are included in both lists. The suffixes ranked in the top 15 that do not appear on the adult's list are: *-able/-ible*, *-ful*, and *-ice*, and those on the adults' but not the children's list are: *-age*, *-ic*, and *-ist*.

Table 5. Comparison of Rank Orders of Suffixes from Children's versus Adult's Literature.

Rank	Children's Suffix	%	Adult's Suffix	%
1	TION	13.60	TION	12.55
2	AL/IAL	10.14	AL/IAL	10.75
3	ER	9.48	ER	10.29
4	Y	8.36	ANT/ENT	6.36
5	MENT	6.58	ATE	5.24
6	OUS/IOUS	5.69	AR/OR	5.05
7	ANT/ENT	5.57	ITY	4.68
8	AN/IAN	5.35	MENT	4.30
9	AR/OR	4.79	ANCE/ENCE	3.55
10	ANCE/ENCE	3.34	Y	3.46
10			AGE	3.46
11	ITY	3.12	IC	2.99
12	ABLE/IBLE	2.68	OUS/IOUS	2.62
13	ATE	2.45	AN/IAN	2.43
13	FUL	2.45		
14	IVE	1.90	IST	2.34
15	ICE/ISE	1.78	IVE	1.96

Interestingly, the first two derivational suffixes (*-tion* and *-al*), which account for 23.7% of all derived words in the children's data, affect stem stress.

The suffix *-tion* requires stress to fall on the syllable before the suffix (i.e., stress is reassigned to the entire derivation following the English stress rules). The suffix *-a/* is quantity sensitive and will shift stress to the syllable before the suffix if it is heavy (Katamba, 1989)⁵. The suffixes ranked 3 through 5 from the children's corpus (24.39% of total corpus) never change the stem word's stress. Thus, almost a quarter of the most frequent derivational suffixes in books directed toward children change stress, whereas another quarter do not.

Conclusion

We do not know whether derivational suffix frequency, and by extension suffix familiarity, affects acquisition. Therefore, it becomes a variable to control or manipulate. Whole word frequency has been established as an important factor in examinations of adult morphological processing, and in other areas of lexical processing (Bradley, 1980; Cole, Beauvillain & Segui, 1989; Forster, 1990; Seidenberg, 1989; Taft & Forster, 1975). It is plausible that suffix frequency may also contribute to processing. The compilation and ranking of suffixes found in children's literature was a necessary precursor to the study that follows. It is now possible to design stimuli with suffix frequency controlled across the two suffix types.

⁵ Recall that syllable weight is determined by the internal structure of the syllable. A heavy syllable has either a final consonant or a long, tense, or diphthongized vowel. A light syllable has no final consonant and contains a short or lax vowel. For example, in the derived word *accidental* stress falls on the presuffixal syllable because it is a closed CVC syllable. In contrast, a word such as *classical* does not have presuffixal stress because resyllabification of the derived word changes the syllabic structure, producing a light, and un-stressable, syllable in the presuffixal position. This becomes clearer as each syllable is produced in isolation for these two examples (N.B., bold type indicates primary stress): /æ.k.sɪ.**dɛn**.təl/ versus /klæs.sɪ.kəl/.

CHAPTER 4: PRODUCTION EXPERIMENT

ELICITED PRODUCTION

The variables and hypotheses of the study were discussed previously.

What follows is a brief restatement of those hypotheses, and what this particular experiment was designed to achieve. The goals of this experiment were fourfold:

- 1) To establish whether children's ability to accurately produce primary stress on derived words differs as a result of the suffix type. Words with neutral suffixes were predicted to be more accurate than words with rhythmic suffixes.
- 2) To determine whether a developmental progression of mastery is observable for either or both of the suffix types. Children's stress assignment accuracy was expected to improve, particularly for the rhythmic derivations as children learn that rhythmic suffixes produce a cyclic domain.
- 3) To learn whether children lexically store stress patterns or assign them by rule. If children perform better on real derived words than on nonsense derivations, then stress may be stored lexically. If no difference is apparent between real and nonsense words, then it is reasonable to conclude that stress is assigned by rule.
- 4) To determine whether there are individual differences among the rhythmic or neutral suffixes as a function of suffix frequency. Children may be more accurate producing words with suffixes that they have had more experience with, as measured by the frequency ranking in the children's literature corpus.

General Method and Procedure

Both the perception and production experiments were conducted in the same session with the same children; however, for clarity, the results of the two experiments will be presented separately. Participants were seen individually by the experimenter in a quiet room. All children completed testing in one session lasting approximately thirty minutes, which included the production experiment, the perception experiment, and completion of the Title Recognition Test (TRT). The TRT was designed by Cipielewski & Stanovich (1992) as a measure of reading experience through familiarity with children's books, and was used as a gross reading measure for the purposes of this study. The results of the TRT can be found in Appendix N.

Participants

Children

Fifty-two children participated in the study: 26 girls and 26 boys. The children were grouped according to age. Group 1 consisted of 19 children (12 girls and 7 boys) with a mean age of 7;2 (years; months), and an age range of 6;6 to 7;9. Group 2 contained 18 children (8 girls and 10 boys) with a mean age of 8;4 and a range of 7;10 to 9;0. Group 3 was composed of 15 children (6 girls and 9 boys) with a mean age of 9;8 and a range of 9;1 to 10;6. Four other children were tested, but not included in the analyses because they failed to meet the pre-test training criteria (see below for more details on the training procedure).

The children's participation was solicited with the cooperation of an elementary school in rural Massachusetts. Participation was contingent upon written parental consent and verbal assent of the child. One child declined to participate.

Parents were requested to fill out a voluntary questionnaire on their child's reading habits, their own educational level, and whether or not their child had a history of speech, language, or hearing problems. A summary of the questionnaire data can be found in Appendix O. No child was reported to have a hearing impairment; however, five children had received speech therapy, one had an early language delay, and one was diagnosed with dyslexia. Only the latter child failed the practice/training criteria; her data were not included in further analyses. All children included in the study were judged by their teachers to be performing appropriately for their age and grade.

Adults

An adult group was necessary to determine the acceptability of the stimuli and tasks, as well as to establish a performance ceiling. The participation of ten adult volunteers (mean age 36) was solicited directly. The tasks and procedures used with adults were identical to those for children. The adult's results appear in Appendix A, and also in the Tables of children's data for comparison, where appropriate. It should be noted that the adults were tested on an earlier version of these tasks. The procedure was identical; however, the pilot stimuli for the production experiment were slightly different (i.e., two words changed) from the stimuli used in the current study. These changes are noted.

Method: Production Study

Procedures

Practice

Participants were told that their help was needed to understand how people learn to make words. The experimenter explained how some words can be broken down into pieces. Children practiced making real derived English words that were familiar to them. For example, children were asked to put '-er' on the end of 'work' to get 'worker'; '-ous' to 'poison' to get 'poisonous'; '-al' to 'accident' to get 'accidental'. Suffixes included in the practice stimuli were not included in the experiment, and stem stress changes occurred with the addition of some of the suffixes (see Appendix B for the practice stimuli). Feedback and correction, when needed, were provided after each derived word. Children's data were included in further analyses only if seven out of ten practice derivations were accurately produced. Three children did not pass this criterion, and their data were excluded from further analyses. All of those children were judged by their teachers to have reading abilities below grade average.

Experiment

After the practice trials, participants were told that they would hear some more words. They were told that the first group of words would be English words that they may have heard before, and that the second group of words would be unfamiliar, "made-up" words (i.e., nonsense words). The children were instructed to add the endings on all of them, just like we had practiced. Children were

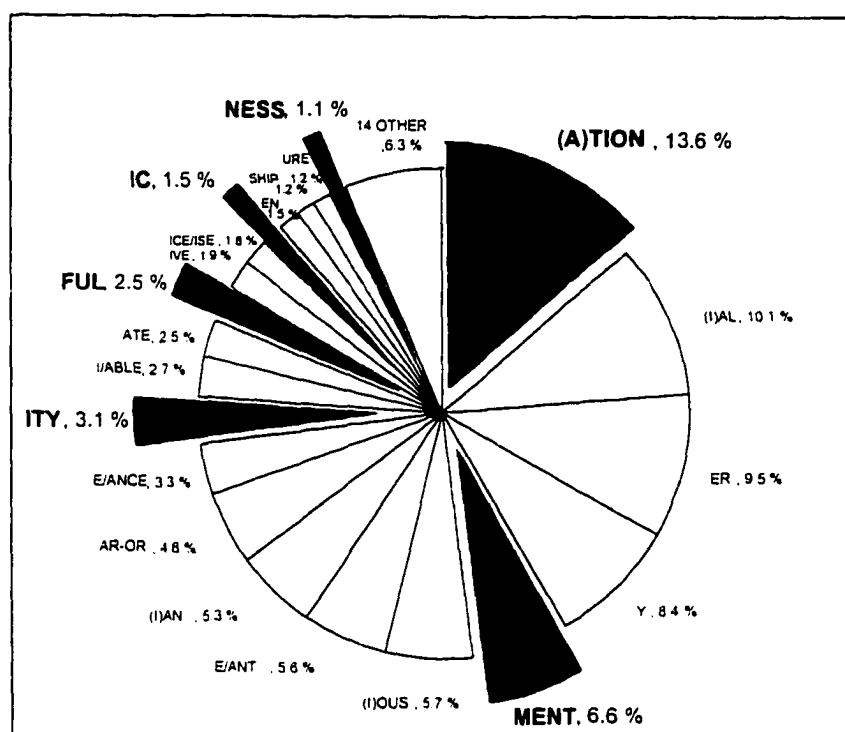
allowed to ask for repetitions of the stimulus word and suffix as needed. All stimuli were presented orally by the experimenter, and all responses were audiotaped for later transcription.

Stimuli

Suffixes

Six suffixes were included in the study. The three rhythmic suffixes that force stress reassignment were *-tion*, *-ic*, and *-ity*. The three neutral suffixes were *-ment*, *-ful*, and *-ness*. Suffixes were chosen and matched based on relative frequency in the children's literature corpus discussed in Chapter 3. The suffixes *-tion* and *-ment* were ranked in the top five most frequently occurring suffixes, *-ity* and *-ful* were ranked between the 10th and 15th most frequent, and *-ic* and *-ness* were ranked between the 16th and 20th most frequent suffixes. Thus, high, mid, and less frequent suffixes are represented in the stimuli. The graph in Figure 5 illustrates the contribution (in percent) of each of the suffixes to the total suffix corpus, and shows the frequency of these suffixes relative to each other.

Figure 5. Suffix Frequency Distribution in Children's Literature.



The suffixes used in this study are indicated by the darker slices of the pie graph.

Real words.

Twenty-two English words were included. Twelve stem words were two-syllables in length and ten were three-syllables. Words containing stems of two and three syllables were included in this study to control for the possibility that children would find words with fewer syllables easier to produce than longer words. There is a discrepancy between the total number of two- and three-syllable stem words because there are no three-syllable words that accept the suffix *-ful*. Except for *-ful*, each suffix was represented twice per syllable length. Thus, each suffix was represented four times for real words, and *-ful* was presented twice. To control for potential stem differences, all stems could stand

alone as free morphemes. When possible, the complete derived real word was present in the children's literature corpus. Four words were present in the corpus in the stem form only: curious, nervous, exclusive, and microscope. The real and nonsense word stimuli are presented in Table 6.

Novel words.

The nonsense words were matched as closely as possible to the real words. Twelve two-syllable and ten three-syllable stems were created. Each suffix was represented twice for both word lengths, as with the real words. Examples of nonword and rhythmic suffixes are as follows: 'gopate' + '-tion'; 'luluf' + 'ity'; 'gilsep' + '-ic'. The non-words were created such that they did not violate English phonotactic rules. The manner of the final consonant in the non-word stem mirrored that of the real words. For example, if a real-word stem ended in a continuant or a stop, a non-word stem did also. This was to ensure that the non-words were acceptable forms for the suffixes to attach to. Syllable stress was balanced across the word conditions; the non-word stems mirrored the real words. Therefore, if a real word had a trochaic or iambic stem stress, the non-word had the same stress pattern.

Table 6. Production Stimuli.

Word Stem				
Rhythmic Suffix	Real words		Nonsense words	
	2 syll.	3 syll.	2 syll.	3 syll.
-tion	vacate - vacation rotate - rotation	execute - execution celebrate - celebration	gopate - gopation naybate - naybation	blimefet - blimefation trebumate-trebumation
-ic	artist - artistic metal - metallic	alphabet - alphabetic microscope - microscopic	rebef - rebefic gilsep-gilsepic	neshigit - neshigitic fusakap - fusakapic
-ity	active - activity noble - nobility	personal - personality curious - curiosity	luluf - lulufity komir-komirity	spedimil - spedimility drefunis - drefuniversity
Neutral Suffix				
-ment	amaze - amazement punish - punishment	develop - development entertain-entertainment	kirdush-kirdushment nabez - nabezment	shefunip-shefunipment tevoulant-tevoulantment
-ness	forgive - forgiveness nervous-nervousness	serious-seriousness exclusive- exclusiveness	libef - libefness chefris - chefrisness	meklitus-meklitusness gawletref- gawletrefness
-ful	power - powerful success - successful		doomer - doomerful pawius - pawiusful	

Pseudorandomized lists were generated for the real words and novel words independently, such that words with the same suffix never appeared consecutively. The two lists were presented separately, with the real words always presented first.

Scoring

Children's productions were recorded on audiotape and transcribed for primary stress by the experimenter. Only primary stress was considered in this experiment; errors involving consonant or vowel change were not counted against a child if the stress fell on the correct syllable. For example, if a child produced the word "microscopic" as /majkroskOPik/ instead of /majkroskAPik/ the item was still counted as correct for stress shift. A second transcriber

transcribed the productions of five randomly selected participants (subjects 102, 105, 201, 301, and 309). Disagreements about the location of primary stress were settled by having the two transcribers listen to the contested items in each other's presence.

The percentage of transcriber agreement was calculated across the five children, for each child individually, and for the real and nonsense words separately and collapsed. Transcription and agreement were based solely on primary stress placement. Other factors such as secondary stress, vowel or consonant agreement were not considered in the calculation of agreement between the two transcribers. Table 7 presents the percentage of primary stress agreement between the two scorers, which includes both correctly and incorrectly stressed productions. The number of items that were not agreed upon are presented in parentheses next to the agreement percentage. The distribution of the items that were scored differently is as follows: one was a real word suffixed with *-tion*, two were real words suffixed with *-ic*, one was a real word suffixed with *-ity*, four were nonsense words suffixed with *-ity* (from subjects 201 and 303), and one was a real word suffixed with *-ness*. Despite these disagreements, overall agreement across the real and nonsense words and the five children scored was considered acceptable at 95.9%.

Table 7. Primary Stress Scoring Reliability.

Subject	Group	Real Words	Nonsense Words	All Words
		(N=22)	(N=22)	(N=44)
102	1	95% (1)	95% (1)	95% (2)
105	1	95% (1)	100% (0)	95% (1)
201	2	100% (0)	91% (2)	95 % (2)
301	3	95% (1)	91% (2)	93% (3)
309	3	95% (1)	100% (0)	98% (1)
Total Disagreements		4	5	9
Overall Percent Agreement		96.4 %	95.5%	95.9 %

The columns illustrate the percent agreement between the two transcribers for each child. The number of disagreements for each child and each word type are indicated in parentheses.

Results

The results were analyzed four ways. The overall analysis examines differences in production accuracy across age, suffix type, and word type. The next series of analyses examined suffix differences within each suffix type. Two ANOVAs were computed separately for the rhythmic (*-tion*, *-ic*, and *-ity*) and the neutral (*-ment*, *-less*, and *-ful*) suffixes. An item analysis determined whether differences existed among the individual real and nonsense word stems. The final analysis examines individual subject performance and error patterns.

Analysis 1: Overall Analysis

The derived-word productions with correct stress were tallied and the mean, standard deviation, and mean proportion correct calculated. For words with rhythmic suffixes, correct stress always fell on the presuffixal syllable. Primary stress in neutrally suffixed words was the same as the stem stress. Recall that each participant produced 24 words with rhythmic suffixes, and 20 words with neutral suffixes. Because the total number of items for each suffix type was not equal⁶, I will show and compare mean proportions correct rather than raw value means. The results in Table 8 show mean proportions and the standard deviations of those proportions for correct primary stress production across groups and suffix type. Means for the raw data are available in Appendix C.

⁶ This is due to the unfortunate fact that languages do not always provide perfectly symmetrical paradigms. The suffix *-ful* does not occur on stem words of more than two syllables.

Table 8. Mean Proportion Correct Derived-word Productions.

Suffix		Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)	
		real stem	nonsense	real stem	nonsense	real stem	nonsense
Rhythmic	<u>M</u>	.34	.32	.59	.53	.78	.73
	<u>SD</u>	.28	.19	.19	.25	.13	.21
Neutral	<u>M</u>	.98	.96	.98	.94	.97	.97
	<u>SD</u>	.03	.04	.08	.08	.05	.05

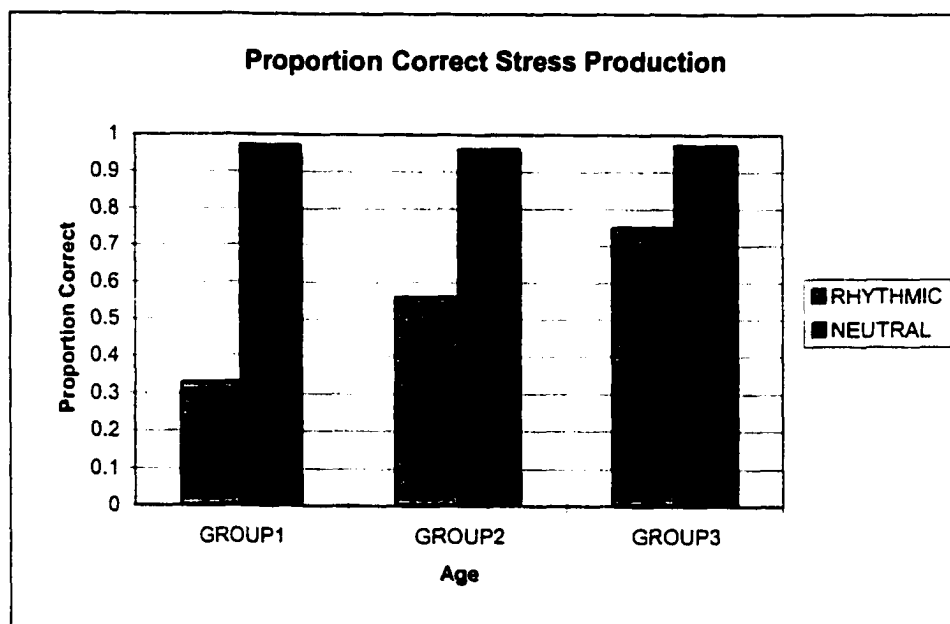
Performing further statistics on proportions is problematic because, like regression, analysis of variance assumes a linear relationship among variables. Proportions cannot exceed a value of one nor go below a value of zero. These limits produce a nonlinear sine curve. Nevertheless, proportions can be re-scaled using an arcsine transformation ($2 * (\arcsin(\sqrt{X}))$) to stretch the upper and lower limits of the sine curve, thus making these data appropriate for linear statistics. All correct stress proportion data were transformed prior to statistical analysis, however all charts and tables in this paper will present the untransformed proportions.

Prior to further analyses, a 2-way ANOVA was used to rule out syllable length of the stem words as a contributing factor. The mean proportion of correct responses for each stimulus item was calculated for each group, and transformed as indicated above. Then the items were categorized as having either 2- or 3-syllable stems, regardless of word (real vs. nonsense) or suffix type (rhythmic v. neutral). Thus, syllable length became the independent grouping variable, and the group responses became the dependent variable. No syllable effect was found, $F(1, 42) < 1$, nor was there an interaction between syllable

length and group, $F(2, 84) = 1.17, p = .31$. A main effect of age (group) was obtained, $F(2, 84) = 28.81, p < .0001$. Syllable length was collapsed for all other analyses.

A 3 x 2 x 2 ANOVA was performed on transformed proportion data. Detailed ANOVA results appear in Appendix C. Main effects were obtained for age, (7-, 8-, and 9-year old children), $F(2, 49) = 18.29, p < .0001$, and suffix (rhythmic vs. neutral), $F(1, 49) = 222.95, p < .0001$, but not for word (real vs. nonsense), $F(1, 49) = 3.21, p = .08$. The age X suffix interaction was significant, $F(2, 49) = 12.75, p < .0001$, due to the ceiling level performance for all ages with the neutral suffixes but a gradual improvement with the rhythmic suffixes. There were no interactions for age or suffix with word, $F(1, 49) < 1$. Because there were no differences between the real and nonsense words for any group, word type was collapsed for both types of suffixes. Figure 6 depicts the proportion of correct stress production by age and by suffix.

Figure 6. Proportion Correct Stress: Collapsed across Word type



Planned comparisons, using an L coefficient that calculated the weighted sum of means, compared the results within and between age groups and suffix types using contrast analysis. Within each age group, correct stress production on neutral suffixed words was significantly better than rhythmic suffixed words. The suffix contrast (rhythmic vs. neutral) for each group is as follows: Group 1 (7 years old), $F(1, 49) = 169.88$, $p < .0001$; Group 2 (8 years old), $F(1, 49) = 70.74$, $p < .0001$; Group 3 (9 years old), $F(1, 49) = 24.24$, $p < .0001$.

In the comparisons between each of the groups, ceiling level performance was observed on the neutral derivations; however, for the rhythmic suffixes all group contrasts were significant. The contrasts between groups for the rhythmic suffixes are as follows: Group 1 v. Group 2, $F(1, 49) = 10.81$, $p = .002$;

Group 1 v. Group 3, $F(1, 49) = 34.13$, $p < .0001$; Group 2 v. Group 3, $F(1, 49) = 7.17$, $p = .01$.

Summary of Analysis 1

These data show that production of words derived with rhythmic suffixes improves as a function of age; older children produce words with correct main stress more often than younger children. Furthermore, all children have more difficulty producing correct main stress on words with rhythmic suffixes than with neutral suffixes. Children across the three age groups are proficient with neutral suffixes. The predominant stress error that children make on rhythmic derivations is that they maintain the stem stress, regardless of whether the stem is a real or nonsense word. In essence, they are treating rhythmic suffixes as if they were neutral suffixes. This error decreases over time as children acquire the cyclic stress rule associated with rhythmic suffixes. Finally, the lack of a word type effect suggests that children are learning a rule, not memorizing each word with its stress pattern, because children perform as well with nonsense stems as they do with real word stems. There is a robust and observable progression of mastery of the stress rules associated with rhythmic suffixes.

In the analysis that follows, the individual suffix tokens will be examined to determine if any one of the suffixes was more likely to elicit an accurately stressed derivation than another.

Analysis 2: Individual Suffix Token Comparisons

Correct scores for each token within both suffix types (rhythmic and neutral) were tallied by age group, word type (real and nonsense), and individual suffix token (*-tion*, *-ic*, and *-ity* for the rhythmic suffixes; *-ment*, *-ness*, and *-ful* for the neutral). Two separate analyses were done: one for the rhythmic suffixes and one for the neutral suffixes. For the rhythmic suffixes, a 3-way repeated-measures ANOVA was used to evaluate the between-subjects variable age (3 levels), and the within-subjects variables word (2 levels) and suffix type (3 levels). The results for the rhythmic and neutral suffixes are reported separately.

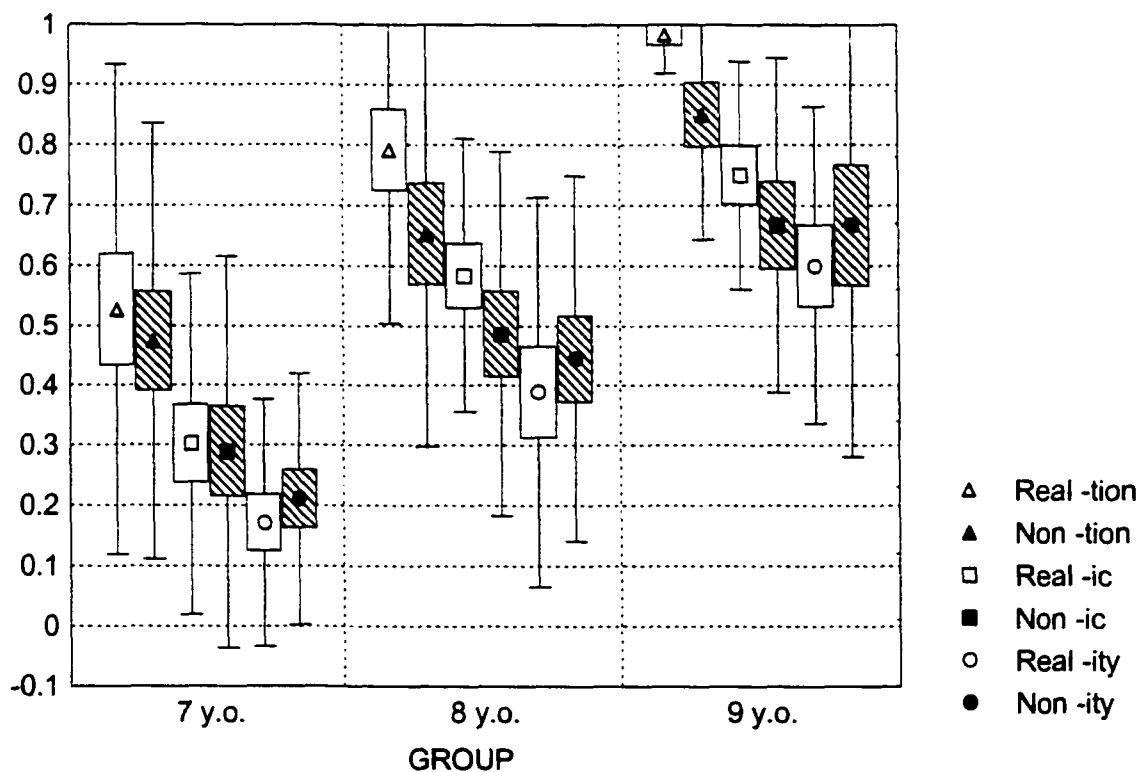
Rhythmic Suffixes

The proportions correct and standard deviations for each of the rhythmic suffixes are presented in Table 9, and are illustrated in Figure 7. The raw values appear in Appendix E.

Table 9. Individual Rhythmic Suffix Mean Proportions and Standard Deviations.

Rhythmic Suffix		Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)		TOTAL	
		real stem	nonsense	real stem	nonsense	real stem	nonsense	real stem	nonsense
-tion	<u>M</u>	.526	.474	.792	.653	.983	.850	.750	.644
	<u>SD</u>	.407	.205	.288	.355	.065	.207	.350	.351
-ic	<u>M</u>	.303	.289	.583	.486	.750	.667	.529	.466
	<u>SD</u>	.284	.326	.227	.303	.189	.278	.230	.336
-ity	<u>M</u>	.171	.211	.389	.444	.600	.667	.370	.423
	<u>SD</u>	.205	.209	.323	.304	.264	.386	.315	.348
TOTAL	<u>M</u>	.333	.325	.588	.528	.778	.728	.550	.511
	<u>SD</u>	.260	.190	.195	.250	.129	.215	.273	.292

Figure 7. Mean Proportions Correct of Individual Rhythmic Suffixes by Word Type and Age Groups.



A 3 X 2 X 3 ANOVA was performed on the transformed proportions, with age, word type, and rhythmic suffix tokens as the variables. ANOVA results appear in Appendix F. There was a main effect of age, $F(2, 49) = 17.33$, $p < .0001$, and a main effect for suffix, $F(2, 98) = 44.79$, $p < .0001$. There was no main effect of word type, but there was a significant interaction between word and suffix, $F(2, 98) = 4.23$, $p = .02$. Further contrasts by age, word type, and suffix token are presented separately.

Age Group Contrasts

Planned comparisons between the groups revealed significant differences between all age groups: Group 1 vs. Group 2, $F(1, 49) = 11.40$, $p = .001$, Group 1 vs. Group 3, $F(1, 49) = 34.08$, $p < .001$, Group 2 vs. Group 3, $F(1, 49) = 6.71$, $p = .013$. The children in Groups 2 and 3 were more accurate at producing accurate stress than the children in Group 1, and the Group 3 was more accurate than Group 2. Further planned comparisons for word type and suffix token were computed on each group individually.

Word Contrasts

For Group 1 (7-year olds), there were no significant differences between real and nonsense words for any of the three rhythmic suffixes, $F(1, 49) < 1$. Because of this, word type was collapsed for Group 1 when contrasting the individual suffixes.

Group 2 (8-year olds) and Group 3 (9-year olds) had similar word type results. Neither group showed significantly different correct productions on real and nonsense words suffixed with *-ic* and *-ity*, $F(1, 49) < 1.0$. However, the word X suffix interaction was determined to be due to differential treatment of real and nonsense *-tion* derivations by Groups 2 and 3. Both groups performed better on real words suffixed with *-tion* than with nonsense words suffixed with *-tion*: Group 2, $F(1, 49) = 4.52$, $p = .039$; Group 3, $F(1, 49) = 4.68$, $p = .035$. This suggests that there may be a lexical effect for the two older groups with only the *-tion* derivations.

Rhythmic Suffix Contrasts

Source tables for the following suffix contrasts appear in Appendix G. For Group 1, word type was collapsed because no difference between real or nonsense stem derivations, for any of the three rhythmic suffixes, was found. When contrasting the three suffixes, significant differences were found between the suffix *-tion* and the other two suffixes: *-tion* vs. *-ic*, $F(1, 49) = 17.16$, $p < .001$; *-tion* vs. *-ity*, $F(1, 49) = 22.41$, $p < .001$. The 7-year old children appeared to produce *-ic* derivations more accurately than *-ity* derivations, however the difference between *-ic* and *-ity* did not reach statistical significance, $F(1, 49) = 3.13$, $p = .08$.

The word contrasts for *-ic* and *-ity* derivations were not significant for Groups 2 and 3, therefore, real and nonsense words were collapsed for those two suffixes. The contrast between *-ic* and *-ity* was not significant for Group 3,

$F(1, 49) = .63$, $p = .43$. However for Group 2, correct responses were significantly greater for *-ic* than for *-ity*, $F(1, 49) = 3.99$, $p = .05$.

Because the word contrasts for *-tion* derivations were significant – Group 2 and Group 3 performance was better for the real than nonsense words suffixed with *-tion* – the suffix contrasts were calculated separately for each word type. The differences between *-tion* and *-ic*, and *-tion* and *-ity* for both real and nonsense words were significantly different for Group 2, $F(1, 49) > 7$, $p < .01$. For Group 3 (9-year olds), real words ending in *-tion* had significantly more correct productions than real *-ic* or *-ity* derivations, $F(1, 49) = 16.69$, $p < .001$ and $F(1, 49) = 27.74$, $p < .0001$ respectively. The nonsense word contrast for Group 3 between *-tion* and *-ic* was significant, $F(1, 49) = 8.8$, $p = .005$, but the contrast between *-tion* and *-ity* was not, $F(1, 49) = 3.1$, $p = .084$

These results show that despite the consistent improvement with age, stress production of words suffixed with *-tion* was more accurate than with the other two rhythmic suffixes. This was true for all age groups. Furthermore, main stress on real word *-tion* derivations was produced more accurately than stress on nonsense words suffixed with *-tion* for the eight- and nine-year old children. This suggests that there may be a lexical effect, at least for *-tion* derivations.

Neutral Suffixes

As Table 10 illustrates, children performed between 89 to 100% accuracy for all neutral suffixes attached to either real or nonsense words. The raw score averages appear in Appendix H. This suggests that performance reached a ceiling and was stable and accurate despite minimal differences. Given the high

levels of accuracy for all age groups, further statistical analyses were not appropriate. Nevertheless, there appears to be something different about the *-ness* derivations compared to either the *-ment* or *-ful* derivations.

Table 10. Individual Neutral Suffix Mean Proportions and Standard Deviations.

Neutral Suffix		Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)	
		real stem	nonsense	real stem	nonsense	real stem	nonsense
-ment	<u>M</u>	1.0	1.0	1.0	.99	1.0	1.0
	<u>SD</u>	0	0	0	.06	0	0
-ness	<u>M</u>	.95	.92	.94	.89	.93	.93
	<u>SD</u>	.10	.15	.14	.15	.11	.11
-ful	<u>M</u>	1.0	.97	1.0	.94	.97	1.0
	<u>SD</u>	0	.11	0	.24	.13	0

Further inspection of the stimulus items revealed that, of the *-ness* suffixes, all errors involved a stress shift to the presuffixal syllable, and almost all errors occurred on the same items: meklitusness; seriousness; nervousness. The next analysis will evaluate these differences further.

Summary of Analysis 2

In summary, suffix frequency may affect accurate stress assignment. Words with the most frequent suffixes, *-tion* and *-ment*, were often produced correctly. However, suffix frequency does not appear to affect the neutral derivations as much as it does the rhythmic derivations. The suffix *-ful* which is the least frequent of the three neutral suffixes was just as accurate as *-ment* for

all the children, suggesting that in this study frequency was not a factor in the production of stress on neutral derivations. The rhythmic suffixes, however, were affected by suffix frequency to some degree.

Stress production on words with the two less frequent suffixes, *-ic* and *-ity*, was significantly less accurate than on words suffixed with the more frequent *-tion*. Better performance on *-tion* than on either *-ic* or *-ity* derivations suggests that suffix frequency affects children's ability to produce primary stress accurately. As determined by the suffix ranking from the children's literature corpus, *-tion* is the most frequent of the three rhythmic suffixes followed by *-ity* then *-ic*. Thus, it appears that frequency, and in turn familiarity, may play some role. Primary stress is produced more accurately on words derived with familiar suffixes than with less familiar suffixes.

If the story ended here, it would be a simple story indeed, but the suffix frequency hypothesis is complicated by the fact that the seven- and eight-year old children performed better with *-ic* derivations than *-ity* derivations. This is a problem because *-ity* is a more frequent suffix than *-ic* according to the children's literature corpus. Possibly the corpus did not sample enough child-directed text to accurately rank infrequent suffixes, or the difference between the most frequent suffix and a less frequent suffix is measurable, but the difference between two less frequent suffixes is not. The suffix *-ity* has another property that might make it more difficult for children to accurately produce – it is two syllables whereas *-tion* and *-ic* are monosyllabic suffixes. Nevertheless, by age

nine, children's ability to form correctly stressed nonsense derivations with *-ity* does not differ from *-tion* derivations.

An additional issue is the lexical effect that appears in the two older groups' performance on real and nonsense *-tion* productions. Although this does not necessarily contradict the suffix frequency effect, it does add an element of complexity to the explanation. Children not only appear to learn the stress rule for the most frequent suffix first, they are simultaneously acquiring more lexical entries with the most frequent suffix.

Analysis 3: Item Analysis

An item by item analysis was conducted to determine whether there were differences among the individual stimulus words. Real-word and nonsense word stems were evaluated separately. Within each word type, each suffix type was evaluated separately. For example, the four real words suffixed with *-ic* were compared with each other, but not with nonsense words suffixed with *-ic* or any other suffix. This was done because there was a suffix effect in earlier analyses (at least for the words with rhythmic suffixes).

This analysis evaluated the relative performance of children on each word within each suffix type. Some words may have been easier or harder to produce accurately than others. The means and standard deviations for each correctly stressed rhythmic derivation appear in Table 11 for each group and across groups. The neutral derivations appear in Table 12. The results for the rhythmic suffix derivations are presented first.

Table 11. Means and Standard Deviations for Rhythmic Suffix Stimulus Words.

Rhythmic Suffixes	Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)		Children Total		Adult (N = 10)
	mean	SD	mean	SD	mean	SD	mean	S.D.	mean
REAL STEMS									
vacation	.47	.51	.67	.49	.93	.26	.67	.47	1.0
rotation	.47	.51	.89	.32	1.0	0	.77	.43	N/A ^a
execution	.59	.51	.86	.38	1.0	0	.79	.41	1.0
celebration	.53	.51	.78	.43	1.0	0	.75	.44	1.0
metallic^b	0	0	.06	.25	.20	.41	.08	.27	.90
artistic	.37	.49	.75	.45	.93	.26	.66	.48	1.0
alphabetic	.32	.48	.75	.45	1.0	0	.66	.48	1.0
microscopic	.47	.51	.81	.40	.93	.26	.72	.45	1.0
activity	.35	.49	.66	.49	.80	.41	.60	.49	.90
nobility	0	0	.28	.46	.40	.51	.22	.42	.90
personality	0	0	.33	.49	.53	.52	.28	.45	1.0
curiosity	.29	.47	.28	.46	.60	.51	.38	.49	1.0
NONSENSE STEMS									
gopation	.53	.51	.78	.43	1.0	0	.75	.44	1.0
naybation	.42	.51	.56	.51	.67	.49	.54	.50	N/A
blimefeton	.38	.50	.67	.49	.73	.46	.58	.50	1.0
trebumation	.53	.51	.61	.50	1.0	0	.69	.47	1.0
rebefic	.44	.51	.69	.48	.47	.52	.53	.50	1.0
gilsepic	.39	.50	.38	.50	.73	.46	.49	.51	1.0
neshigitic	.17	.38	.44	.51	.67	.49	.41	.50	.90
fusakapic	.11	.32	.56	.51	.80	.41	.47	.50	1.0
lulufity	.32	.48	.56	.51	.67	.49	.50	.50	.70
komirity	.16	.37	.33	.49	.60	.51	.35	.48	1.0
spedimility	.16	.37	.50	.51	.80	.41	.46	.50	.90
drefuniversity	.21	.42	.44	.51	.60	.51	.40	.50	.80

^a The two stimuli marked N/A were not tested on adults because the adults were tested on an earlier version of this test.

^b The items in bold type were significantly different from others in the same category (e.g., the real words suffixed with -ic).

Rhythmic Suffixes

Although there were significant main effects for age in all previously reported comparisons, for the purposes of this analysis, the groups were collapsed because the relevant comparison was among the individual words. Thus, by collapsing the age groups the relative performance overall for each stimulus word could be evaluated.

Real-Word Stems

A one-way ANOVA to evaluate differences among the four real words ending with *-tion* (i.e., vacation, rotation, execution, and celebration) revealed no significant differences, $F(3, 147) = 1.33, p = .26$.

The comparisons among the real *-ic* derivations (i.e., artistic, metallic, alphabetic, and microscopic) revealed a significant item effect, $F(3, 141) = 36.9, p < .0001$, suggesting that some of the *-ic* derivations were easier or harder to produce than others. Further planned comparisons showed that this effect was attributable solely to the stimulus word "metallic", for which performance was significantly poorer than any of the other *-ic* derivatives, $F(1, 47) > 76, p < .0001$. Planned comparisons between all other *-ic* derivations did not reach significance, $F(1, 47) < 1$.

Among the *-ity* derivations in the real-word stem condition, there was a significant main effect of items, $F(3, 141) = 8.84, p < .0001$, indicating that some of the *-ity* derivations were easier or harder than others. Planned comparisons

revealed that children were significantly better at producing the stimulus word "activity" with accurate stress than any of the other three *-ity* words, $F(1, 47) > 6$, $p < .02$. Furthermore, the contrast of "nobility" versus "curiosity" was also significant, $F(1, 47) = 4.55$, $p = .04$, suggesting that "nobility" was generally less accurate than "curiosity". No other contrasts were significant, $F(1, 47) > .73$, $p > .10$.

Nonsense-Word Stems

There was a significant item effect for the nonsense *-tion* derivations, $F(3, 147) = 4.01$, $p = .009$. Planned comparisons between the individual nonsense *-tion* derivations revealed significant differences between "gopation" and "naybation", $F(1, 49) = 8.6$, $p = .005$, "gopation" and "blimefeton", $F(1, 49) = 6.07$, $p = .02$, and "naybation" and "trebumation", $F(1, 49) = 4.86$, $p = .03$. These results suggest that "gopation" was easier to produce with accurate stress than either "naybation" or "blimefeton", and that "naybation" was the least likely to be produced with accurate stress.

There was no item main effect for either the nonsense *-ic* derivations, $F(3, 138) < 1$, or the nonsense *-ity* derivations, $F(3, 147) = 1.29$, $p = .28$.

Neutral Suffixes

The averages for each neutral suffixed item produced correctly, by each age group and across all age groups, appear in Table 13. Due to the word production ceiling effect with neutral derivations, statistical analyses were not appropriate. Nevertheless, the following observations can be made.

For the most part, children were able to say the derived words with accurate stress, although a few items stand out as problematic for the children (these are in bold type in Table 12). In particular, items suffixed with *-ness* were most likely to be produced with a stress shift. These will be discussed further below.

Table 12. Means and Standard Deviations for Neutral Suffix Stimulus Words.

Neutral Suffixes	Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)		Children Total		Adult
	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.	mean
REAL STEMS									
amazement	1	0	1	0	1	0	1	0	1
punishment	1	0	1	0	1	0	1	0	1
development	1	0	1	0	1	0	1	0	1
entertainment	1	0	1	0	1	0	1	0	1
forgiveness	1	0	1	0	1	0	1	0	1
nervousness	.88	.34	.94	.24	.80	.41	.88	.33	1
seriousness	1	0	.88	.33	.93	.26	.94	.24	1
exclusiveness	1	0	1	0	1	0	1	0	1
powerful	1	0	1	0	1	0	1	0	1
successful	1	0	1	0	.93	.26	.98	.14	1
NONSENSE STEMS									
nebezment	1	0	1	0	1	0	1	0	1
kirdushment	1	0	1	0	1	0	1	0	1
shefunipment	1	0	1	0	1	0	1	0	1
tevoulantment	1	0	.94	.24	1	0	.98	.14	.90
libefness	1	0	1	0	1	0	1	0	1
chefrisness	1	0	.94	.24	1	0	.98	.14	1
meklitusness	.75	.45	.71	.47	.67	.49	.71	.46	.40
gawlitrefness	1	0	.94	.24	1	0	.98	.14	1
dumerful	1	0	1	0	1	0	1	0	1
pawlusful	.94	.25	1	0	1	0	.98	.14	.90

Bold type indicates items that elicited fewer correct responses relative to the ceiling performance on most of the other stimuli.

Real-Word Stems

All real derivations suffixed with *-ment* were produced with correct stress for all ages. The two real words suffixed with *-ful* were also very accurate. Some of the words suffixed with *-ness*, however, were different from the others. In particular, errors were more frequent on the items "nervousness" and "seriousness" than on either "forgiveness" or "exclusiveness".

Nonsense-Word Stems

For the nonsense derived words, the items suffixed with *-ment* and the items suffixed with *-ful* were all produced accurately. Again, the only significant differences were found in the *-ness* derivations. The item "meklitusness" was produced with inappropriate stress more often than "libefness", "chefrisness", and "gawlitrefness". Curiously, adults were even more willing to shift stress to the penultimate syllable on the item "meklitusness" than children.

Although children erred on very few neutral suffixed words, a pattern emerges when we look more closely at the stems of the words that they produced incorrectly. Errors predominantly occurred on words with similar phonetic and syllabic features. The stem words of three *-ness* derivations that were found to be different from the other *-ness* derivations all ended in / Δ s/. The number of children changing stress to the presuffixal syllable, and the percentage these errors represent of the total group are presented in Table 13.

Table 13. Number of Children (and Group Percentage) who Produced -ness Derivations with Presuffixal Stress.

Stimulus Item	Group 1	Group 2	Group 3
nervousness	3 (16%)	1 (6%)	3 (20%)
seriousness	0	2 (11%)	1 (7%)
meklitusness	5 (26%)	6 (33%)	4 (27%)

Analysis 4: Individual Differences

This analysis was undertaken to highlight any differences among the children. Some children may show a different pattern of errors than others. For example, there may be some children in Group 1 who did not accurately produce stress on any of the rhythmic derivations, while others demonstrated near perfect performance. Results from the rhythmic and neutral derivations are reported separately. Within the discussion of each suffix type, the age groups are presented independently.

Rhythmic Suffixes

Group 1: 7-year old children

Table 14 shows the tally and percentages of accurate stress production for each child in Group 1 for real and nonsense rhythmic derivations. For each of the word types there were 12 rhythmic derivations, and 24 total derivations. The

participants are ordered by level of total accuracy. The word type difference is the total number of items produced with correct stress on real stems minus the raw total correct on nonsense stems.

There were no children in Group 1 who performed accurately on all the stimuli; however, some children clearly had more developed phonological systems than others. Performance across the word types was similar for most children. Six children (31.6%) performed exactly the same on real and nonsense stems, as indicated by a difference score of zero. Real words had an advantage for five children (26.3%). Three children were slightly better on real words than nonsense words (difference score of 1 or 2), and two children appeared to perform much better on the real words than the nonsense words (difference scores of 4 and 6). Seven children (36.8%) performed slightly better on nonsense words than on real words, and one child who was unable to accurately stress any real words was able to correctly produce four nonsense words.

If we divide the group into quarters, starting from the top of the list, we begin to see that age appears to be related to performance, even within this one group. The average ages are: 7;4 (years;months) for the first five children, 7;3 for the second five, 7;1 for the third five, and 6;9 for the last four. Nevertheless, age cannot be the sole indicator of performance because the youngest participant in the study (#103 was 6;6 years old) was also one of the best at producing accurate stress on rhythmic derivations.

Table 14. Individual Production Performance: Rhythmic Suffixes, Group 1

Participant	Age	Real Stem	Nonsense Stem	Total	Word Type Difference
103	6;6	9 (75%)	8 (67%)	71%	1
117	7;7	8 (67%)	9 (75%)	71%	-1
111	7;8	7 (58%)	9 (75%)	67%	-2
115	7;6	6 (50%)	8 (67%)	58%	-2
119	7;7	7 (58%)	7 (58%)	58%	0
107	6;7	5 (42%)	5 (42%)	42%	0
118	7;9	8 (67%)	2 (17%)	42%	6
114	7;8	5 (42%)	4 (33%)	38%	1
116	7;8	3 (25%)	4 (33%)	29%	-1
106	6;11	3 (25%)	3 (25%)	25%	0
109	6;10	3 (25%)	3 (25%)	25%	0
113	7;4	5 (42%)	1 (8%)	25%	4
101	7;1	2 (17%)	2 (17%)	17%	0
102	6;10	0 (0)	4 (33%)	17%	-4
112	7;5	3 (25%)	1 (8%)	17%	2
108	7;0	1 (8%)	1 (8%)	8%	0
104	7;4	0 (0)	1 (8%)	4%	-1
105	6;8	0 (0)	1 (8%)	4%	-1
110	6;9	0 (0)	1 (8%)	4%	-1

The numbers in the real and nonsense stem columns indicate the raw score of items correct (proportion correct in parenthesis). The highest possible raw score for either real or nonsense stem is 12. The Total column shows the proportion correct across the two word types, and the Word Type Difference column shows the raw score difference between real and nonsense stem (real minus nonsense).

Group 2: 8-year old children

The data from Group 2 are organized exactly like the Group 1 data. The tally of correct stress productions, percentages, and difference scores are all included in Table 15, and are arranged by overall proportion from best to worst subject performance.

No child from Group 2 accurately stressed all the words. As indicated by the difference scores, only three children (17%) erred on the same number of real as nonsense words. Eight children (44%) did better on the real words than on the nonsense words, and seven children (39%) were more accurate on the nonsense words than on the real words.

Unlike the accuracy related age progression seen with Group 1, no such pattern is evident for Group 2. The mean age for the first five children was 8;3, for the next four children it was 8;6, for the following four it was 8;1, and for the last five children the mean age was 8;6.

There appears to be a different pattern emerging among the 8-year old children than the one seen with the 7-year olds. Of the children who performed well (the first nine children from the top half of the list in Table 15), five of them performed better on the nonsense words than on real words, which represents 71.4% of the children showing this pattern. The children who did not perform as well overall (from the bottom half of the list) contributed six of the eight (75%) children who were more accurate at real words than nonsense words.

Table 15. Individual Production Performance: Rhythmic Suffixes, Group 2.

Participant	Age	Real Stem	Nonsense Stem	Total	Word Type Difference
201	7;11	10 (83%)	10 (83%)	83%	0
204	8;1	10 (83%)	10 (83%)	83%	0
212	8;4	9 (75%)	10 (83%)	79%	-1
218	9;0	9 (75%)	10 (83%)	79%	-1
214	8;10	8 (67%)	11 (92%)	79%	-3
215	8;2	10 (83%)	8 (67%)	75%	2
217	8;11	8 (67%)	9 (75%)	71%	-1
210	8;8	9 (75%)	7 (58%)	67%	2
216	8;5	7 (58%)	8 (67%)	63%	-1
202	8;1	8 (67%)	4 (33%)	50%	4
203	7;11	5 (42%)	5 (42%)	42%	0
206	8;2	6 (50%)	4 (33%)	42%	2
205	8;0	5 (42%)	4 (33%)	38%	1
207	7;11	4 (33%)	5 (42%)	38%	-1
211	9;0	6 (50%)	3 (25%)	38%	3
213	8;9	6 (50%)	2 (17%)	33%	4
209	8;5	6 (50%)	1 (8%)	29%	5
208	8;5	1 (8%)	3 (25%)	17%	-2

The double line divides the list in half.

The numbers in the real and nonsense stem columns indicate the raw score of items correct (proportion correct in parenthesis). The highest possible raw score for either real or nonsense stem is 12. The Total column shows the proportion correct across the two word types, and the Word Type Difference column shows the raw score difference between real and nonsense stem (real minus nonsense).

Group 3: 9-year old children

Again, the organization of the data is identical to the first two groups and can be seen in Table 16. Group 3 presents an interesting pattern of results, because it is an overlap of the age progression seen in Group 1 and the accuracy pattern seen in Group 2.

If we break the group into quarters, the mean age of the first three children is 9;8, 10;0 for the next four; 9;5 for the following four; and 9;2 for the last four. Group 3 had the fewest children (15), thus these means are based on very few children. If we instead look at the first half of the group (N = 8) the mean age is 10;0 and the second half (N = 7) has a mean age of 9;4. Hence, better performance is seen generally among the older children.

Turning now to the performance across word types, one child produced all the words with appropriate stress. Three children (20%) had a difference score of zero; they performed exactly the same on real and nonsense derivations. Eight children (53%) stressed real words correctly more often than nonsense words, and of these, five were in the second half of the group composed of the younger and less proficient children. Four children (27%) performed better on nonsense words than real words. All four of these children were in the first half of the group – the half that was more accurate overall.

Table 16. Individual Production Performance: Rhythmic Suffixes, Group 3.

Participant	Age	Real Stem	Nonsense Stem	Total	Word Type Difference
312	10;3	12 (100%)	12 (100%)	100%	0
313	9;5	10 (83%)	12 (100%)	92%	-2
307	10;2	11 (92%)	10 (83%)	88%	1
310	10;4	10 (83%)	11 (92%)	88%	-1
311	9;8	11 (92%)	10 (83%)	88%	1
309	9;8	9 (75%)	10 (83%)	79%	-1
314	10;6	11 (92%)	8 (67%)	79%	3
315	10;0	7 (58%)	11 (92%)	75%	-4
302	9;3	10 (83%)	7 (58%)	71%	3
308	10;0	9 (75%)	8 (67%)	71%	1
301	9;4	8 (67%)	8 (67%)	67%	0
305	9;3	9 (75%)	7 (58%)	67%	2
306	9;1	8 (67%)	8 (67%)	67%	0
304	9;1	8 (67%)	7 (58%)	63%	1
303	9;3	7 (58%)	2 (17%)	38%	5

The double line divides the list in half.

The numbers in the real and nonsense stem columns indicate the raw score of items correct (proportion correct in parenthesis). The highest possible raw score for either real or nonsense stem is 12. The Total column shows the proportion correct across the two word types, and the Word Type Difference column shows the raw score difference between real and nonsense stem (real minus nonsense).

Groups 2 and 3 show a similar pattern in which children performing better on the nonsense words than on the real words (i.e., negative numbers in the difference columns) overlap with children performing among the best in their group. The two groups were collapsed, and a Spearman Rank Order Correlation was used to examine the relationship between the total correct and the

difference scores. The results indicate that indeed there is a relationship between the two scores, $R = -.43$, $p = .01$ ($N=33$). Although this was a post-hoc analysis, with a small sample, there does appear to be a relationship between the ability to accurately stress a nonsense derivation and overall performance. Generally, children who did well on this task overall were better at generalizing the stress rules associated with rhythmic suffixes to novel words than children who performed poorly or even marginally well overall.

Neutral Suffixes

In comparison to the rhythmic suffixes, individual performance on the neutral derivations is relatively prosaic. Tables 17, 18 and 19 contain the data for Groups 1, 2 and 3 respectively. Most children (in all three groups) performed very well, with a maximum of two errors (90% accuracy overall). No child stands out from the others, nor is there a discernable pattern either by age or errors.

Table 17. Individual Production Performance: Neutral Suffixes, Group 1

Participant	Age	Real Stem	Nonsense Stem	Total	Word Type Difference
101	7;1	10 (100%)	10 (100%)	100%	0
102	6;10	10 (100%)	10 (100%)	100%	0
104	7;4	10 (100%)	10 (100%)	100%	0
105	6;8	10 (100%)	10 (100%)	100%	0
106	6;11	10 (100%)	10 (100%)	100%	0
107	6;7	10 (100%)	10 (100%)	100%	0
109	6;10	10 (100%)	10 (100%)	100%	0
110	6;9	10 (100%)	10 (100%)	100%	0
116	7;8	10 (100%)	10 (100%)	100%	0
112	7;5	10 (100%)	10 (100%)	100%	0
103	6;6	10 (100%)	9 (90%)	95%	1
111	7;8	10 (100%)	9 (90%)	95%	1
113	7;4	9 (90%)	10 (100%)	95%	-1
114	7;8	9 (90%)	10 (100%)	95%	-1
115	7;6	10 (100%)	9 (90%)	95%	1
118	7;9	9 (90%)	10 (100%)	95%	-1
119	7;7	10 (100%)	9 (90%)	95%	1
108	7;0	9 (90%)	9 (90%)	90%	0
117	7;7	10 (100%)	8 (80%)	90%	2

Table 18. Individual Production Performance: Neutral Suffixes, Group 2.

Participant	Age	Real Stem	Nonsense Stem	Total	Word Type Difference
203	7;11	10 (100%)	10 (100%)	100%	0
208	8;5	10 (100%)	10 (100%)	100%	0
209	8;5	10 (100%)	10 (100%)	100%	0
211	9;0	10 (100%)	10 (100%)	100%	0
213	8;9	10 (100%)	10 (100%)	100%	0
215	8;2	10 (100%)	10 (100%)	100%	0
216	8;5	10 (100%)	10 (100%)	100%	0
217	8;11	10 (100%)	10 (100%)	100%	0
201	7;11	10 (100%)	9 (90%)	95%	1
206	8;2	10 (100%)	9 (90%)	95%	1
210	8;8	10 (100%)	9 (90%)	95%	1
212	8;4	10 (100%)	9 (90%)	95%	1
214	8;10	10 (100%)	9 (90%)	95%	1
202	8;1	8 (80%)	10 (100%)	90%	-2
204	8;1	10 (100%)	8 (80%)	90%	2
205	8;0	9 (90%)	9 (90%)	90%	0
207	7;11	10 (100%)	8 (80%)	90%	2
218	9;0	9 (90%)	9 (90%)	90%	0

Table 19. Individual Production Performance: Neutral Suffixes, Group 3.

Participant	Age	Real Stem	Nonsense Stem	Total	Word Type Difference
302	9;3	10 (100%)	10 (100%)	100%	0
304	9;1	10 (100%)	10 (100%)	100%	0
305	9;3	10 (100%)	10 (100%)	100%	0
308	10;0	10 (100%)	10 (100%)	100%	0
311	9;8	10 (100%)	10 (100%)	100%	0
312	10;3	10 (100%)	10 (100%)	100%	0
301	9;4	9 (90%)	10 (100%)	95%	-1
303	9;3	9 (90%)	10 (100%)	95%	-1
306	9;1	10 (100%)	9 (90%)	95%	1
307	10;2	10 (100%)	9 (90%)	95%	1
309	9;8	9 (90%)	10 (100%)	95%	-1
310	10;4	10 (100%)	9 (90%)	95%	1
313	9;5	9 (90%)	10 (100%)	95%	-1
314	10;6	9 (90%)	10 (100%)	95%	-1
315	10;0	10 (100%)	9 (90%)	95%	1

Discussion

Several conclusions can be drawn from these data. The hypothesis that primary stress assignment would be easier on words with neutral suffixes than on words with rhythmic suffixes was strongly supported. Neutral derivations were uniformly accurate, while rhythmic derivations were frequently produced as if they were neutral; children retained the original stem stress in all incorrect productions of rhythmic derivations. Furthermore, age did not affect the production of neutral derivations, whereas there was a clear age effect for rhythmic derivations. We can conclude that children gradually and steadily master the ability to produce accurate stress on derivations with rhythmic suffixes during their early school-age years. There is no such change with neutral derivations, demonstrated by near perfect performance even in the youngest age group tested. This supports the hypothesis that noncyclicity is learned first, then overgeneralized until the rhythmic suffixes are learned and marked [+cyclic]. The results demonstrated that children are learning which suffixes are marked for a cyclic domain.

The real and nonsense stem words were used to differentiate between a lexically stored representation and a rule-based account of primary stress assignment. Considering that there was no difference at any age between the two stem types (real and nonsense) for either rhythmic or neutral derivations, children do not appear to be searching their lexicons and accessing a derived word with primary stress pre-assigned. Of course, this is demonstrated primarily

by performance on the rhythmic derivations. The results indicate that in the case of rhythmic suffixes children are learning a rule. Furthermore, rule learning appears to be affected to some degree by the suffix involved – either by suffix frequency or suffix features.

Generally, there was little variation in performance between the individual neutral suffixes; children achieved a high level of accuracy on all three suffix tokens (*-ment*, *-ness*, and *-ful*). The *-ness* effect, appears to be due to items that all share similar prefixal features; they all end in /ʌs/ (e.g., *-ous*). In fact, words ending in *-ous* have unique properties. They can be followed by the neutral suffix *-ness* (e.g., *serious/seriousness*). They can attract primary stress on the prefixal syllable if followed by a rhythmic suffix (e.g., *curious/curiosity*; *generous/generosity*; *viscous/viscosity*), or *-ous* can be deleted altogether (e.g., *ferocious/ferocity*; *atrocious/atrocidity*). In addition, *-ous* and its variation *-ious* are suffixes in their own right, and they are rhythmic suffixes. Thus, there may be something special about /ʌs/ in word final position that was not predicted, hence not properly controlled.

Turning to the rhythmic suffixes, there was a very clear difference between the most frequently occurring suffix *-tion* and the other two. Accuracy on the most frequent rhythmic suffix was greater than on the less frequent suffixes. There was also less variability among the individual *-tion* stimuli than among the *-ic* or *-ity* stimuli. This is suggestive of a frequency effect.

The analysis of the individual children revealed two important patterns. Generally, even within a given group, accuracy on rhythmic derivations appears

to be related to age. This conclusion is tempered by evidence of some younger children performing quite well relative to other children in their group and the absence of this pattern among children in Group 2, suggesting that although age is an important predictor of performance, it cannot be the only one. The second pattern in the data is that 8- and 9-year old children who performed in the top half of their group appear to be using a different strategy than the children in the bottom half of their group. Children who were less accurate overall (across both word types) tended to be more accurate on real derivations than on nonsense derivations. This pattern was reversed for children who performed well overall. An explanation of these results may be that children who perform well on this type of production task are better at generalizing rules than children who do not perform well. Moreover, children who did not perform well overall may be more reliant on lexical representation, and therefore are more accurate with real words than with nonsense word stems.

CHAPTER 5: PERCEPTION EXPERIMENT

JUDGMENT TASK

This experiment was designed to examine the same hypotheses as the production study. The specific goals of the perception experiment were as follows:

- 1) To establish whether children judge word stress on morphologically complex words differently as a function of the type of suffixation involved. Based on the hypothesis that noncyclic suffixes (i.e., neutral) are learned first and that cyclic suffixes must be marked, neutrally suffixed words were predicted to be more accurate than rhythmically suffixed words.
- 2) To determine whether children's accuracy improves with age, for either or both of the suffix types. Again, improvement should coincide with an increase in age, especially for the rhythmic derivations. Older children, who presumably have more experience with the language, might have analyzed and marked rhythmic suffixes as [+cyclic], while the younger children might not have.
- 3) To learn whether stress patterns are stored lexically or if they are assigned by rule. Children may find real derivations easier to judge than invented derivations with nonsense word stems, thus exhibiting a lexical effect. The other possibility is that children's judgments are based on the phonological

rules of their grammars, in which case no difference between stress judgments of real and nonsense derivations would be observed.

- 4) To determine whether there are differences among the rhythmic and neutral suffixes corresponding to relative suffix frequency. Words with frequent or familiar suffixes may be judged more accurately than less frequent suffixes.

In many areas of language development, the ability to detect, perceive, or understand an aspect of language often precedes the ability to produce it accurately. Likewise, children may be able to perceive and judge accurate stress on morphologically complex words before they can produce it. Comparisons between the two experiments are found in Chapter 6.

Method

Participants

The participants were the same children who participated in the production experiment.

Procedures

All children participated in the perception experiment after they participated in the production experiment. Participants were told that they would hear two words and that their job was to determine which word sounded more like English. They were instructed to answer “first” or “second” depending on which word they preferred.

Practice

All children practiced making stress judgments on several minimal stress pairs (see Stimuli section for further clarification). First, morphologically simple words were orally presented to the children. For example, if the child heard 'STOrY' and 'stoRY', or 'Llbrary' and 'liBRARY', he or she then indicated which “sounded better”. Then the child was given three familiar⁷ derived words in pre-recorded pairs (e.g., 'HONorable' v. 'honORable', 'POlsonous' v. 'poiSONous') to practice judging. Feedback on the accuracy of their judgment was given after each practice pair.

⁷ These words were taken from the children's literature corpus, and were assumed to be familiar to school-aged children.

Children must have accurately judged four of five practice pairs (2 monomorphemic, and 3 derived words) in order to be included in the study. One child did not meet this criterion, and his data were excluded from further analyses.

Experiment

The experimental words for the perception task, like the production task, consisted of real and nonsense English words, although they were different word sets. The words were pre-recorded on an audio tape in minimal stress-pairs. The children made acceptability judgments of the words by choosing the first or second word. The experimenter manually recorded the children's choices on a score sheet. Participants were allowed to hear a word pair again if requested, and they were provided breaks if needed.

Stimuli

The perception stimuli were similar to the production stimuli, except that in this experiment children heard entire derived words. The same six suffixes used in the production experiment were used in the perception task. Three suffixes shifted stress in the stem and three did not. There were two word lists, one consisting of 22 derived real words and the other with 22 derived nonsense words. For each list, 12 stem words were two-syllables in length, and 10 had three-syllable stems. Each of the six suffixes was represented twice for words of each syllable length, except for *-ful* which can only be attached to one- or two-syllable words.

Syllable stress

The words for the perception experiment were recorded in minimal stress-pairs. One member of the pair had stress on the correct syllable and the other member of the pair had incorrect primary stress on a different syllable in the word. For the real words with rhythmic suffixes, stress must fall on the syllable before the suffix (i.e., presuffixal). This is not a requirement for neutral suffixed words. The incorrect stress for rhythmic suffix derivations corresponded to the stem stress. For example, if the stimulus word was 'symbolic' the child heard two words, one with appropriate stress (e.g., 'symBOLic'), and one with stress appropriate for the stem, but not for the derived word (e.g., 'SYMbolic'). For the neutral suffix derivations, correct stress was always on the antepenultimate syllable, and the incorrect stress fell on the presuffixal syllable. For example, for the stimulus word 'environment', children heard the correct 'enVIRonment' and the incorrect 'envirONment'. Non word stress was matched to real word stress. The perception stimuli appear in Table 20.

The word lists were pseudorandomized, such that no individual suffix appeared consecutively. The order that children heard either the correctly or incorrectly stressed word first, or second, was randomized by list. Children always heard the real word list prior to the nonsense word list.

Table 20. Perception Stimuli.

Word Stem				
Rhythmic Suffix	Real words		Nonsense words	
	2 syll.	3 syll.	2 syll.	3 syll.
-tion	inFORmation - inforMAtion RElation - reLAtion	EDucation - eduCAtion OPeration - opeRAtion	KRANdition - kranDItion EBbation - ebBAtion	ODronition - odroNItion TREbitition - trebiTItion
-ic	ATomic - aTomic SYMbolic - symBOLic	REAListic - reaLIStic eLECTronic - electRONic	TESpetic - tesPEtic ATrilic - atRILic	RASlekaric - rasleKARic ubRAtimic - ubraTIMic
-ity	AUthority - auTHORity PROSPerity - prosPERity	POSSibility - possiBILity UNiversity - uniVERsity	KLORipity - kloRIPity RUpidity - ruPIDity	ATavility - ataVILity ONalarity - onaLARity
Neutral Suffix				
-ment	ARgument - arGUment GOVERNment - goVERNment	emBARassment - embaRASsment enVIRonment - envirONment	BLEPishment - blePISHment KANdonment - kanDONment	grePULachment - grepuLACHment uSTELonment - usteLONment
-ness	PLEAsantness - pleaSANTness RESTfulness - restFULness	etFEctiveness - effecTIVENess deLICiousness - delicIOUSness	PUNdidness - punDIDness STERuveness - sterUVeness	niSIDipness - nisiDIPness ePROgiousness - eprogIOUSness
-ful	Pitiful - piTIful WONderful - wonDERful		SAtirful - saTRIful ROMpidful - romPIDful	

Scoring

The judgment task required a binary choice. The children's responses were indicated on a response sheet during testing. The correct and incorrect responses were then tallied and proportions were calculated according to children's correct stress preference (i.e., correct responses divided by total responses). For the rhythmic suffix derivations, correct primary stress fell on the

presuffixal syllable, and for neutral suffix derivations correct stress fell elsewhere in the word, but never on the presuffixal syllable.

Nonsense words with neutral suffixes were not included in the analysis because there was no way of determining where the stress should fall. Recall that neutral derivations retain the stem's primary stress, however with no isolated stem provided, the accuracy of stress assignment cannot be determined. Furthermore, there are many English words with iambic (i.e., weak-strong) stress patterns that take neutral suffixes (e.g., assessment, forgiveness, successful). Therefore, although this factor could be controlled in the real words by including no neutral derivations with presuffixal stress, it cannot be controlled in the nonsense words. In contrast, all rhythmic suffixed words must follow the rule associated with the suffix, regardless of stem stress. Derived words, real or nonsense, with rhythmic suffixes must have presuffixal stress.

Results

Four analyses were performed. The first analysis (Overall Analysis) compared the stress preferences across the age groups between the real and nonsense stem words with rhythmic suffixes and the real words with neutral suffixes. The second analysis (Suffix Token Analysis) evaluated the individual differences among the different suffixes. The third analysis (Item Analysis) examined whether there were differences between any of the stimulus items. Several ANOVAs were calculated. For the rhythmic derivations, real and nonsense words were examined separately by suffix type (i.e., the real word *-tion* derivations were compared with each other, the nonsense word *-tion* derivations were compared with each other, etc). The final analyses investigated whether there were individual subject differences within each group for each stimulus condition.

Analysis 1: Overall Analysis

As in the production experiment, an initial 2-way ANOVA was used to evaluate the effect, if any, of the syllable length of the stem words. The mean proportions for correct judgments were calculated for each stimulus item for the three age groups, then categorized by syllable length (either 2- or 3-syllables). The proportion were then arcsine transformed before performing the ANOVA, and all subsequent analyses. There was a main effect of age, $F(1, 64) = 8.97$,

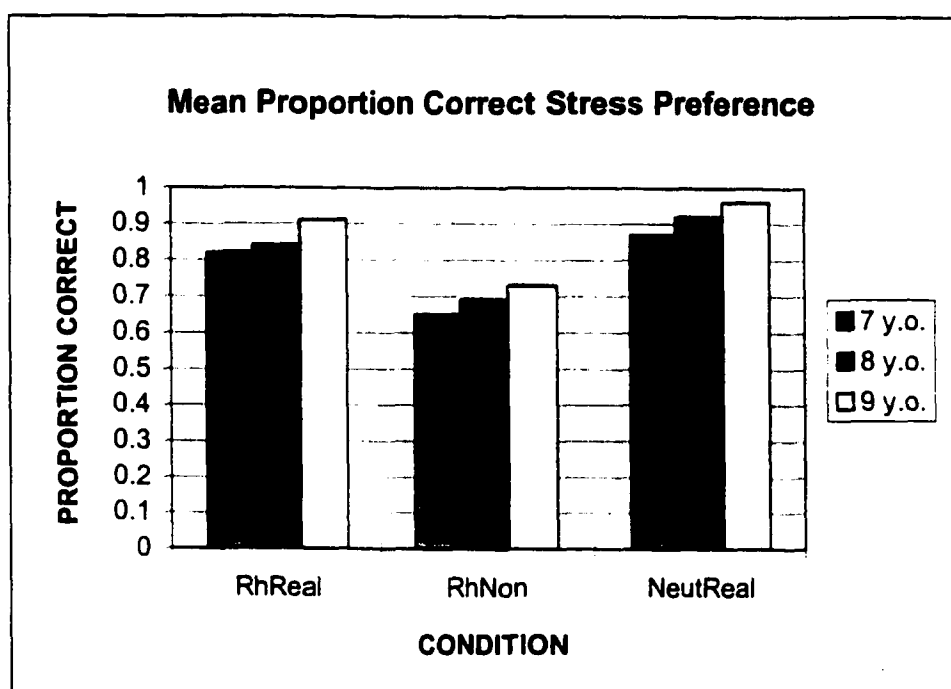
$p < .001$, but no effect of syllable length and no interaction between age and syllable length, $F(1, 32) < 1$, and $F(2, 64) < 1$, respectively. Syllable length was collapsed for all further analyses.

As mentioned previously, the neutral derivations with nonsense word stems were not included in any of the analyses due to the inappropriateness of scoring a preference "correct" or "incorrect" when participants had no indication of where stem stress fell prior to the derivation. Thus, we were left with three, slightly unbalanced, conditions that could be scored decisively: rhythmic derivations with real stems (RhReal); rhythmic derivations with nonsense stems (RhNon), and neutral derivations with real stems (NeuReal). The proportion of correct choices for each age group was calculated for these three conditions. Table 21 shows the mean proportions and standard deviations of correct stress preference by age group and condition. These data are graphically represented in Figure 8. The raw values appear in Appendix I.

Table 21. Proportion Means and Standard Deviations of Correct Stress Preference.

Suffix		Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)	
		real stem	nonsense	real stem	nonsense	real stem	nonsense
Rhythmic	M	.81	.65	.84	.69	.91	.73
	SD	.09	.15	.09	.17	.08	.12
Neutral	M	.87	N/A	.92	N/A	.96	N/A
	SD	.11	N/A	.11	N/A	.07	N/A

Figure 8. Mean proportions of correct stress preference: Perception



A two-way repeated measures ANOVA with one between-subjects variable of age (7-, 8-, and 9-year old), and one within-subjects variable of condition (RhReal, RhNon, and NeuReal) was performed on these data. The results revealed a main effect of age, $F(2, 49) = 6.17, p < .004$, and condition, $F(2, 98) = 58.20, p < .0001$, but no significant interaction between age and condition, $F(4, 98) < 1$. Put simply, children's ability to accurately judge stress placement improved as a function of age, but differed according to the type of stimulus they were evaluating. To further examine these results, planned comparisons were calculated between and within the age and condition

variables. The group contrasts are discussed first, followed by the condition contrasts.

Age Group Contrasts

Individual contrasts between the Groups for the rhythmic derivations with real word stems (RhReal) resulted in several statistically significant differences. The 9-year old children were more accurate judges of correct stress placement than the 8-year old children, $F(1,49) = 5.90$, $p = .02$, and the 7-year old children, $F(1, 49) = 9.43$, $p < .003$. However, the 8-year old children's performance was not significantly different from the 7-year old children's performance, $F(1, 49) < 1$. For the rhythmic derivations with nonsense word stems (RhNon), performance between the three groups was not measurably different, despite a developmental trend: Group 2 versus Group 1 or Group 3 $F(1, 49) < 1$, and Group 1 versus Group 3, $F(1, 49) = 1.54$, $p = .22$. The only significant group contrast in the last condition -- neutral derivations with real word stems (NeutReal) -- was between Groups 1 and 3, $F(1, 49) = 7.04$, $p = .01$. Although performance across age was generally very good, this result suggests that there is a gradual, age related improvement in neutral suffixed word judgments.

Taken together, we see that the 9-year old children in Group 3 were better judges of stress than the 7-year old children in Group 1 in both the RhReal and the NeutReal conditions. Although the contrasts between Groups 1 and 2 and between Groups 2 and 3 were not significant, performance does appear to minimally improve with age and across all the conditions.

Condition Contrasts

The condition contrasts examined differences within each group across the different word and suffix types. All three groups achieved a similar pattern of performance, which was clearly dependent upon the stimulus condition.

Judgments of the neutral suffix on real word stems (NeutReal) were the most accurate for all age groups, followed by rhythmic derivations on real word stems (RhReal), then nonsense stems with rhythmic suffixes (RhNon). This pattern was repeated for all age groups, however it was most robust in the youngest children.

Across word type (with suffixes collapsed), contrasts between the RhReal and the RhNon conditions were significantly different for all groups: Group 1, $\underline{F}(1, 49) = 11.97, p < .001$; Group 2, $\underline{F}(1, 49) = 10.59, p < .002$; Group 3, $\underline{F}(1, 49) = 18.50, p < .0001$. Thus, judgments of real rhythmic derivations were more accurate for all the groups than nonsense rhythmic derivations. Across suffix type (with words collapsed), the RhReal and the NeutReal contrasts were also significantly different for all groups: Group 1, $\underline{F}(1, 49) = 6.70, p < .013$; Group 2, $\underline{F}(1, 49) = 15.57, p < .001$; Group 3, $\underline{F}(1, 49) = 8.98, p < .004$. This strong pattern differentiating the rhythmic from the neutral suffixes was previously seen in the production study.

Summary of Analysis 1

Three factors appear to affect stress preference as measured by a minimal stress-pair judgement task. These factors include age, whether the derivation includes a rhythmic or neutral suffix, and whether the word stem is a

real word or a nonsense word. Generally, accuracy of stress judgments improves as age increases, especially for words with rhythmic suffixes. At all ages, stress was judged correctly more often for the neutral derivations than for the rhythmic derivations. The results of the production experiment revealed a similar trend. This suggests that not only is there something different about the stress with these two types of suffixes, but that children are sensitive to this difference and are mastering the stress rules at different rates. Words with neutral suffixes are easier to judge and produce, in part because they do not require the extra step of cycling through the stress assignment rules again; they are phonologically less complex.

Unlike the results of the production experiment, there was a strong effect of word type on rhythmic derivations. Children determined correct stress in a stress-pair more accurately when the stem was a real word than if it was a nonsense stem. This suggests that there is a lexical effect, because it was more difficult for children to judge words they had never heard before. Thus, they may have some kind of representation of the whole derived word stored in memory.

Analysis 2: Suffix Token Comparisons

This analysis is broken down by suffix type. Words with rhythmic suffixes were analyzed separately from those with neutral suffixes. Results from the two suffix types are reported separately.

Rhythmic Suffixes

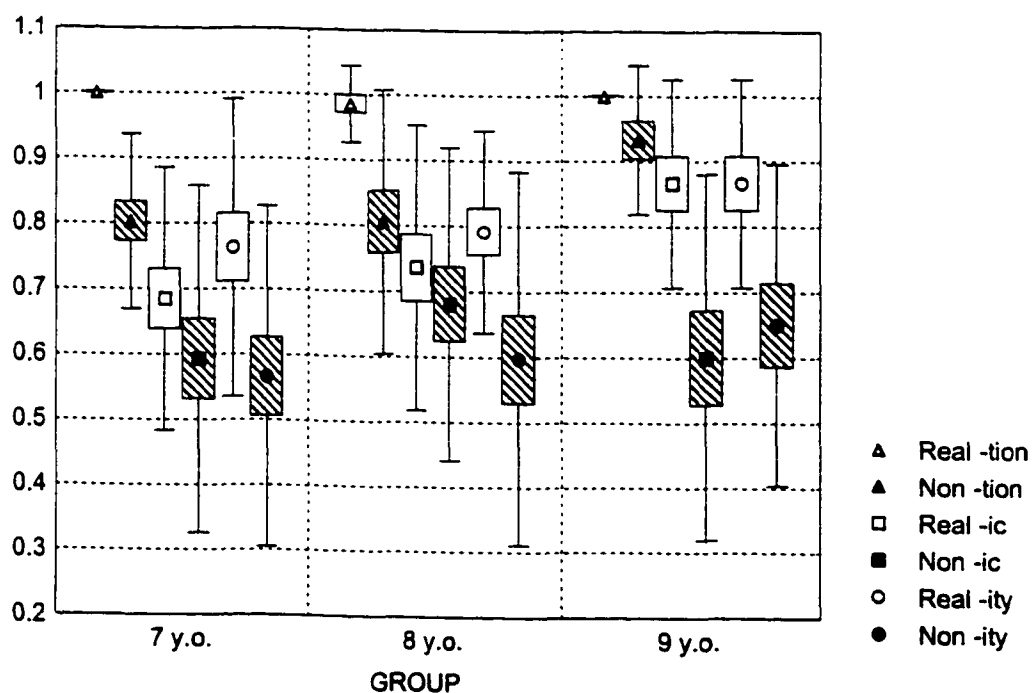
Mean proportions of correct stress judgments and standard deviations for each of the three rhythmic suffixes by age and word type can be found in Table 22. The raw data are in Appendix J. These results are graphically depicted in Figure 9.

It is apparent from Table 22 that children performed at ceiling levels on the real derivations ending in the suffix *-tion*. Thus, a general ANOVA was not appropriate, however, several contrasts were possible.

Table 22. Individual Rhythmic Suffix Perception (Mean Proportions and Standard Deviations.

Rhythmic Suffix		Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)		TOTAL	
		real stem	nonsense	real stem	nonsense	real stem	nonsense	real stem	nonsense
-tion	<u>M</u>	1.0	.80	.99	.81	1.0	.93	1.0	.84
	<u>SD</u>	0	.13	.06	.20	0	.11	.03	.16
-ic	<u>M</u>	.68	.59	.74	.68	.87	.60	.75	.63
	<u>SD</u>	.20	.27	.22	.24	.16	.28	.21	.26
-ity	<u>M</u>	.76	.57	.79	.60	.87	.65	.80	.60
	<u>SD</u>	.23	.26	.15	.29	.16	.25	.19	.26
TOTAL	<u>M</u>	.82	.65	.84	.69	.91	.73		
	<u>SD</u>	.08	.19	.06	.15	.06	.12		

Figure 9. Rhythmic Suffix Mean Proportion Correct Stress Judgment, by Group, Word Type, and Individual Suffix.



N.B., The box is 1 SE, and the whiskers are 1 SD around the mean.

Age Group Contrasts

To isolate the differences between the groups, a one-way ANOVA was performed with word type and rhythmic suffix token collapsed: Group 1 vs. Group 2, $F(1, 49) < 1$; Group 1 vs. Group 3, $F(1, 49) = 6.95$, $p = .01$; Group 2 vs. Group 3, $F(1, 49) = 3.53$, $p = .07$. Thus, the only statistically significant difference with judging rhythmic derivations was found between the youngest and oldest children.

Two-way ANOVAs were used to evaluate the data further. With respect to the individual rhythmic suffixes (word type collapsed), Group 3 performed better than either Group 1, $F(1, 49) = 6.64$, $p < .05$ or Group 2, $F(1, 49) = 6.14$, $p < .05$, only on *-tion* derivations (this avoids statistical problems with the ceiling-level real *-tion* derivations by collapsing them with the nonsense *-tion* derivations). Where possible, suffix and word type were contrasted independently. Group 3 was better than Group 1 on nonsense words suffixed with *-tion*, $F(1, 49) = 7.40$, $p = .009$. Group 3 was also better than Group 1 at making stress judgments for real words ending in *-ic*, $F(1, 49) = 6.27$, $p = .02$. In sum, the 9-year old children (Group 3) were more accurate judges of correct stress than the 7-year old children.

Word Type Contrasts

Within each group, real and nonsense derivations were compared for each suffix token, except for *-tion* derivations on which children exhibited ceiling-level performance. Thus, a two-way ANOVA was used for each group, with word

(real vs. nonsense) and suffix token (*-ic* vs. *-ity*) as the variables. The word contrast table is contained in Appendix K. The results for Groups 1 and 2 are similar. For Group 1, accurate stress judgments on real words exceeded those on nonsense words for words suffixed with *-ity*, $F(1, 49) = 6.75$, $p = .01$, but not with *-ic*, $F(1, 49) = 1$. The pattern for Group 2 is the same. Contrasts between the real and nonsense word judgments of *-ity* derivations were statistically significant, $F(1, 49) = 5.15$, $p = .03$, with real words having the advantage over nonsense words. However, real and nonsense word judgments were not different for *-ic* derivations, $F(1, 49) < 1$.

The 9-year old children comprising Group 3 present a slightly different picture. Group 3 demonstrated significantly better performance on real words than nonsense words that were suffixed with both *-ic*, $F(1, 49) = 8.77$, $p = .005$, and *-ity*, $F(1, 49) = 7.72$, $p = .008$.

Suffix Contrasts

Further contrasts between the individual suffix tokens were conducted with real words and nonsense words separately within each group. Again, the real *-tion* derivations were omitted due to ceiling performance. The results from the suffix contrasts are illustrated in Appendix L. All age groups presented with a similar pattern of results.

For both Groups 1 and 3, stress judgments of the nonsense *-tion* derivations were better than those of nonsense *-ic* derivations, (Group 1,

$F(1, 49) = 6.81, p < .05$; Group 3, $F(1, 49) = 20.88, p < .0001$), and nonsense *-ity* derivations, (Group 1, $F(1, 49) = 9.24, p < .01$; Group 3, $F(1, 49) = 19.78, p < .0001$). Furthermore, the accuracy of *-ic* and *-ity* judgments were not significantly different from each other in either real words, (Group 1, $F(1, 49) = 1.47, p = .23$; Group 3, $F(1, 49) < 1$), or nonsense words, (both groups, $F(1, 49) < 1$).

For Group 2, the 8-year old children, the pattern of results is similar but not identical to the other two groups. In contrast to the other two groups, the nonword contrast between *-tion* and *-ic* was not significant, $F(1, 49) = 3.20, p > .05$, while the *-tion* and *-ity* nonword contrast was significant, $F(1, 49) = 9.75, p < .01$. No difference was identified between *-ic* and *-ity* on either real or nonsense word stems, $F(1, 49) < 1$.

Summary: Rhythmic Suffixes

To summarize these results with the rhythmic suffixes, we see that stress judgment accuracy modestly improves with age, and that performance is better on real word derivations than on nonsense derivations. This was previously established in Analysis 1. The additional information gained is the specific contributions of the three rhythmic suffix tokens; there are differences among the suffixes.

The greatest group difference lies between the youngest and oldest groups for nonsense words suffixed with *-tion*, and real words suffixed with *-ic*. If 9-year old children's performance was better than 7-year old's only on real

derivations, a reasonable conclusion would be that the older children perform better because they have had more exposure to the derivations included in the study. However, due to the age effect with nonsense derivations also, rule learning is also involved. If children were not learning the cyclical stress rules for rhythmic suffixes, then we would expect performance to be at chance across all ages, which is not the case. Even for nonsense words suffixed with *-ity* (on which performance was relatively poor compared to the other stimuli) mean accuracy gradually improves across the three age groups, from 57% to 60% to 65% correct stress judgments for Group 1, 2, and 3 respectively, although the differences never reach statistical significance.

The word contrasts revealed that accuracy was better for real words suffixed with *-ity* than nonsense words, for all groups. Accuracy on real words suffixed with *-ic* was better than the nonsense words only for the 9-year old children. Furthermore, real *-tion* derivations reached ceiling levels for all groups, and they appeared to be more accurate than nonsense *-tion* derivations for the two younger groups (7- and 8-years old children). The 9-year old children were comparably accurate with the nonsense as with the real *-tion* derivations. Thus, as in the previous analysis, real word derivations have an advantage over nonsense derivations, which supports a lexical exposure hypothesis. This contrasts with the Production experiment, in which no lexical effect was found. The difference between the two experiments will be discussed further in Chapter 6.

With respect to the suffixes, all words that end in *-tion*, whether real or nonsense, appear to have an advantage over *-ic* and *-ity* derivations. No statistical difference between *-ic* and *-ity* words was obtained for any group. This provides support for a frequency effect because *-tion* is the most frequently occurring rhythmic suffix of the three.

Neutral Suffixes

All statistical analyses on the neutral suffixed word judgments were done on the words with real stems only. The performance on word judgments with neutral suffixes can be seen by the mean proportions correct and standard deviations in Table 23. The raw values appear in Appendix M. Generally, as in the production experiment, children were very accurate on judgments of neutral derivations.

Considering the excellent performance of all children on the *-ment* derivations, and the ceiling-level performance of the 9-year old children in Group 3 on all the derivations, a general ANOVA was inappropriate. However, individual contrasts for Groups 1 and 2 were conducted.

Table 23. Mean Proportion Correct and Standard Deviations of Individual Neutral Suffixes on Real Word Stems: Perception Task.

		Group 1 (7 y.o.)	Group 2 (8 y.o.)	Group 3 (9 y.o.)	TOTAL
		real stem	real stem	real stem	
-ment	<u>M</u>	.97	.99	.97	.98
	<u>SD</u>	.08	.06	.09	.07
-ness	<u>M</u>	.76	.90	.97	.87
	<u>SD</u>	.26	.15	.09	.20
-ful	<u>M</u>	.71	.83	.93	.82
	<u>SD</u>	.35	.30	.18	.30
TOTAL	<u>M</u>	.84	.92	.96	
	<u>SD</u>	.19	.16	.07	

Age Group Contrasts

A one-way ANOVA between Groups 1 and 2 with suffix type collapsed revealed a near significant difference, $F(1, 49) = 3.71, p = .06$. Further observation of each group's overall performance, suggests that accuracy judging words with neutral suffixes gradually improved with age.

The data were broken down further, to evaluate differences between the age groups for each neutral suffix (where possible). A two-way ANOVA was used, with age (2 groups) and suffix (3 neutral suffixes) as variables. All children performed very well for *-ment* derivations. However, there were significant group

contrasts for *-ness* and *-ful*. Group 2 was better than Group 1 on *-ness* derivations, $F(1, 49) = 4.49$, $p = .04$, however not on *-ful* derivations, $F(1, 49) = 1.67$, $p = .20$. Although statistics were not appropriate, as indicated by their near ceiling performance, the children in Group 3 were more accurate judges of stress placement than those in Group 1 on derivations ending in both *-ness* and *-ful*.

Suffix Contrasts

With groups collapsed, contrasts between the individual neutral suffix tokens revealed no overall difference between *-ness* and *-ful*, $F(1, 49) = 1$. However, the differences between *-ment* and *-ness*, and *-ment* and *-ful* were statistically significant, $F(1, 49) = 12.94$, $p = .0007$, and $F(1, 49) = 10.45$, $p = .002$, respectively – due to the excellent performance on *-ment* derivations.

Summary: Neutral Suffixes

Taken together, these results suggest that stress judgment accuracy is affected by age and suffix token. Specifically, the 9-year old children are better judges of stress on neutrally suffixed words than are the 7-year old children, and there appears to be a steady progression in accuracy with age. This may be due in part to the larger vocabularies of the older children compared to the younger children. There may also be differences among the individual stimulus items chosen, which will be explored in the next analysis.

The suffix effect appears to coincide with relative frequency of the suffixes examined. The suffix *-ment* is the most frequent suffix encountered by children,

as measured in the children's literature corpus, and the stress on words suffixed with *-ment* are judged appropriately more often than words suffixed with either *-ness* or *-ful*.

Analysis 3: Item-by-item Analysis

The individual words were compared to each other within each suffix token and word type (i.e., all real stem *-tion* words were contrasted, all nonsense *-ness* words were contrasted, etc). Each stimulus item was scored such that if a child accurately chose the correct member of the minimal stress pair, that item received a score of "1", if a child was incorrect, that item was scored "0".

Rhythmic suffixes are reported first, and are separated into real and nonsense words.

Rhythmic Suffixes

Each group's mean proportion of correct stress judgments for each stimulus item is presented in Table 24. The mean proportion was calculated by tallying the children who accurately judged a given stimulus item, then dividing the total correct responses by the total number of children in the group.

The real word derivations were evaluated separately from the nonsense word derivations. The real word stems are discussed first. As in the production experiment, the primary interest was to compare the individual stimulus items within each suffix token, where possible. Therefore, the data were collapsed across the groups.

Table 24. Mean Proportions and Standard Deviations for Rhythmic Suffix

Stimulus Words: Perception Accuracy.

Rhythmic Suffixes	Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)		Children Total		Adult (N = 10)
	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.	mean
REAL STEMS									
information	1	0	1	0	1	0	1	0	1
relation	1	0	.94	.24	1	0	.98	.14	1
education	1	0	1	0	1	0	1	0	1
operation	1	0	1	0	1	0	1	0	1
atomic	.68	.48	.83	.38	1	0	.83	.38	1
symbolic	.63	.50	.61	.50	.73	.46	.65	.48	1
realistic	.53	.51	.56	.51	.67	.49	.58	.50	1
electronic	.89	.32	.94	.24	1	0	.94	.24	1
authority	.79	.42	.78	.43	.93	.26	.83	.38	1
prosperity	.58	.51	.50	.51	.73	.46	.60	.50	1
possibility	1	0	1	0	1	0	1	0	1
university	.68	.48	.89	.32	.80	.41	.79	.41	1
NONSENSE STEMS									
krandition	.95	.23	.89	.32	.93	.26	.92	.27	1
ebbation	.95	.23	.89	.32	1	0	.94	.24	1
odronition	.95	.23	.78	.43	1	0	.90	.30	1
trebitition	.37	.50	.67	.49	.73	.46	.58	.50	.80
tespetic	.74	.45	.89	.32	.53	.52	.73	.45	.80
atrilic	.68	.48	.78	.43	.73	.46	.73	.45	1
raslekaric	.47	.51	.50	.51	.53	.52	.50	.50	.90
ubratimic	.47	.51	.56	.51	.60	.51	.54	.50	.80
kloripity	.47	.51	.67	.49	.67	.49	.60	.50	.90
rupidity	.58	.51	.50	.51	.27	.46	.46	.50	.90
atavility	.84	.37	.89	.32	.93	.26	.88	.32	1
onalarity	.42	.51	.33	.49	.73	.46	.48	.50	1

The items in bold type were significantly different from others in the same category (e.g., the real words suffixed with -ic).

Real Word Stems

An ANOVA was not appropriate for the real *-tion* derivations due to ceiling-level performances across the three groups. ANOVAs were used to evaluate the differences among the real *-ic* and *-ity* derivations.

There was a significant main effect for the *-ic* derivations, $F(3, 147) = 8.19, p < .0001$. Planned comparisons contrasted each of the *-ic* stimulus items with each other. Stress judgments for the item "atomic" were more accurate than for both "symbolic" and "realistic", $F(1, 49) = 3.91, p = .05$, and $F(1, 49) = 8.51, p = .005$, respectively. Furthermore, performance on the stimulus item "electronic" was also better than "symbolic", $F(1, 49) = 12.56, p = .0009$, and "realistic", $F(1, 49) = 23.76, p < .0001$.

There was also a significant item effect for the *-ity* derivations, $F(3, 147) = 9.65, p < .0001$. The stimulus word "possibility" was the only real *-ity* derivation to be judged correctly by all children. In addition, "prosperity" appeared to be the most difficult to judge. Performance on "authority" was significantly better than on "prosperity", $F(1, 49) = 6.93, p = .01$, and performance on "university" was almost significantly better than on "prosperity", $F(1, 49) = 3.83, p = .06$.

Nonsense Word Stems

There were also some differences among the nonsense words with rhythmic suffixes. For nonsense words ending in *-tion*, there was an item effect,

$F(1, 147) = 13.15, p < .0001$. The item effect was due to the stimulus “trebetition” which was judged incorrectly significantly more often than “krandition”, $F(1, 49) = 19.86, p < .0001$, “ebbation”, $F(1, 49) = 19.16, p < .0001$, and “odronition”, $F(1, 49) = 13.26, p = .0007$.

The nonsense words ending in *-ic* were significant for item, $F(1, 147) = 3.35, p = .02$. There were significantly more errors for “raslekaric” and “ubratimic” than for either “tespetic” or “atrilic”. The results of the contrasts are as follows: “tespetic” v. “raslekaric”, $F(1, 49) = 5.97, p = .02$; “tespetic” v. “ubratimic”, $F(1, 49) = 4.23, p = .05$; “atrilic” v. “raslekaric”, $F(1, 49) = 6.27, p = .02$; “atrilic” v. “ubratimic”, $F(1, 49) = 4.08, p = .05$.

Finally, for the nonsense words suffixed with *-ity* there was an item effect, $F(1, 147) = 10.71, p < .0001$, and a significant interaction between age and item, $F(1, 147) = 2.34, p = .03$. These were the only stimuli in which an interaction between age and item appeared. The item effect was due to the stimulus “atavility” which received significantly more correct judgments than “kloripity”, $F(1, 49) = 12.51, p = .0009$, “rupidity”, $F(1, 49) = 28.18, p < .0001$, and “onalarity”, $F(1, 49) = 19.92, p < .0001$. The interaction appears to be due primarily to the groups’ performance on the item “onalarity”. Nine-year old children gave more correct stress judgments than 8-year olds, $F(1, 49) = 5.55, p = .02$. The difference between 7- and 9-year old children was nearly significant for “onalarity”, $F(1, 49) = 3.46, p = .07$, and “rupidity”, $F(1, 49) = 3.32, p = .07$, which is something of a paradox because the youngest children performed better (although not quite statistically better) than the oldest children.

Neutral Suffixes

The mean proportion and standard deviation for each neutral suffix item and age group are reported in Table 25. Where appropriate, the groups were collapsed and t-tests were used to evaluate the differences between the stimulus items of each suffix type.

Table 25. Mean Proportions and Standard Deviations for Neutral Suffix Stimulus

Words: Perception Accuracy.

Neutral Suffixes	Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)		Children Total		Adult (N = 10)
	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.	mean
REAL STEMS									
argument	1	0	1	0	.93	.26	.98	.14	1
government	.89	.32	1	0	.87	.35	.92	.27	1
embarrassment	1	0	1	0	1	0	1	0	1
environment	1	0	.94	.24	1	0	.98	.14	1
pleasantness	.89	.32	1	0	1	0	.96	.19	1
restfulness	.89	.32	.78	.43	.93	.26	.87	.34	1
effectiveness	.58	.51	.83	.38	1	0	.79	.41	1
deliciousness	.79	.42	.89	.32	1	0	.88	.32	.90
pitiful	.53	.51	.89	.32	1	0	.79	.41	1
wonderful	.79	.42	.83	.38	.93	.26	.85	.36	1

The items in bold type were significantly different from others in the same category (e.g., the real words suffixed with -ness).

For the items suffixed with *-ment*, performance was good across the three groups. All children were accurate judging derivations suffixed with *-ment*.

To explore the overall differences between the words suffixed with *-ness*, the groups were collapsed and the individual items were contrasted. Overall, stress judgments of the word “pleasantness” were significantly better than “effectiveness”, $t(df\ 51) = 3.27$, $p = .002$, and nearly significantly better than “restfulness”, $t(df\ 51) = 1.94$, $p = .06$. Across the groups, the only item that showed remarkable improvement was the word “effectiveness”, which may not have been familiar to the youngest children.

Although the two stimulus items ending in *-ful* (“pitiful” and “wonderful”) did not differ from each other overall, $t(df\ 51) < 1$, (i.e., with groups collapsed), they did differ significantly for the youngest group (7-years old), $t(df\ 18) = -2.04$, $p = .056$. Accurate stress was more difficult to judge for “pitiful” than “wonderful” for Group 1, but not for the other two groups. This may be due to unfamiliarity of the word “pitiful” to the youngest group.

Summary of Analysis 3

There were item differences among the real and nonsense rhythmic stimulus items, and item and age differences among the neutral stimulus items. Familiarity appears to play a role in the performance with real words. This is particularly evident with the neutral stimuli. There was no age effect for the rhythmic derivations because of ceiling-level performance, however, there does appear to be a gradual, age related improvement in stress judgment accuracy for the *-ic* and *-ity* derivations.

Of course, for the nonsense rhythmic stimuli there is no familiarity explanation, and yet children were more (or less) accurate on some items. But it is here, specifically the items on which all children performed poorly that we again see an age-related improvement. This evidence suggests that word familiarity is not the only factor at work. In fact, this is evidence of rule learning. For example, all children erred more frequently on the item “trebetition” than on the other three nonsense *-tion* derivations. They preferred “TREbetition” over “trebeTItion”. However, a closer look reveals a steady improvement with age; correct responses increased from 37% to 67% to 73% for Groups 1, 2, and 3 respectively. This pattern is in accord with a rule-based account in which children are learning where stress falls in rhythmic derivations.

Analysis 4: Individual Differences

As with the production data, an analysis of each individual child’s performance was done to determine if some children were better at stress judgments than others. The data for each group can be seen in Tables 26, 27, and 28. All three conditions (RhReal, RhNon, and NeutReal) can be found on these tables. As was done previously in the production tables, these data are ordered by total percentage correct for the combined real and nonsense rhythmic derivations.

Performance within the three groups does not appear to be related to age; there is no pattern to suggest that older children are performing better than

younger children within a group. Across the three groups, RhReal derivations were more accurate than RhNon derivations, with only five exceptions (9.6% of all the children) where more nonsense derivations were judged accurately than real derivations. Those exceptions were contributed by some of the most accurate children, although there are too few to identify any pattern.

There were also a few children whose RhReal accuracy exceeded RhNon accuracy more than most children. This is indicated by a difference score greater than the norm. The four participants' scores shown in bold type have a difference score of 5 or greater, meaning that they were correct on at least five more real rhythmic derivations than nonsense rhythmic derivations. The decision to make 5 the cutoff point was arbitrary, but it highlights the fact that some children had a stronger lexical bias than others.

Unlike the production experiment, the condition including nonsense neutral derivations was not available for comparison. However, several observations can be made. In Group 1, accuracy on the NeutReal derivations appears to follow overall accuracy on the rhythmic derivations. Children who judged the rhythmic derivations correctly also tended to judge the neutral derivations correctly. There are also several cases (marked on the tables with asterisks) where accuracy on NeutReal derivations was below that of the rhythmic derivations overall. This pattern is less evident for Group 2 and does not appear at all for Group 3, because of near ceiling performance.

Table 26. Individual Perception Performance: Group 1

Participant	Age	Rhythmic Real Word	Rhythmic Nonsense Word	Rhythmic Total	Rhythmic Word Type Difference	Neutral Real Word
104	7;4	10 (83%)	12 (100%)	92%	-2	10 (100%)
113	7;4	11 (92%)	10 (83%)	88%	1	9 (90%)
119	7;7	11 (92%)	10 (83%)	88%	1	10 (100%)
101	7;1	10 (83%)	10 (83%)	83%	0	9 (90%)
103	6;6	11 (92%)	8 (67%)	79%	3	10 (100%)
112	7;5	10 (83%)	9 (75%)	79%	1	9 (90%)
116	7;8	11 (92%)	8 (67%)	79%	3	10 (100%)
109	6;10	9 (75%)	9 (75%)	75%	0	9 (90%)
102	6;10	12 (100%)	5 (42%)	71%	7	9 (90%)
106	6;11	10 (83%)	7 (58%)	71%	3	10 (100%)
110	6;9	10 (83%)	7 (58%)	71%	3	5 (50%) *
111	7;8	10 (83%)	7 (58%)	71%	3	8 (80%)
114	7;8	9 (75%)	8 (67%)	71%	1	8 (80%)
118	7;9	9 (75%)	8 (67%)	71%	1	6 (60%) *
107	6;7	9 (75%)	7 (58%)	67%	2	6 (60%) *
105	6;8	9 (75%)	6 (50%)	63%	3	8 (80%)
117	7;7	8 (67%)	7 (58%)	63%	1	9 (90%)
108	7;0	9 (75%)	5 (42%)	58%	4	6 (60%)
115	7;6	8 (67%)	6 (50%)	58%	2	8 (80%)

Participants who performed better than most on the RhReal than on the RhNons items (as indicated by a difference score of > 5), are shown in bold type.

The "*" indicates participants whose proportion correct for neutral derivations (NeutReal) was worse than the proportion correct for all rhythmic derivations (Rhythmic Total).

Table 27. Individual Perception Performance: Group 2

Participant	Age	Rhythmic Real Word	Rhythmic Nonsense Word	Rhythmic Total	Rhythmic Word Type Difference	Neutral Real Word
207	7;11	11 (92%)	11 (92%)	92%	0	9 (90%)
201	7;11	10 (83%)	11 (92%)	88%	-1	10 (100%)
204	8;1	11 (92%)	10 (83%)	88%	1	10 (100%)
211	9;0	11 (92%)	10 (83%)	88%	1	8 (80%) *
203	7;11	10 (83%)	10 (83%)	83%	0	10 (100%)
205	8;0	10 (83%)	10 (83%)	83%	0	9 (90%)
210	8;8	12 (100%)	8 (67%)	83%	4	10 (100%)
218	9;0	11 (92%)	9 (75%)	83%	2	10 (100%)
213	8;9	11 (92%)	8 (67%)	79%	3	9 (90%)
216	8;5	10 (83%)	9 (75%)	79%	1	10 (100%)
212	8;4	11 (92%)	7 (58%)	75%	4	10 (100%)
206	8;2	9 (75%)	8 (67%)	71%	1	6 (60%) *
209	8;5	8 (67%)	9 (75%)	71%	-1	9 (90%)
214	8;10	8 (67%)	9 (75%)	71%	-1	9 (90%)
215	8;2	10 (83%)	6 (50%)	67%	4	8 (80%)
202	8;1	9 (75%)	6 (50%)	63%	3	10 (100%)
208	8;5	10 (83%)	5 (42%)	63%	5	9 (90%)
217	8;11	9 (75%)	4 (33%)	54%	5	9 (90%)

Participants who performed better than most on the RhReal than on the RhNons items(as indicated by a difference score of > 5), are shown in bold type.

The "*" indicates participants whose proportion correct for neutral derivations (NeutReal) was worse than the proportion correct for all rhythmic derivations (Rhythmic Total).

Table 28. Individual Perception Performance: Group 3

Participant	Age	Rhythmic Real Word	Rhythmic Nonsense Word	Rhythmic Total	Rhythmic Word Type Difference	Neutral Real Word
306	9;1	11 (92%)	12 (100%)	96%	-1	9 (90%)
305	9;3	12 (100%)	10 (83%)	92%	2	10 (100%)
314	10;6	11 (92%)	10 (83%)	88%	1	10 (100%)
304	9;1	12 (100%)	8 (67%)	83%	4	10 (100%)
307	10;2	11 (92%)	9 (75%)	83%	2	9 (90%)
308	10;0	10 (83%)	10 (83%)	83%	0	10 (100%)
311	9;8	11 (92%)	9 (75%)	83%	2	10 (100%)
315	10;0	11 (92%)	9 (75%)	83%	2	10 (100%)
302	9;3	11 (92%)	8 (67%)	79%	3	10 (100%)
309	9;8	10 (83%)	9 (75%)	79%	1	10 (100%)
310	10;4	11 (92%)	8 (67%)	79%	3	10 (100%)
312	10;3	12 (100%)	7 (58%)	79%	5	10 (100%)
313	9;5	10 (83%)	9 (75%)	79%	1	8 (80%)
301	9;4	11 (92%)	7 (58%)	75%	4	8 (80%)
303	9;3	10 (83%)	6 (50%)	67%	4	10 (100%)

Participants who performed better than most on the RhReal than on the RhNons items(as indicated by a difference score of > 5), are shown in bold type.

Discussion

Recall that there were four issues examined in the perception experiment. The first was to examine whether accurate stress judgments on neutral derivations differed from rhythmic derivations. The second issue was whether a developmental progression was observable across the age groups included in the study. Third, to determine whether suffix frequency affected performance. Fourth, whether a lexical effect could be demonstrated by better performance judging real words than nonsense words.

The findings of the perception study, like those of the production experiment, showed that children judged primary stress more accurately on real words with neutral suffixes than on words with rhythmic suffixes (collapsed across suffix type), and that children's judgments generally improve as a function of age, with the exception of real *-tion* derivations on which all children performed well. Furthermore, suffix frequency does appear to be a factor because children correctly judged derivations with frequent suffixes (e.g., *-tion* and *-ment*) more often than derivations with less frequent suffixes (e.g., *-ic*, *-ity* and *-ness* and *-ful*).

Unlike the results of the production experiment, a lexical effect was obtained in the perception experiment between the real and nonsense rhythmic derivation judgments. Children were more accurate on real derivations than on

nonsense derivations. The reasons for this difference will be explored in the following chapter, which compares the results of the two experiments.

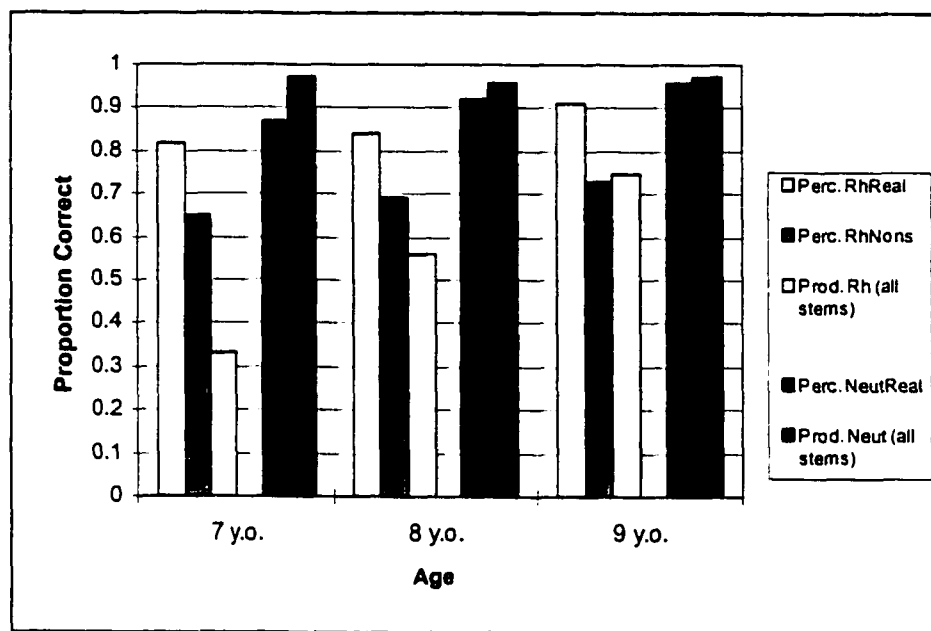
CHAPTER 6: PERCEPTION AND PRODUCTION

The goal of this section is to compare, contrast, and synthesize the results of the production and perception tasks. On the surface, the two tasks examined the same rules underlying rhythmic and neutral suffixation. The experiments were designed similarly and they employed similar stimuli. Nevertheless, some patterns of results were consistent across the perception and production tasks, whereas other patterns were not.

Common Patterns

There are three very consistent and compelling patterns of results across the two experiments. First, there is clearly a difference between rhythmic and neutral suffixes. In both the perception and productions tasks, children's performance on words with neutral suffixes was always better than their performance on words ending with rhythmic suffixes. In fact, neutral suffixes were so easy for the children they reached near ceiling performance levels. This can be seen in the consolidated graph in Figure 10. The data from the neutral derivations in both the perception and production experiment are seen in the two rightmost, darker columns for each age group. The rhythmic suffix data are represented in the three, lighter colored leftmost columns. All data are collapsed across the individual suffixes in each suffix type.

Figure 10. Consolidated Performance Data from the Perception and Production Experiments.



A second common pattern is that performance improved with age on words across the two experiments (i.e., there was a main effect of age in both perception and production of stress). The oldest children were generally more accurate on the experimental tasks than the younger children. The third consistent result reflects the effects of suffix frequency. In both experiments, performance on words derived with the most frequent rhythmic suffix, *-tion*, were better than those derived with the less frequent suffixes, *-ic* and *-ity*.

Differences

The obvious difference between the perception and production results is that generally, children performed more accurately on the rhythmic derivations in the perception task than in the production task. The differences between the perception and production results are found in the performance on both the real and nonsense stems, but they are most striking between the real rhythmic derivations. The data presented in Figure 11 show accuracy levels (in proportion correct) of real and nonsense stems with rhythmic suffixes. The two columns on the left for each age level represent real stem words and the two columns on the right are the nonsense stem words. Production data are indicated by the lighter colored columns. Perception task accuracy exceeds production accuracy on both the real and nonsense stems for the 7- and 8-year old children. However, the difference between the two tasks diminishes with increased age, especially for rhythmic derivations with nonsense stem words.

Figure 11. Rhythmic Derivation Data from the Perception and Production Tasks.



Performance accuracy was high for the neutral derivations across both tasks. However, when we compare the neutral derivations across the two tasks, production accuracy is slightly higher than perception, as seen in Figure 12. This is the reverse of the pattern seen for the rhythmic derivations, where perception was better than production. However, this pattern of decreased accuracy in the perception task can be traced to just a few stimulus items that were probably unfamiliar to the youngest children (i.e., “pitiful” and “effectiveness”). Again this

difference decreases with age; in the oldest group, the scores from the two tasks approximate each other.

Figure 12. Neutral Derivation Data from the Perception and Production Tasks.

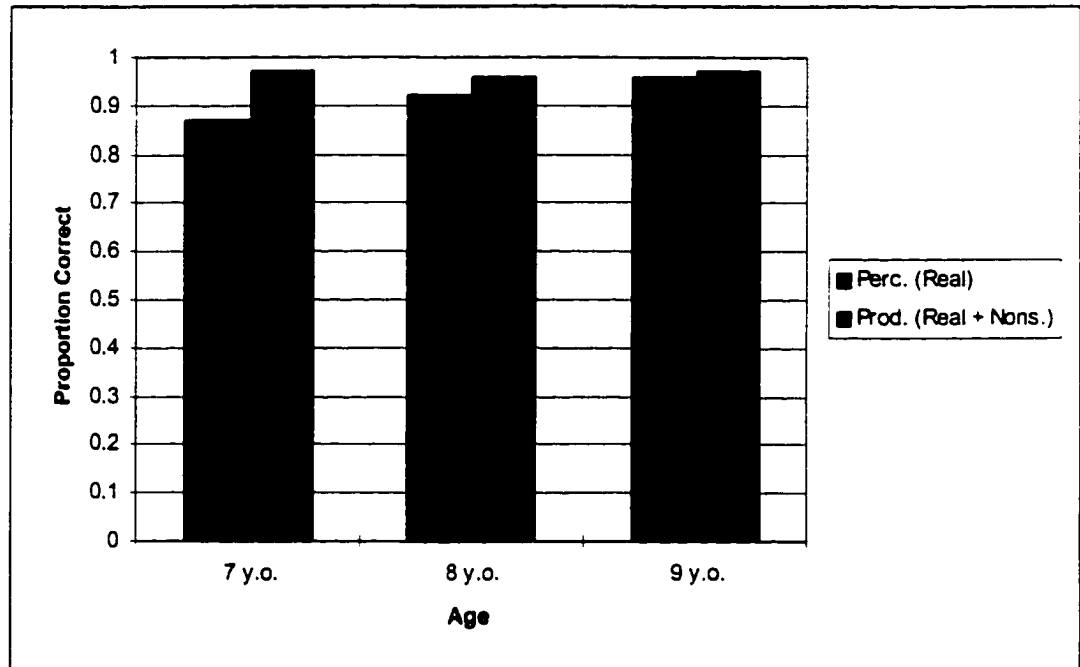


Figure 13 a, b, and c illustrate performance on the individual rhythmic derivations across the two tasks. The *-tion* derivations are shown in Figure 13a, separated by task and by stem (real or nonsense)⁸. Results for the *-ic* and *-ity* derivations are shown in Figure 13b and 13c respectively. The production results are in the rightmost column(s). Again, the discrepancy between perception and production accuracy decreases with age, and in the case of *-tion*, accurate

⁸ Production results are separated into real and nonsense stems only for the *-tion* derivations because only the *-tion* derivations exhibited a difference in the word condition for Groups 2 and 3. Production results for the other two suffix types are collapsed across word condition for all groups.

production of real derivations surpasses perception of nonsense derivations by age nine, although this is due to difficulty with only one of the four *-tion* derivations in the perception task (i.e., “trebition”). Also, production is better than perception of nonsense *-ic* derivations for the 9-year old children. As noted previously, performance on *-tion*, the most frequent rhythmic suffix included in the study, is better than that of the other two rhythmic suffixes regardless of the task.

Figure 13a. Perception and Production Data for *-tion* Derivations

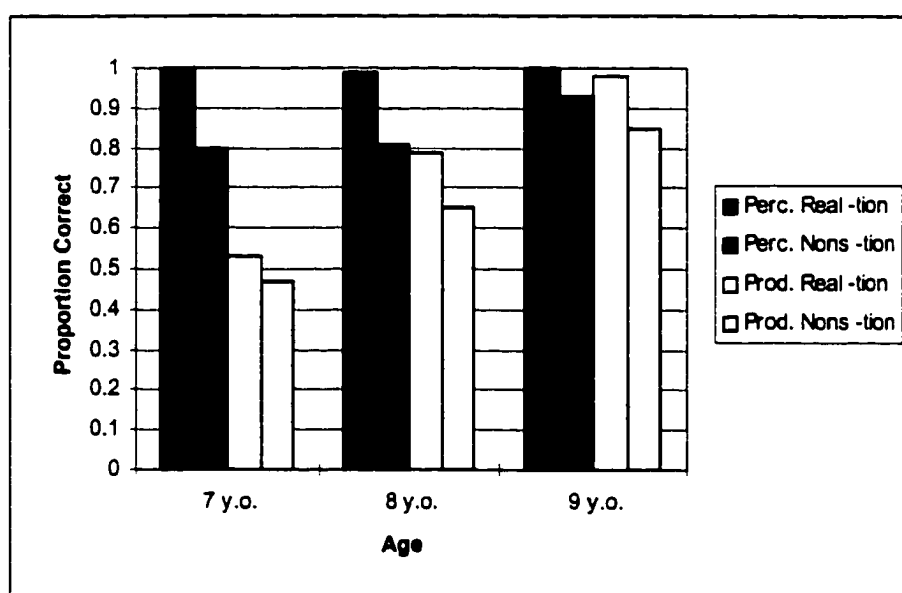


Figure 13b. Perception and Production Data for *-ic* Derivations

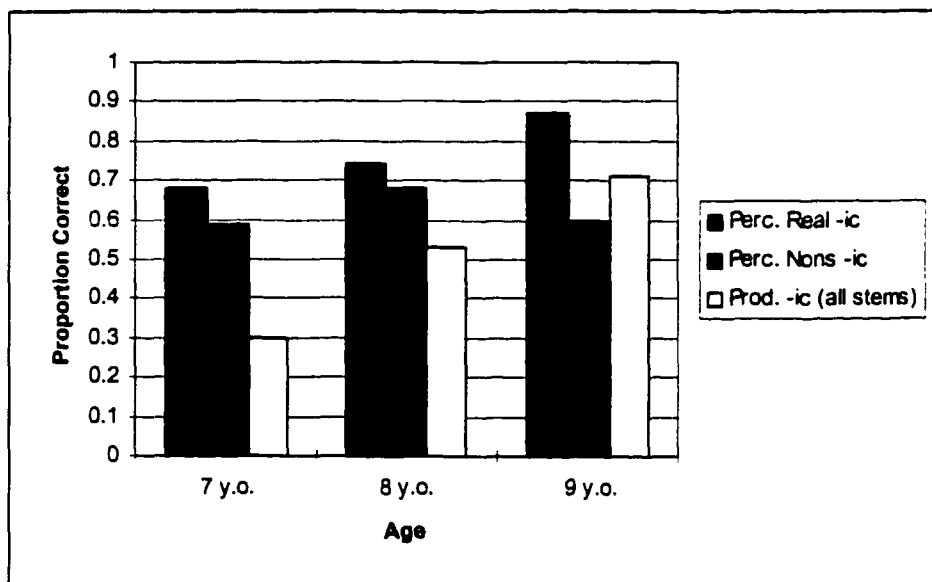
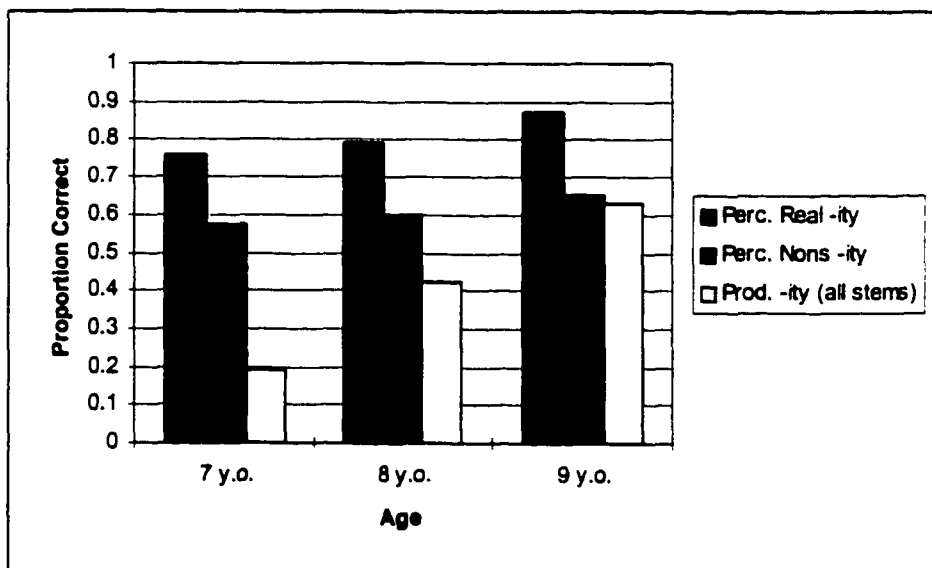


Figure 13c. Perception and Production Data for *-ity* Derivations



Discussion

The differences between the perception and production performance can be attributed partially to the tasks themselves. The perception task placed fewer metalinguistic and cognitive requirements on the children than the production task. Recall that in the production task children were given a suffix then a stem and asked to combine them into a word. Thus, children were required to keep the two morphemes in their memory, switch them so that the suffix was on the end of the word, then say it out loud, assigning primary stress somewhere in the word. Furthermore, the younger children might not have had the morphological awareness or word attack strategies that the older children had. In contrast, the perception task was more passive. Children had only to listen to a minimal stress pair and indicate their preference for one of them. Thus, the production task may have placed more demands on children to keep in memory and consciously manipulate free and bound morphemes. As children's metalinguistic skills improved, performance accuracy on the production task became more like the perception task.

One of the more puzzling results is that a difference is obtained between the real and nonsense words in the perception task, but is not consistent in the production task (i.e., only for *-tion* derivations for the 8- and 9-year old children). This difference is a reflection of how the stimuli are processed in the lexicon, and are a direct (albeit inadvertent) consequence of the tasks employed. However,

before the discussion of the present results can commence, the issue of lexical representation and processing must be addressed.

What we know about words includes both semantic and formal knowledge, the latter of which includes phonological, morphological, and orthographic representations (Burani & Caramazza, 1987; Chialant & Caramazza, 1995). The theories used to explore lexical representation are based in lexical access, and as such they are mainly models of word recognition. Early theories of lexical processing contributed models that were of two types: whole-word access models and morphological decomposition models. In the former type, all words – morphologically simple and complex – have their own lexical entry (Lukatela, Gligorijevic, Kostic and Turvey, 1980), whereas in the latter type, all words are automatically decomposed into morphemic units (Taft & Forster, 1975).

Current models of lexical processing suggest a middle ground, in which both a whole-word and a decomposition path are available. Which path is chosen depends primarily on distributional properties such as word frequency and affix productivity⁹ (Bybee, 1995; Chialant & Caramazza, 1995; Schreuder & Baayen, 1995). At the heart of these models is the assumption that a very frequent word, whether simple or polymorphemic, would have its own lexical

⁹ Productivity is defined differently by different authors, however a general definition relies upon semantic transparency or coherence (e.g., a given affix has the same meaning in all environments, like the inflectional ending -s to indicate plurality), conceptual complexity (e.g., concrete vs. abstract), and frequency of occurrence (Aronoff, 1976; Bybee, 1995; Chialant & Caramazza, 1995; Clark, 1993; Schreuder & Baayen, 1995.)

representation. Decomposition would be required for novel and infrequent words (Chialant & Caramazza, 1995), or for semantically transparent complex words where the individual morphemes have regular and predictable meanings (Schreuder & Baayen, 1995). Based on these models, processing, and in particular accessing real derived words and nonsense derivatives involves two different processes: whole-word, or direct, access and access through morphological decomposition.

Although the current study was not designed to examine lexical access issues, it did make two assumptions. First, the rules of lexical phonology were assumed to be a compulsory component of the production and recognition of a word. This assumption is not controversial in light of the lexical processing models; all lexical representations must have a phonological form. In addition, recognition of a word might require that it be broken down, or decomposed, into morphological units to be accessed. Lexical phonology can account for both of these facts.

The second assumption involved the character of the lexicon and the routes available to arrive at a word's representation. The rules of lexical phonology are indeed within the lexicon as part of a word's representation, but there is also more information included in that representation (e.g., semantic, formal, and perhaps some general gestalt knowledge). Furthermore, there is more than one way to arrive at the underlying form (Bybee, 1995; Chialant & Caramazza, 1995; Schreuder & Baayen, 1995). Thus, lexical phonology is a part of a larger whole, and although speech production requires active participation of

the lexical phonological rules to give a word phonological form, including the correct primary stress, perception may rely more heavily on the larger whole than solely on morphophonological information to access a word. Consequently, the assumption that the only way to the representation of a word is through lexical phonology, and in particular through the morphophonological rules that apply after affixation, may not be true.

We can infer that adults have the direct access and morphological decomposition routes available to them when accessing words, which accounts for their ceiling performance in both the production and perception tasks, regardless of suffix or word type. Children, however, are doing something different. The consistent lexical effect in the perception experiment is not surprising when we enlarge our view of the lexicon to include direct access to entire derived words. Children are accessing words directly, without appealing to decomposition, which is why even the youngest children find words with incorrect stress, like "embarASSment", "elECtronic", and "inFORmation", not only easy to dismiss but humorous. Conversely, they must use the morphophonological route in the production experiment and when judging nonsense derivations. With this new perspective, let us return to the two experiments.

In the production task, participants were given stems and suffixes to combine, and regardless of whether the stem was a real English word or not, they started at the same place – at the beginning of the morphophonological rules. With respect to real derivations, adults produced and recognized the newly formed words rapidly and with few exceptions. In contrast, children may have

accessed and recognized a real stem word from their lexicon (i.e., the word provided, such as “active” or “celebrate”), however, they did not necessarily recognize the derived word until they joined the two morphemes, applied the lexical phonological rules correctly, and processed the final output. For example, a child who was told to attach the suffix *-tion* to the end of “celebrate”, would have accessed and understood the word “celebrate”, but not until the derivation was correctly formed would he/she recognize “celebration”. In fact, there were children who would quietly work on putting a real derivation together before they gave their answer, and sometimes in the process of deriving the word or hearing themselves say the word, they would suddenly recognize the derived word in their lexicons. This did not always happen, and children could still produce a word correctly (with correct stress) without recognizing the entire derived word, as would be the case for the nonsense stems. Thus, a child can produce a word correctly without recognizing it, suggesting he/she is simply applying rules that might not access a word’s meaning, but he/she cannot recognize a word without producing it correctly (i.e., correct application of the lexical phonological rules).

In order to recognize a word, it must be accessed – either through a direct route or through the decomposition route. Considering the lack of consistent differences between the real and nonsense words in the production task, we may conclude that collectively children were forming rhythmic derivations by applying the phonological rules without accessing the semantic representation. That is, children were asked to morphologically compose words independent of any lexical access. Only the oldest children in the study, the 9-year olds, began to

exhibit measurable differences between real and nonsense words with the most frequent and most accurate rhythmic suffix *-tion*.

In the perception task, the entire derived word was given to the children. Upon hearing a familiar word, a child could compare the stress of that word to his or her stored representation of the derived word. In fact, many children laughed when they heard the incorrect stress on “embarASSment” or “eIECtronic”, presumably because primary stress clearly conflicted with their stored representation of these words. Real word perception is tapping into a different level of the lexicon than the lexical phonology rules; children are using a direct route rather than a decomposition route to arrive at a lexical representation. Furthermore, if children are accessing real derivations without appealing to decomposition, then they must have stress also stored (in some form) with the whole word representation.

Judging nonsense rhythmic derivations demanded more analysis than real words, and required thorough understanding of the rules for rhythmic suffixes. In order to judge a derived nonsense word with a rhythmic suffix it must be decomposed and the suffix identified, then fed back through the phonological rules. In this way, judging nonsense derivations resembles the requirements of the production task, although the former task involves both analysis and synthesis whereas the latter task required only synthesis. If we re-examine the data in Figures 13a, b, and c, we see that, without fail, the pattern of the nonsense perception data is closer to the production data pattern than it is to the

real word perception data. In fact, by age nine nonsense rhythmic derivation perception and rhythmic derivation production are very similar.

Further evidence that children are accessing the derived word in the perception task but not in the production task comes from a post hoc examination of the derived word frequencies and accuracy levels. It is well established that the lexicon is sensitive to frequency information (Bradley, 1980; Forster, 1990; Taft & Forster, 1975). Frequencies for the real rhythmic derivations used in the two tasks were obtained from Carroll, Davies, and Richman (1971), and were numerically represented by a Standard Frequency Index (SFI). The SFI is a logarithmic scaling of the estimated frequency per million. Thus, a word with an SFI of 90 would be expected to occur in one out of ten words; a word with an SFI of 80 occurs in one out of 100; a word with an SFI of 40 occurs in one in a million. The SFI was compared to the sum of correct responses across all children ($N=52$) for a given derived word. The raw data appear in Appendix P for both tasks. If the assumption that children are accessing the whole derived word in the perception task but not the production task is accurate, then we should see a derived word frequency effect in the perception task only. In fact, this is what occurs. A strong positive and significant correlation is found between the SFI and accuracy for perception, $r = .76$, $p = .004$, but not for production, $r = -.12$, $p = .70$.

This evidence supports two claims. First, children are accessing the whole derived word in the perception task, but not in the production task. With respect to real derivations, the two tasks are not measuring the same parts of the lexical

system. The perception task tapped into lexical representations that are frequency sensitive, whereas the production task accessed the morphophonological rules directly. Second, these results also support the claim that children have whole rhythmic derivations stored in their lexicons with primary stress represented with the rhythmic derivations. Children are accessing lexical representations directly in the perception task, however, the task required that they choose the correct primary stress from a pair of minimal stress pairs. Thus, the only way children could have judged stress and shown a frequency effect of the rhythmic derivations is if they also had primary stress stored with the representation of the derivation.

Unlike adults, who are able to use both the direct access route and the morphological decomposition route with equal proficiency, children appear to have the direct route available, but are still in the process of developing the decomposition route. Children can use the direct access route to a lexical representation when they hear a derived word that already has a lexical entry. This appears to be what children are doing when judging real words in the perception task. However, when children must use the decomposition route (e.g., for either production or nonsense derivation judgments), their performance is worse than when they use the direct access route. This is confirmation that the parts of the methodology employed in this study are evaluating morphophonological rule development. The lexical phonological rules triggered after affixation involve both morphological and phonological processes. These are likely the same processes used in the decomposition route. Therefore, a

decomposition route to the lexicon would not be fully functional if the rules associated with that route were not yet fully formed. That is, if children do not have a rhythmic suffix marked for [+cyclic] stress rules, then they will not be able to judge or produce derivations with that suffix as well as they would judge or produce derivations that were stored as whole units in their lexicon.

CHAPTER 7: GENERAL DISCUSSION

Contrary to prior studies examining the development of derivational morphology, this study isolated the phonological (i.e., suprasegmental) elements characteristic of two types of English suffixes: rhythmic and neutral. Although other studies included words with stress alternations, they focused on lexical and semantic development (Stotko, 1992; Tyler & Nagy, 1989; Wysocki & Jenkins, 1987) or reading and spelling development (Carlisle, 1988; Templeton & Scarborough-Franks, 1985). The few studies that have addressed phonology directly, either concentrate on segmental changes (Moskowitz, 1973), or focus on morphological productivity, rather than phonological rules (Gordon, 1989), or examine lexical processing of phonologically transparent versus phonologically opaque derivations (Windsor & Hwang, 1999b).

This study examined the development of morphologically conditioned stress alternations in English. To that end, a perception and production experiment was designed with rhythmic and neutral derivations and administered to 7- 8- and 9-year old children. Unlike prior developmental work on morphophonology, this study specifically explored phonological rule acquisition. The results of these experiments will be discussed in two ways. First, the specific hypotheses proposed earlier in this paper will be reviewed in light of the results from the two experiments. Then the results will be considered from a learnability perspective.

Hypotheses

Rhythmic and Neutral Suffix Differences

The study was designed to examine the phonological differences between rhythmic and neutral suffixes. I hypothesized that because the suffixes to which young children are exposed are all noncyclic [-cyclic], such as inflections and neutral suffixes like *-er*, school-aged children should have already acquired the phonological rules for neutral suffixes. Furthermore, children should err more often on words with rhythmic suffixes than with neutral suffixes not only because neutral suffixes are more semantically transparent, as suggested by others (Derwing & Baker, 1979, 1986; Tyler & Nagy, 1989), but because rhythmic derivations are phonologically more complex than neutral derivations.

Phonological complexity has been found to be a factor in children's lexical processing (Stotko, 1992; Windsor & Hwang, 1999b), however this study examined the rule learning underlying phonological complexity (i.e., stress alternations). Specifically, it was hypothesized that children would treat rhythmic suffixes like neutral suffixes because they have not yet deduced that rhythmic suffixes are [+cyclic]. Therefore, children were expected to make not only more errors on rhythmic than neutral derivations, but predictable errors. The types of errors predicted were that children would assume all suffixes were [-cyclic], and, hence, require no reapplication of the stress rules, resulting in an absence of stress shift. Simply, children were expected to retain stem stress in rhythmic derivations like they would in neutral derivations.

In both the production and perception experiments, the results clearly indicated that neutral derivations were easier for children to perceive and produce accurately than rhythmic derivations. This is essentially a replication of studies that also found a similar dissociation between the two suffix types (Gordon, 1989; Stotko, 1992; Windsor & Hwang, 1999b). Performance on neutral suffixes was near, or at, ceiling levels for every age tested across the two experiments. Furthermore, the types of errors that children made on rhythmic derivations were exactly those predicted; they failed to shift stress. This evidence supports the theory that children are initially assuming that all suffixes in English are [-cyclic].

Developmental Evidence of Rule Acquisition

Clearly, even children as young as 7-years old have no difficulty producing or perceiving neutral derivations. We can conclude that the children in this study already knew the noncyclic rules by the time they were 7-years old, and therefore, no age related improvement was observable. Conversely, performance with the rhythmic derivations showed a robust developmental pattern in the production experiment, and a general developmental trend in the perception experiment. The oldest children correctly reassigned stress in rhythmic derivations more often than the youngest children in both the perception and production experiments. This is evidence that children are acquiring the phonological rules for rhythmic suffixes.

Stress rule learning for rhythmic derivations was most apparent in the production study. With an increase in age, children were able to produce novel and real rhythmic derivations accurately. Accuracy on rhythmic derivations improved significantly between the 7- and 8-year old children and the 8- and 9-year old children. The 7-year old children produced accurate stress on only 33% of the rhythmic derivations tested. The 8-year olds improved to 56%, and the 9-year olds were clearly using rules, resulting in accurate stress production on 76% of the rhythmic stimuli.

There are several factors that may account for these results. First, although there is clearly an age-related developmental progression of rule acquisition, age alone cannot fully explain children's performance. There was variability among the children in the same age group, especially in the younger groups. Second, some children (often the youngest) may not have been fully aware that the rhythmic suffixes used in this study were separate morphemes, whereas the older children had more morphological awareness. This would unquestionably be the first step if suffixes are lexically marked for certain phonological rules. Although morphological awareness was not sufficiently controlled in this study, it seems plausible that this may have affected individual children's performance. Finally, exposure to the language and specifically to the types of rhythmic derivations examined in this study may account for the improvement across groups, and possibly account for some of the differences within the groups. Doubtlessly, these factors are woven tightly together, and at this juncture, we are unable to take them apart sufficiently. Nevertheless, we

can conclude that children are more accurate with primary stress production and perception as they get older because they have recognized that English has two different types of suffixes, and they are forming rules in their grammars. The oldest children, of course, have had the most experience with the language, and much like children who learn the difference between regular and irregular past tense after a period of overgeneralization, they have identified the differences and do not make as many mistakes as the younger children.

Lexical Storage versus Rule Application

The contrast between real and nonsense derived words was included to determine whether children assign primary stress by rule, or if they store primary stress with a lexical entry. Children's production of nonsense derivations provided evidence that children were applying the rhythmic stress rules. Furthermore, children were not using a strategy of just repeating back the stem word with the suffix appended, because even the youngest children were able to accurately shift stress on some of the derived words: as mentioned above, the 7-year old children were able to accurately stress 33% of the rhythmic derivations they produced (34% on real and 32% on nonsense derivations). To the extent that they knew the [+cyclic] rule associated with a rhythmic suffix, the children applied that rule to both real and nonsense stem words. This was true across the three age groups.

In contrast, a lexical effect was present in the perception experiment for all age groups. Children were more accurate judges of primary stress on real

derivations than on nonsense derivations. This pattern was uniform across all age groups. Nevertheless, children were able to judge the stress placement on nonsense derivations fairly well (e.g., 65%, 69% and 73%, for 7-, 8-, and 9-year old children respectively). Since nonsense derivations cannot have lexical entries in the lexicon, primary stress placement could not have been stored with these forms. However, nonsense rhythmic derivations still have predictable, and rule-based primary stress determined by the suffixes themselves. Therefore, knowledge of the [+cyclic] rule associated with rhythmic suffixes will increase the likelihood of judging rhythmic derivations accurately. Children must have used some rule knowledge to judge the nonsense derivations with rhythmic suffixes as well as they did.

Despite the lexical effect in the perception experiment, children are clearly learning and applying rules. Children demonstrate knowledge and acquisition of rules not only in the production experiment, but also in their ability to judge nonsense derivations accurately. Nevertheless, the whole story is more complicated than either application by rule or lexical storage of derived forms. As indicated by the perception results, children also must have a fully formed lexical representation for some rhythmic derivations, with stress as part of the representation. This has interesting repercussions for learning. Children are not only learning the rules of rhythmic derivations, they are also building their lexicons, and it appears that perhaps the lexical items precede the rule. This will be discussed further in the learnability section to follow.

Suffix Frequency Effects

The results from the preliminary experiment, which established suffix frequency rankings from a children's literature corpus, are themselves interesting for the strikingly similar distribution of suffixes in children's literature to suffixes in adult literature (Mathews, 1998). These results also enabled the variable of suffix frequency to be controlled in the perception and production experiments.

There is developmental evidence to suggest that children are sensitive to the frequency of the input they receive. Tardif, Shatz and Naigles (1997) concluded that part of the reason that children learning English have a noun bias whereas children learning Mandarin have a verb bias is because of the frequency of nouns and verbs in the speech directed at children. In English, nouns are more often heard by children, while in Mandarin verbs are more numerous¹⁰. The hypothesis regarding suffix frequency was that children would acquire the phonological rules for more frequent and familiar suffixes prior to less frequent suffixes. A high, mid, and low frequency suffix was examined for both the rhythmic (*-tion*, *-ity*, and *-ic*, respectively) and neutral (*-ment*, *-ness*, and *-ful* respectively) suffix types in both the perception and production experiments.

Because children performed so well on the neutral derivations, a suffix frequency effect is difficult to determine in the production experiment. However, there is some indication in the perception study that performance on *-ment*, the most frequent neutral suffix tested, is better than for the two suffixes of lesser

¹⁰ The authors found an effect of both types and tokens of verbs and nouns in child directed speech across the two languages.

frequency for the 7- and 8-year old children.

A suffix frequency effect is more readily apparent with the rhythmic derivations. Children's performance was consistently better on the most frequent rhythmic suffix, *-tion*, than on either of the other two rhythmic suffixes. This was true across the two experiments. The suffix *-tion* was the most frequent suffix, and represented 13.6% of all the suffixes sampled in the children's literature corpus. The suffix *-ity* represented 3.12% of the sample, and *-ic* contributed 1.45% of the suffixes in the sample. Thus, there is a considerable discrepancy between the distribution of the most frequent suffix compared to the mid or least frequent suffix. Possibly, the difference between the mid and least frequent suffix was not large enough to produce a measurable effect.

Nevertheless, the perception experiment provides some evidence that children may be sensitive even to the distributional differences of *-ity* and *-ic*. In the perception of real derived words. Although not a statistically significant difference, 7- and 8-year old children performed better on *-ity* than *-ic* derivations (76% and 68% correct for 7-year olds, 79% and 74% correct for 8-year olds, on *-ity* and *-ic* respectively). This difference between *-ity* and *-ic* real derivations disappeared for the 9-year old children (87% and 87%), but on *-ity* nonsense derivations they achieved 65% accuracy compared to *-ic* nonsense derivations at 60%. Again, these are not statistically significant differences; however, they may reflect the frequency with which children hear these suffixes.

In sum, all of the hypotheses were supported to some degree. Clearly children master the phonological rules for neutral suffixes prior to those for

rhythmic suffixes. Moreover, children's production errors uphold the hypothesis that they are applying the [-cyclic] rule for neutral suffixes to the rhythmic suffixes. There appears to be a strong suffix frequency effect for the most frequent rhythmic suffix; however, there is less support for a frequency effect among the mid and low frequency rhythmic suffixes. Furthermore, there is little evidence that suffix frequency affects the neutral suffixes, however, that would be expected if all suffixes are assumed to behave like a neutral suffix. Finally, the bulk of evidence demonstrates that children between the ages of seven and ten are learning the phonological stress rules for the rhythmic suffixes included in this study.

Learnability

There are two central learnability issues raised in this study. One is how do children learn to stop overgeneralizing the stress pattern of the neutral suffixes. The second is how do children acquire the stress rules for rhythmic suffixes and generalize them in novel derivations. These issues will be discussed separately.

Overgeneralization

As mentioned previously (in Chapter 2), the demands of acquiring English suffixes require that children isolate a given suffix, identify the meaning of the suffix, determine the syntactic constraints of the suffix, and formulate a phonological rule for the suffix. They must do all of these steps with positive

evidence alone; children must rely on the input they receive. For children to be able to acquire the subtleties of suffixation, they must rely on their sensitivity to the distributional information in the input they are receiving, and appeal to the principles of Uniqueness and conventionality. Recall that Pinker's (1989) Uniqueness principle (similar to Clark's principle of contrast) states that there cannot be two forms with the same meaning, and the principle of conventionality (Clark, 1993) states that children will use positive evidence to drop their erroneous form and adopt the adult, conventional form. There is a third principle that also comes in to play: the principle of productivity (Clark, 1993). This principle states that the earliest forms acquired are the most productive forms (i.e., frequent and often semantically transparent). Children are believed to use these principles when learning inflectional suffixes, compound word formation, and the distribution of early derivational suffixes (e.g., agentive *-er*) (Pinker, 1989; Clark, 1993; Clark, Hecht & Mulford, 1989).

In the course of acquiring the phonological rules for rhythmic suffixes children appear to be overgeneralizing the more common and more familiar [-cyclic] rule of the neutral suffixes. Over time, children appear to be establishing the correct rule. There are some parallels here with other overgeneralization of inflectional suffixes, such as the regular past tense.

During acquisition of the regular past tense, children must first be able to identify the suffix *-ed*¹¹, associate it with the past tense meaning, formulate a rule

¹¹ In reference to *-ed*, I implicitly include the regular past tense allomorphs, however as first noted by Berko (1958), there are differences in children's ability to use the different allomorphs.

for application, and then learn which verbs accept the regular past tense form and which verbs do not. Recall that the regular past rule is often applied to verbs that have a lexical, irregular past form (e.g. run/ran/*runned). Children who make overgeneralizations have identified the suffix, attributed meaning to it, devised an application rule, but they have not yet learned which verbs accept the rule and which have an irregular form. With continued exposure to the language, acquisition of the lexical past forms, and appeals to the acquisition principles of uniqueness and conventionality, children eventually stop overgeneralizing in favor of the conventional adult form because they cannot allow two forms with the same meaning (e.g., runned and ran) in their lexicons.

In the present study we see a similar pattern. Once children have established the noncyclic phonological rule for neutral suffixes, they overgeneralize it to all suffixes; children assume that all suffixes are [-cyclic]. In much the same way that a verb must be identified as having an irregular past tense, rhythmic suffixes must be marked as cyclic in the lexicon. Children must learn which suffixes are [-cyclic] and which are [+cyclic]¹². The analogy to the acquisition of the past tense rule and lexical forms falls somewhat short of what children must do when acquiring the rhythmic suffix stress rule. Instead of determining which forms receive past tense by rule and which forms are lexically marked for past tense, children acquiring the derivational system are learning and distinguishing between two sets of morphophonological rules. A further

¹² Interestingly, according to the Lexical Phonology model, irregular past tense forms are generated at Level 1, where it was also hypothesized that rhythmic derivations are formed.

difference is that the [+/- cyclic] phonological rules are assumed to be lexically stored with the suffix, as opposed to inflectional markers which are appended outside of the lexicon and after all word formation rules have applied. Having pointed out these differences, the fact remains that children are overgeneralizing the [-cyclic] rules to rhythmic derivations. In this regard, children's errors bear some similarity to overgeneralization errors in other areas of morphological acquisition.

Children as young as age 7 appear to be in the process of identifying and forming the phonological rules for rhythmic suffixes. Although the 7-year old children are overgeneralizing the [-cyclic] rule to the rhythmic suffixes more than the two older groups, they are able to demonstrate some knowledge of the rhythmic suffix stress rules (i.e., 33% accuracy in rhythmic derivation production). They are not uniformly treating all suffixes as neutral. Furthermore, the suffixes on which children perform best are the suffixes they hear the most. The rhythmic suffix with the highest frequency would provide children with the most positive evidence (i.e., 7-year old children's stress production of *-tion* derivations was 50% accurate). Thus, children are already employing the principle of productivity as demonstrated by their differential treatment of high and lower frequency suffixes. In addition, they may be in the process of using the uniqueness and conventionality principles to guide them as they use the positive input they receive. Much like children who are inconsistent with irregular past tense, the 7-year old children are inconsistent with the [+cyclic] rule of rhythmic suffixes. By the time children are 9-years old, primary stress is 92% correct in their

production of *-tion* derivations, suggesting that they have recognized that *-tion* is a rhythmic not a neutral suffix (via the uniqueness principle), they know that *-tion* follows different phonological rules, and they know what those phonological rules are (via the principle of conventionality).

Although this study did not examine semantic or syntactic factors, other studies have indicated that children acquire the ability to recognize base morphemes in derived words by fourth grade (Tyler & Nagy, 1989). Furthermore, the ability to recognize the relationship between a derived word and a stem form increases from preschool through adulthood, and is influenced by both semantic and phonetic similarity (Derwing & Baker, 1979; 1977). Knowledge of the syntactic properties of derivational suffixes (e.g., knowledge that words ending in *-tion* and *-ment* are nouns, and *-ic* words are adjectives) appears to begin in fourth grade, and continues through eighth grade (Tyler & Nagy, 1989). Furthermore, there is evidence from a number of studies which shows that children are willing to overgeneralize, and accept overgeneralizations made with neutral suffixes (Tyler & Nagy, 1989; Stotko, 1992; Windsor & Hwang, 1999b). The study reported here is limited in its ability to address the relationships or order of acquisition between phonological, semantic, and syntactic knowledge with respect to derivational suffixes. Thus, it remains an empirical question whether children learn the phonological stress rules prior to the meaning or

syntactic distribution of a rhythmic suffix¹³.

In sum, children's behavior shows that learning the phonological rules for rhythmic suffixes is not much different from other areas of language learning. Children overgeneralize the [-cyclic] phonological rules of neutral suffixes to rhythmic suffixes. With positive evidence and time, in conjunction with the principles of uniqueness, conventionality, and productivity, children begin to notice that some suffixes are [+cyclic]. Starting with the most frequent rhythmic suffix (via the principle of productivity), there is a period in which children inconsistently produce rhythmic derivations as either [+ cyclic] or [- cyclic] (i.e., producing them with correct and incorrect stress). Once children realize a suffix can be associated with either one or the other type of phonological rule, but not both (via the uniqueness principle), they begin to adopt the conventional rule which is to lexically mark a rhythmic suffix [+cyclic]. The remaining question, which I will presently address, is how do children learn the stress rules for rhythmic suffixes.

Acquisition of cyclic rules

Children may learn isolated derived forms as lexical units, much like they may store unanalyzed syntactic phrases as whole units in early development (e.g., a preschool child may appropriately use the phrase "I don't know" long before they have the rules for negation and "do" insertion). As children learn

¹³ Once the [+cyclic] rule is associated with rhythmic suffixes it becomes possible for children to produce correctly, and, by extension, to read rhythmic derivations that they have not entirely analyzed semantically. Thus, some aspects of a lexical representation may be more fully developed than others.

more forms that have a common affix they reach a point where they have accumulated enough data where patterns begin to be identified. By way of illustration, a child may learn the meaning of words such as “celebration” or “education” before having the lexical representation of either “celebrate” or “educate” or before having isolated the suffix *-tion* as a word-forming derivational ending. Only after acquiring a number of *-tion* words, and perhaps a number of stem words, will children begin to identify a pattern. The pattern then becomes part of a separate representation for the suffix itself. Furthermore, what must be identified in this pattern, or representation, is the semantic, syntactic, and phonological characteristics of the suffix *-tion*. Once the phonological rule is developed it can be generalized to novel forms. Thus, once a rhythmic suffix is lexically marked [+cyclic] it will be treated as [+cyclic] on any words to which it is attached.

The evidence from this study supports this view. First, all children show a lexical effect on words with rhythmic derivations in the perception study, which indicates that they have lexical representations for at least some of the stimuli tested. Although this study does not provide information on all the details of children’s lexical representations, we can deduce that the representations include some information about stress placement, otherwise children would not have performed as well as they did when judging minimal stress pairs.

Second, if children are using distributional information, then the suffix frequency effect is to be expected. Children would learn the rules for the most common suffixes first. Indeed, children mastered the rules for the most frequent

suffix earliest and most completely. Thus, the more words a child hears with a given suffix, the more positive evidence he or she receives, which in turn influences his ability to identify and analyze it. Consequently, exposure helps a child to learn the phonological rule for that suffix.

Finally, some interesting differences surfaced in the individual performances of the children in the production experiment. Some children performed better on the real stems than nonsense stems (the lexical-children), while others performed as well or better on the nonsense stems (the rule-children). In general, the lexical-children who did better on the real stems than the nonsense stems did not perform as well on the production task overall. Possibly, these children have not established the rule for the rhythmic suffixes yet, and they continue to rely more heavily on the lexical representation. The rule-children are able to generalize the [+cyclic] rule for the rhythmic suffixes they were given to novel stems. Furthermore, this pattern is only apparent in the two older groups, suggesting that the rule is being formed between ages 8 and 9. This coincides with the evidence in the previous section, which showed that the 7-year old children are more likely to overgeneralize the [-cyclic] rule, but may be in the early stages of identifying the [+cyclic] rule. It is also possible that children differ in their metalinguistic skills, in particular their morphological awareness or general word attack skills (e.g., their ability to put a word together when given only the pieces). The production task relied heavily on metalinguistic manipulation of stems and suffixes. Thus, younger children may have had more

difficulty with the task due to other reasons in addition to rule identification and application.

I suggest that in the course of acquiring rhythmic suffixes, children first learn rhythmic derivations as whole lexical units. After they have a critical mass of lexical items with the same suffix, they begin to identify patterns and build a representation in the lexicon for that suffix. This entails that more frequent suffixes would reach that critical mass first, and thus be analyzed prior to less frequent suffixes. Children may rely on a lexical representation of a whole derivation until a still incomplete suffix representation is formed¹⁴, as the 7-year old children appear to do. Once the suffix representation is available, children must ascertain and store the appropriate phonological stress rule. When the [+cyclic] rule is stored with a rhythmic suffix representation, it becomes available for generalizing to novel environments. The suffix representation becomes more stable with age, because as age increases so does stress reliability on rhythmic derivations. Finally, the suffix representation is complete (solely from a phonological perspective) when only the correct phonological rule is stored and few stress errors are evidenced. The 9-year old children appear to be approaching this last stage with *-tion* derivations, although no children in this study perform at adult levels on all the rhythmic derivations.

¹⁴ Presumably, the suffix representation would include semantic, syntactic and phonological information, however, I see no theoretical reason why these different types of linguistic information cannot be learned and appended to the lexical representation at different times. Thus, it is possible to have an incomplete suffix representation.

Future Directions

This study was in many ways a baseline study for examining phonological acquisition of the derivational system in English. Thus, at the conclusion of this study many questions are raised, and several research directions present themselves.

From a theoretical lexical phonology perspective, stress assignment is only one of several cyclic rules. Stress assignment is unique in that it applies to monomorphemic words, and cyclically to polymorphemic words with rhythmic suffixes. The other cyclic rules, such as vowel and consonant alternations, apply only after a rhythmic derivation is formed (i.e., they never apply to monomorphemic words). Since children already know the English stress assignment rules, they just need to learn that some suffixes apply the same cyclic stress rules in derived environments. The other cyclic rules are restricted to only certain vowels and consonants preceding certain rhythmic suffixes (e.g., consonant & vowel: divide/division/divisive; consonant only: elude/elusive/elusory; vowel only: vane/vanity). Thus, it would be interesting to see at what point children acquire these other cyclic rules. Given that children in this study produced derivations like "microscopic" in which they correctly shifted stress, but did not change the vowel, I suspect that children learn some vowel alternations later than the cyclic stress assignment rules.

Another theoretical question that remains to be explored is how children syllabify rhythmic derivations that require a stress shift. This issue is closely related to stress because stress assignment is sensitive to syllable structure. A

closer examination of whether there is a developmental progression in the ability to syllabify derived words is warranted. We may find that syllabification, or perhaps, re-syllabification is difficult for younger children. There are some rhythmic suffixes that shift stress only if certain syllabic conditions are met. For example, *-a/* will allow stress to shift to the presuffixal syllable only if it is a closed syllable. Examination of these types of suffixes may provide information on syllabification and children's sensitivity to syllable weight.

The relationship between metalinguistic ability and stress shift in rhythmic derivations is another general area to examine. I suspect that metalinguistic skills influenced performance in this study, considering that the tasks involved manipulating and objectifying language. This study did not sufficiently explore children's metalinguistic skills as a performance factor. It may be the case that those children who found the tasks easier also performed better than those that found the tasks difficult. It may also be the case that children who have better phonological awareness skills for segments perform better on these types of suprasegmental tasks. For example, children who can sound out words or can manipulate phonemes in words may also find manipulating stems and suffixes facile. If so, the lack of a strong relationship between performance on the stress tasks and book exposure was somewhat surprising, considering the evidence linking phonological abilities with reading skill. At this point, a relationship with reading and stress shift on rhythmic suffixes cannot be ruled out. Curiously, even among the adult pilot subjects, some individuals responded more quickly and

more accurately than others. Possibly, some individual variation on this type of task is never completely eradicated upon achieving the adult grammar.

Testing different populations may provide insight into the acquisition of morphophonological rules, and may yield pedagogical or therapeutic benefits. Very few studies have examined derivational processes, specifically the phonological rules associated with rhythmic suffixes, with disordered populations. Windsor and Hwang (1999b) included children with specific language impairment (SLI) in their study of lexical processing of neutral and rhythmic derivations. They argued that SLI children have difficulty with rhythmic derivations due to the added processing load that accompanies rhythmic (what they call phonologically opaque) derivations. Nevertheless, how children with SLI learn rules, specifically morphophonological stress rules, is still largely unknown. One would suspect that, given the documented difficulty SLI children have with morphology (Leonard, 1989) and with grammatical rules in general (Crago and Allen, 1996), these children would have particular difficulty acquiring morphologically conditioned stress rules.

Children with dyslexia are another population with noted difficulties in linguistic areas, specifically metalinguistic skills. Phonological awareness has been found to predict later reading success in a number of studies (Bryant, Bradley, MacLean & Crossland, 1989; Stanovich, Cunningham & Cramer, 1984; Vellutino & Scanlon, 1987). In addition, morphological skills have been found to be related to reading. Morphological awareness is closely associated with reading skills (Carlisle, 1995), and morphological skills may both be affected by

and improve reading ability (Fowler & Liberman, 1995). Thus, phonological and morphological awareness may be factors for children with reading problems, and as a result, these children might also have difficulty acquiring the rhythmic suffix stress rules, which involve both morphological and phonological processes.

Cross-linguistic studies could provide information on the universality of the types of rules examined in this study. Although in English, neutral suffixes, and the related [-cyclic] rules were learned first, there is no reason to believe that they are the universal default. In fact, many languages have inflectional endings that trigger the [+cyclic] rules, such as Polish and Spanish. Thus, children are exposed to suffixes that are semantically transparent but not structurally simple. Furthermore, studies with people learning English as a second language, or with bilingual children, could provide us with information on the effects of interference from a first language with a different phonological stress system (e.g., a tone language, like Chinese, or a fixed stress language like French), and the strategies or skills required to master the English system. From personal experience, it is far more difficult to understand someone who has not mastered the prosodic system (e.g., where word stress or sentence stress falls) than someone who has difficulties with the segmental system (e.g., regular sound substitutions). Determining not only how the stress rules in these other languages work, but also their affect on learning a second language may have important pedagogical implications.

There is clearly more work to be done if we are to understand the interaction between phonology and derivational morphology. This study shed

some light on the issue, but perhaps the greater contribution of this study is that future researchers of the acquisition of derivational morphology will have a firmer, linguistically based, understanding of the phonological variable. That is not to say that the semantic and syntactic factors do not play a crucial role, in fact they may play a larger role. How these different aspects of linguistic development interact or differentially contribute to development remains largely unknown. However, we now have evidence that in addition to attending to syntactic and semantic information, children in the early school years are also acquiring the phonological stress rules.

Appendix A: Adult Pilot Data

		Production		Perception	
		real	nonsense	real	nonsense
rhythmic	all	.98	.93	1	.93
	-tion	1	.98	1	.93
	-ic	.98	.98	1	.93
	-ity	.95	.85	1	.93
neutral	all	1	.94	.99	N/A
	-ment	1	.98	1	N/A
	-ness	1	.85	.98	N/A
	-ful	1	.98	1	N/A

Proportions of correct stress production and perception by adults (N=10).

Appendix B: Production Training Stimuli

1. friend -ship
2. smell -y
3. work -er
4. Rome -an
5. comedy -an*
6. danger -ous
7. mystery -ous
8. classic -al
9. accident -al
10. honor -able

* The vast majority of children did not accurately produce or attempt to produce this item.

The following were also used as practice for the youngest children (ages 6;6 - 7;2)

base + ball

teach + ing

friend + ly

Appendix C: Means and Standard Deviations of Raw Scores of Correct Stress Production.

Suffix		Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)	
		real stem	nonsense	real stem	nonsense	real stem	nonsense
Rhythmic	<u>M</u>	4	3.9	7.1	6.3	9.3	8.7
	<u>SD</u>	3.2	2.3	2.3	3.0	1.5	2.6
Neutral	<u>M</u>	9.8	9.6	9.8	9.4	9.7	9.7
	<u>SD</u>	.3	.4	.8	.8	.5	.5

N. B., Total possible for the rhythmic suffixes is 12, and 10 for the neutral suffixes.

**Appendix D. AGE by SUFFIX by WORD Analysis of Variance Results:
Production.**

Source	df (effect, error)	MS error	F
Between Subjects			
Age	2, 49	.237	18.29 ***
Age X Suffix Type	2, 49	.372	12.75 ***
Age X Word Type	2, 49	.079	.17
Within Subjects			
Suffix Type	1, 49	.372	222.95 ***
Word Type	1, 49	.079	3.21
Suffix X Word	1, 49	.153	.13
Age X Suffix X Word	2, 49	.153	.53

*** = $p < .0001$

Appendix E: Individual Rhythmic Suffix Means and Standard Deviations: Production.

		Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)	
Rhythmic Suffix		real stem	nonsense	real stem	nonsense	real stem	nonsense
-tion	<u>M</u>	2.11	1.89	3.16	2.61	3.93	3.40
	<u>SD</u>	1.63	1.45	1.15	1.42	.258	.828
-ic	<u>M</u>	1.21	1.16	2.33	1.94	3.0	2.67
	<u>SD</u>	1.13	1.30	.907	1.21	.756	1.11
-ity	<u>M</u>	.684	.842	1.56	1.76	2.40	2.67
	<u>SD</u>	.820	.834	1.39	1.22	1.06	1.54

N. B., The maximum possible raw score is four.

Appendix F. AGE by WORD by RHYTHMIC SUFFIX ANOVA Results: Production.

Source	df (effect, error)	MS error	F
Between Subjects			
Age	2, 49	2.25	17.33 ***
Age X Word Type	2, 49	.50	.35
Age X Suffix	4, 98	.51	.17
Within Subjects			
Word Type	1, 49	.50	1.75
Suffix Token	2, 98	.51	44.79 ***
Word X Suffix	2, 98	.38	4.23 *
Age X Word X Suffix	4, 98	.38	.27

* = $p < .05$, *** = $p < .0001$

Appendix G. Suffix Contrasts for Rhythmic Suffixes by Age Group: Production

Source	df (effect, error)	MS error	F
Suffix Contrasts			
Group 1 (7-year olds): Word Type collapsed			
-tion v. -ic	1, 49	.41	17.16 ***
-tion v. -ity	1, 49	.66	22.41 ****
-ic v. -ity	1, 49	.46	3.13
Suffix Contrasts			
Group 2 (8-year olds)			
Real words: -tion v. -ic	1, 49	.34	15.04 ***
Non words: -tion v. -ic	1, 49	.30	9.17 **
Real words: -tion v. -ity	1, 49	.40	33.28 ****
Non words: -tion v. -ity	1, 49	.66	7.18 **
All words: -ic v. -ity	1, 49	.46	4.0 *
Suffix Contrasts			
Group 3 (9-year olds)			
Real word: -tion v. -ic	1, 49	.34	16.69 ***
Non word: -tion v. -ic	1, 49	.30	8.80 **
Real word: -tion v. -ity	1, 49	.40	27.74 ****
Non word: -tion v. -ity	1, 49	.66	3.10
All words: -ic v. -ity	1, 49	.46	.63

* = $p < .05$, ** = $p < .01$, *** = $p < .001$, **** = $p < .0001$

Appendix H: Individual Neutral Suffix Means and Standard Deviations: Production.

		Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)	
Neutral		real stem	nonsense	real stem	nonsense	real stem	nonsense
Suffix							
-ment	<u>M</u>	4	4	4	3.94	4	4
	<u>SD</u>	0	0	0	.24	0	0
-ness	<u>M</u>	3.79	3.68	3.78	3.56	3.73	3.73
	<u>SD</u>	.41	.58	.55	.62	.48	.46
-ful	<u>M</u>	2	1.95	2	1.89	1.93	2.0
	<u>SD</u>	0	.23	0	.47	.26	0

N. B., The maximum possible is four for *-ment* and *-ness*, and two for *-ful* derivations.

Appendix I: Means and Standard Deviations of Raw Scores of Correct Stress Perception.

Suffix		Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)	
		real stem	nonsense	real stem	nonsense	real stem	nonsense
Rhythmic	<u>M</u>	9.8	7.84	10.1	8.33	10.9	8.73
	<u>SD</u>	1.10	1.83	1.11	2.03	.70	1.49
Neutral	<u>M</u>	8.4	N/A	9.22	N/A	9.6	N/A
	<u>SD</u>	1.60	N/A	1.04	N/A	.74	N/A

N. B., Total possible for the rhythmic suffixes is 12, and 10 for the neutral suffixes.

Appendix J: Individual Rhythmic Suffix Means and Standard Deviations: Perception.

Rhythmic Suffix		Group 1 (7 y.o.)		Group 2 (8 y.o.)		Group 3 (9 y.o.)	
		real stem	nonsense	real stem	nonsense	real stem	nonsense
-tion	<u>M</u>	4	3.2	3.9	3.2	4	3.7
	<u>SD</u>	0	.5	.20	.80	0	.50
-ic	<u>M</u>	3	2	2.9	2.7	3.5	2
	<u>SD</u>	1	1	.90	1	.60	1
-ity	<u>M</u>	3	2	3	2	3	3
	<u>SD</u>	1	1	1	1	1	1

N. B., The maximum possible raw score is four.

Appendix K. Real word stems contrasted with nonsense stems for each rhythmic suffix: Perception.

Source	df (effect, error)	MS error	F
Word Contrasts		Group 1 (7-year olds)	
(real v. nonsense)			
-ic	1, 49	.46	1.0
-ity	1, 49	.43	6.75 **
		Group 2 (8-year olds)	
-ic	1, 49	.46	.60
-ity	1, 49	.43	5.15 *
		Group 3 (9-year olds)	
-ic	1, 49	.46	8.77 **
-ity	1, 49	.43	7.72 **

* = $p < .05$, ** = $p \leq .01$, **** = $p < .0001$

Appendix L. Individual suffix contrasts for each age group: Perception.

Source	df (effect, error)	MS error	F
Suffix Contrasts		Group 1 (7-year olds)	
All words: -tion v. -ic	1, 49	.24	48.34 ****
Non words: -tion v. -ic	1, 49	.34	6.81 *
All words: -tion v. -ity	1, 49	.26	32.93 ****
Non words: -tion v. -ity	1, 49	.31	9.24 **
All words: -ic v. -ity	1, 49	.47	.50
Suffix Contrasts		Group 2 (8-year olds)	
All words: -tion v. -ic	1, 49	.24	26.40 ****
Non word: -tion v. -ic	1, 49	.34	3.20
All words: -tion v. -ity	1, 49	.26	30.64 ****
Non word: -tion v. -ity	1, 49	.31	9.75 **
All words: -ic v. -ity	1, 49	.46	.21
Suffix Contrasts		Group 3 (9-year olds)	
All words: -tion v. ic	1, 49	.24	34.84 ****
Non word: -tion v. -ic	1, 49	.34	20.88 ****
All words: -tion v. -ity	1, 49	.26	29.21 ****
Non word: -tion v. -ity	1, 49	.31	19.78 ****
All words: -ic v. -ity	1, 49	.46	.04

* = $p < .05$, ** = $p \leq .01$, *** = $p < .001$, **** = $p < .0001$

Appendix M: Individual Neutral Suffix Means and Standard Deviations: Perception.

		Group 1 (7 y.o.)	Group 2 (8 y.o.)	Group 3 (9 y.o.)
		real stem	real stem	real stem
-ment	<u>M</u>	3.9	3.9	3.9
	<u>SD</u>	.30	.20	.40
-ness	<u>M</u>	3	3.6	3.9
	<u>SD</u>	1	.60	.40
-ful	<u>M</u>	1	2	2
	<u>SD</u>	1	1	0

N. B., The maximum possible is four for *-ment* and *-ness*, and two for *-ful* derivations.

Appendix N: Title Recognition Test

Title Recognition Test

Several studies have found a relationship between print exposure and standardized language measures (Cipielewski & Stanovich, 1992; Senechal, LeFevre, Hudson & Lawson, 1996; Stanovich & West, 1989). Considering the research reviewed in Chapter 1 linking children's morphological analysis skills and reading abilities (Anglin, 1993; Carlisle, 1988; Wysocki & Jenkins, 1987), it seemed possible that reading skills could influence morphophonological knowledge or vice versa. Moreover, metaphonological skills (e.g., phonological awareness) are predictive of later reading abilities (MacDonald & Cornwall, 1995) and are related to morphological awareness (Carlisle & Nomanbhoy, 1992). There have also been studies directly linking reading and orthographic abilities with vowel alternations that frequently co-occur with stress change (e.g., local/locality) (Jaeger, 1984; Templeton & Scarborough-Franks, 1985). Therefore, it would not be surprising if the acquisition of stress rules examined in the present study was related to reading. Since this was not the primary goal of the study, an easily administered, broad measure of reading ability was sought and found in the Title Recognition Test (Cipielewski & Stanovich, 1992).

The Title Recognition Test (TRT), (Cipielewski & Stanovich, 1992), was designed as a way to predict reading ability that did not rely on parent reports of the amount of time their children spent reading. Their hypothesis was that "differences in print exposure predict variation in the development of reading

comprehension" (p. 77), and they wanted a measure of print exposure that was relatively unbiased, easy to administer, and cognitively simple for children. The TRT requires only scanning for familiar items.

The authors took 25 book titles from children's reading lists, teachers' suggestions, and from lists generated from groups of children. They mixed the real titles with 13 foils (invented titles) for a total of 38 items. Appendix N1 contains the TRT. Fourth and fifth grade children (N=98, mean age 10 years), were told to scan the list of titles and mark only the ones they were certain were titles of real books. The children were also administered a battery of other tests, including several standardized reading tests (e.g., reading comprehension subtest of the Iowa Tests of Basic Skills and subtests from the Stanford Diagnostic Reading Test), and a child-oriented Author Recognition Test (ART) that was designed similarly to the TRT, but with author's names instead of titles. Some of the standardized tests had been previously administered to the children when they were in third grade, then again in fifth grade to evaluate reading improvement.

Cipielewski and Stanovich found positive correlations between performance on the TRT and all the standardized tests measured at both the third and fifth grade levels. Correlations ranged from $r = .44$ to $r = .58$, and all were significant with a $p < .05$. The only standardized test given at both grades three and five was the Reading Comprehension subtest from the Iowa Test of Basic Skills. The third and fifth grade scores were significantly correlated, $r = .55$,

$p = .05$. Thus, the correlations obtained with the TRT were as good as those obtained with standardized tests. Furthermore, the authors concluded that print exposure, as measured by the TRT, was a good predictor of reading comprehension between third and fifth grades. Cipielewski and Stanovich state that, "print exposure appears to be both a consequence of developed reading ability and a contributor to further growth in that ability" (p. 85). The ART was not as good a predictor of reading ability as the TRT.

The TRT was borrowed in its entirety for the current study to see if print exposure was a predictor of performance on either the elicited production task or the judgment task. If there is a relationship between performance on the TRT and the stress tasks, it is probable that reading ability is a factor also.

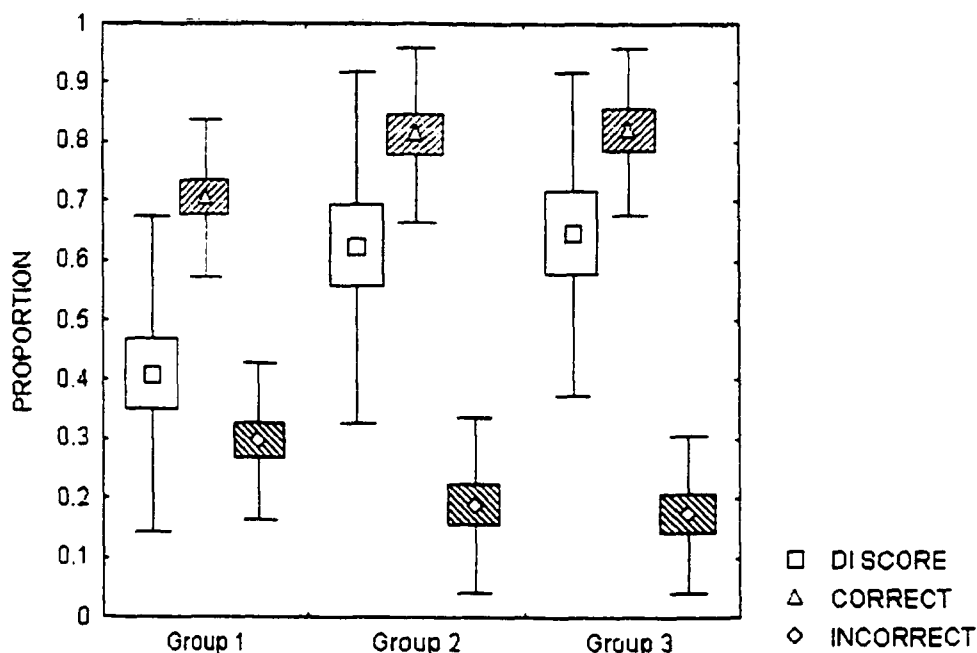
Subjects and Procedure

All children were given the TRT after the stress production and perception tasks previously reported. The children were given a sheet of paper with the list of titles and a pen, and told to mark the titles they knew. It was emphasized to the children that they should be absolutely sure of their answer and not guess, because some of the titles were not real. For children whose reading skills were still developing, (i.e., many of the children in Group 1), the titles on the list were read to them aloud, and the children were given time to decide whether or not they knew that book.

Scoring and Results

The TRT was scored by counting the number of correct and incorrect titles for each child. The proportion of correct titles was calculated by dividing the number correct by the total title choices (correct + incorrect). The proportion of the incorrect titles chosen was calculated in the same way as the correct titles. As in the Cipielewski and Stanovich study, each child's incorrect proportion was subtracted from the correct proportion for a "discrimination index" (DI). The DI score provides an estimate of accuracy. Children who only chose real book titles would have a DI of 1, regardless of how many of the real titles they chose. Children who marked half real titles and half false titles would have a DI of zero, indicating that they were guessing. The raw scores, proportions and DI for each child appear in Appendix N2. Proportions and the DI's were averaged by group. These values appear in Figure 14.

Figure 14. Box and whisker graph of TRT proportions (correct and incorrect) and the discrimination index (correct proportion - incorrect proportion).



N.B., Center point is mean, box is ± 1 SE, whiskers are ± 1 SD.

The mean DI for Group 1 was .41 (SD = .27), Group 2 was .62 (SD = .30), and Group 3 was .65 (SD = .27). The mean DI across all children (N=98, mean age 10 years old) in Cipielewski and Stanovich's study was .52 (SD = .15). Thus, the data obtained in the current study fall within the same range as those found in prior research. Nevertheless, a one-way ANOVA comparing the Groups on the DI, confirmed statistically significant differences between the Groups, $F(2, 49) = 3.98$, $p = .03$, and a post-hoc Newman-Keuls revealed that the difference between Groups 1 and 2 and 1 and 3 were significant, $p = .02$ and

$p = .04$, respectively, but the difference between Groups 2 and 3 was not significant, $p = .81$.

To determine whether a relationship exists between the TRT, as a measure of reading ability, and performance on the stress tasks, a correlation and partial correlation was performed across all children (groups collapsed), with age as a covariant. Prior to calculations, all proportions were arcsine transformed. The results of the correlations are presented in Table 29.

Table 29. Results for the regression between performance on stress tasks, DI from the TRT, and age.

Experiment	Stem Condition	Correlation	Partial Correlation	
		with DI	with Age only	with DI only
Production	Rhythmic Real	.45*	.59*	.20
	Rhythmic Nonsense	.38*	.53*	.13
	Neutral Real	-.14	-.06	-.09
	Neutral Nonsense	-.002	.02	-.01
Perception	Rhythmic Real	.22	.61*	-.12
	Rhythmic Nonsense	.26	.53*	-.02
	Neutral Real	.14	.27	-.002

* = $p < .001$

The stem condition was the dependent variable with age and DI as the independent variables.

For the production task, positive and significant correlations were obtained between the DI scores alone and real words with rhythmic suffixes, $r = .45$,

$p < .001$, and nonsense words with rhythmic suffixes, $r = .38$, $p < .001$. In contrast, production of neutrally suffixed words did not correlate with the TRT: real words, $r = -.14$, $p > .05$, and nonsense words, $r = -.002$. However, when age is factored out in the partial correlation, there is no relationship found between the TRT and accurate production of rhythmic derivations with real stems, $r = .20$, $p = .17$, or nonsense stems, $r = .13$, $p = .37$. No significant correlations were observed between the TRT and any of the conditions in the perception task. Age correlates with the rhythmic derivations in both experiments, and age significantly correlates with DI, $r = .47$, $p < .001$.

Discussion

Two caveats temper the interpretation of these data. First, although there is evidence that the TRT predicts reading skills, it is not a standardized assessment of reading skills. At best, the TRT is a very gross measure of reading skills via print exposure. Furthermore, the TRT was originally designed for children older than the children in the current study (10 years old in the previous study versus 7-, 8- and 9-years old in the present study). In fact, the youngest children in the present study did not perform as accurately as the older children. This may be because the youngest children were more impulsive and prone to guessing (incorrectly) or because they were unfamiliar with some of the books but wanted to please the experimenter. The second area of concern is that the correlations in the current study were computed on relatively few data points, and as a result are of questionable statistical reliability. A larger sample

may produce less statistical variance, and a more representative measurement of the population's performance.

The absence of any correlation with the TRT and the perception or production task is puzzling. If reading is related to knowledge of morphophonological stress alternations, then why would it not be apparent in both the perception and production tasks? There are several possible responses to this question. Again, it may be an issue of sample size. Perhaps reading and the stress alternations associated with rhythmic suffixes are related, but more subjects need to be tested to see a statistically measurable effect in all test conditions. Of course, the TRT may not be a sensitive enough measure of reading. Perhaps a standardized test of reading ability would provide a more reliable measurement, which in turn would be more likely to be related to morphophonological rule learning. Another possibility is that the perception task was so much easier than the production task that we can't see a clear developmental progression because of the near ceiling performance on the perception task, and hence, we see no correlation with the TRT.

The results from the TRT are suggestive, but by no means conclusive. This initial probe into the relationship between reading and morphologically conditioned stress alternation certainly points toward further exploration. Considering that prior work has established a link between reading and morphological analysis and phonological awareness, this is a logical direction in which to aim.

Appendix N1: Title Recognition Test Stimuli

A Light in the Attic
 How to Eat Fried Worms
 Call of the Wild
 * The Lost Shoe
 The Chosen
 * Hot Top
 Tales of a Fourth Grade Nothing
 The Polar Express
 * He's Your Little Brother!
 The Indian in the Cupboard
 The Cybil War
 Homer Price
 Heidi
 * Ethan Allen
 * Don't Go Away
 Freedom Train
 James & the Giant Peach
 * Joanne
 By the Shores of Silver Lake
 * Skateboard
 Superfudge
 Dr. Doolittle
 * It's My Room
 * The Schoolhouse
 From the Mixed-up Files of Mrs. Basil E. Frankweiler
 Island of the Blue Dolphins
 Ramona the Pest
 Iggie's House
 * Sadie Goes to Hollywood
 The Great Brain
 * The Missing Letter
 Misty of Chincoteague
 Dear Mr. Henshaw
 * The Rollaway
 Harriet the Spy
 The Lion, the Witch and the Wardrobe
 * Searching the Wilds

N.B., Titles marked with an asterisk are foils (i.e., they are not real book titles).

Appendix N2: TRT Results.

Raw scores, proportions, and discrimination index (DI) for individual children within each group.

Group 1					
subj	proportion correct	proportion incorrect	DI	raw scores	
				correct	incorrect
101	0.83	0.17	0.66	10	2
102	0.7	0.3	0.4	14	6
103	0.59	0.41	0.18	13	9
104	0.67	0.33	0.34	14	7
105	0.58	0.42	0.16	7	5
106	0.65	0.35	0.3	15	8
107	0.75	0.25	0.5	9	3
108	0.76	0.24	0.52	16	5
109	0.62	0.38	0.24	8	5
110	0.53	0.47	0.06	8	7
111	0.68	0.32	0.36	13	6
112	0.71	0.29	0.42	12	5
113	0.59	0.41	0.18	10	7
114	0.92	0.08	0.84	11	1
115	0.63	0.37	0.26	5	3
116	0.72	0.28	0.44	13	5
117	0.53	0.47	0.06	8	7
118	1	0	1	6	0
119	0.91	0.08	0.83	11	1
mean	0.704	0.296	0.408	10.68	4.84
SD	0.133	0.134	0.2664	3.164	2.544
Group 2					
subj	proportion correct	proportion incorrect	DI	raw scores	
				correct	incorrect
201	1	0	1	5	0
202	0.73	0.27	0.46	8	3
203	0.85	0.15	0.7	11	2
204	0.73	0.27	0.46	8	3
205	0.77	0.23	0.54	10	3
206	0.7	0.3	0.4	14	6
207	0.58	0.42	0.16	11	8
208	0.55	0.45	0.1	12	10
209	0.71	0.29	0.42	12	5
210	0.84	0.16	0.68	16	3
211	0.88	0.13	0.75	7	1

**Group 2 -
continued**

212	0.71	0.29	0.42	15	6
213	1	0	1	9	0
214	1	0	1	9	0
215	1	0	1	8	0
216	0.7	0.3	0.4	14	6
217	0.88	0.13	0.75	7	1
218	1	0	1	10	0
mean	0.813	0.1883	0.6243	10.333	3.167
SD	0.148	0.147	0.295	3.049	3.05

Group 3

subj	proportion correct	proportion incorrect	DI	raw scores	
				correct	incorrect
301	0.67	0.33	0.34	12	6
302	0.6	0.4	0.2	12	8
303	0.62	0.28	0.34	16	10
304	0.77	0.23	0.54	10	3
305	0.67	0.33	0.34	12	6
306	0.72	0.28	0.44	13	5
307	0.87	0.13	0.74	13	2
308	1	0	1	12	0
309	1	0	1	11	0
310	1	0	1	15	0
311	0.87	0.13	0.74	13	2
312	0.91	0.09	0.82	10	1
313	0.78	0.22	0.56	14	4
314	0.92	0.08	0.84	12	1
315	0.91	0.09	0.82	10	1
mean	0.821	0.173	0.648	12.333	3.267
SD	0.140	0.132	0.2728	1.759	3.127

Appendix O: Questionnaire Summary

Questionnaire

The parents of the children who participated in this study were asked to fill out a brief questionnaire. Completion of the questionnaire was voluntary and not a prerequisite for participation in the study. Appendix O1 contains the full questionnaire. Questionnaires for two children were not completed. The data that follow are intended to provide descriptive information about the participants in this study.

The questionnaire consisted of six questions. Three questions pertained to the reading habits of the children. They included questions regarding how many books per month the child reads, if the child reads at home, and what books the child likes to read. The fourth question established the parents' education level, and the last two questions requested information on whether the child had any speech, language or hearing problems and if there were family members with a history of speech, language or learning problems.

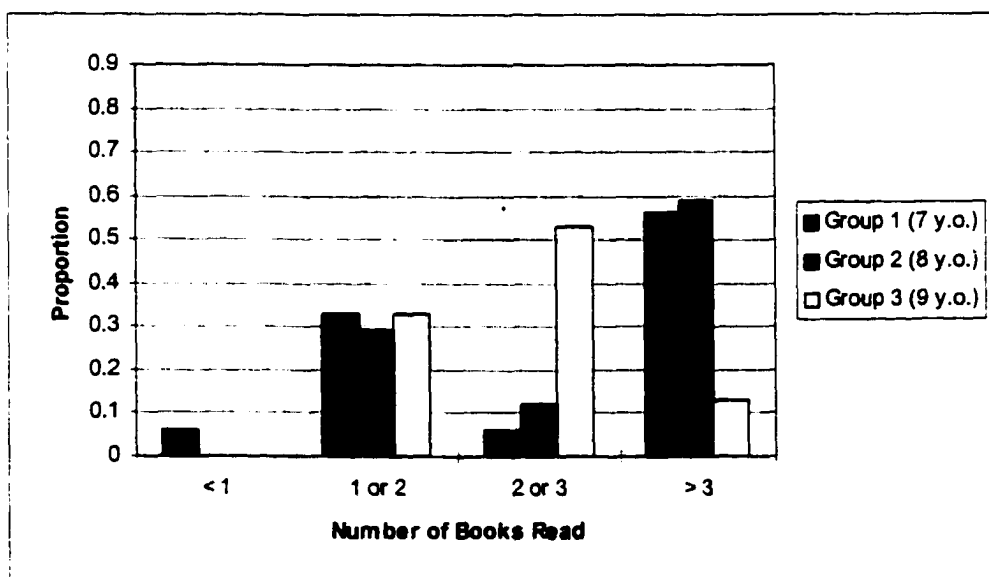
Where possible, the answers from the questionnaire were tallied by age group and a group average was obtained. These averages include only the children for whom questionnaires were completed.

Reading Behavior

The data on parent-reported reading behavior appear in Figure 15. All children in the three age groups were reported to read at home (100%), although the amount that they read appeared to decrease as they get older. The 7- and 8-year old children were reported as reading at least three books per month (56% and 59% respectively), whereas the 53% of the 9-year old children read only two or three books per month.

This may reflect the type and difficulty of the reading material children are reading at these different ages. A book appropriate for a nine-year old child may have an elaborate story-line and multiple chapters. This may take longer to read than a single chapter, simple story that seven-year old children would read.

Figure 15. Parent estimates of number of books read by their children.

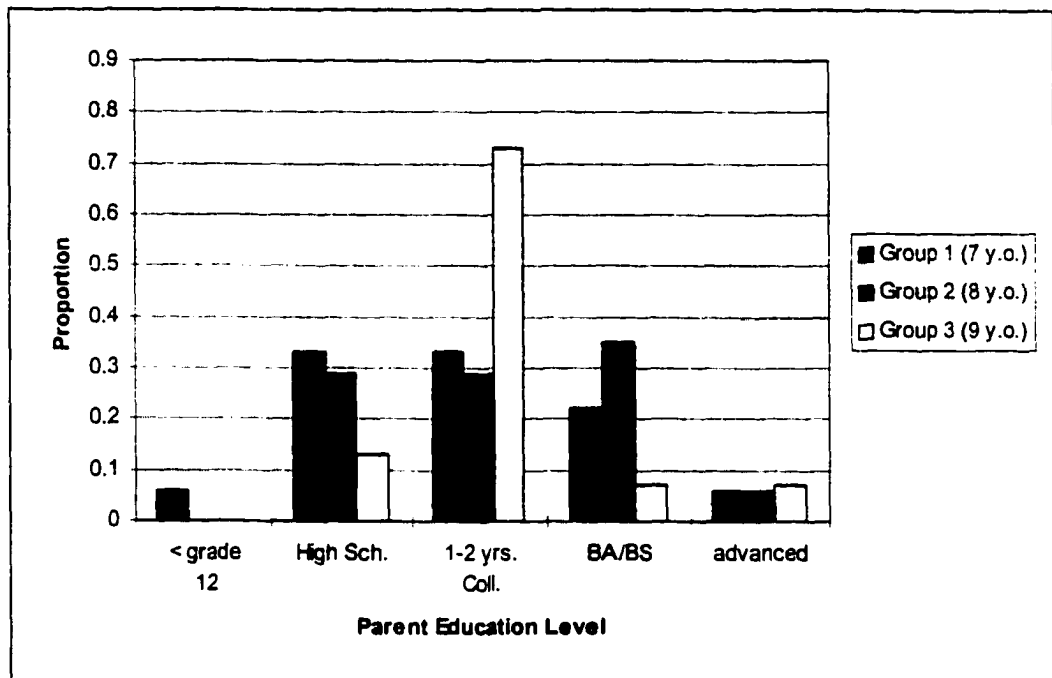


Parent Education

The data on the parents' education are reported in Figure 16. Where two levels of education were reported – one for each parent – only the highest one was included in the average. Most parents reported at least a High School education, however, many had attended one or two years of college (including technical programs), especially the 9-year old children's parents. As tempting as it may be to suggest that the oldest group performed better as a result of their parents' education, there really aren't enough data to make this claim.

Furthermore, even if the parents' education does play a role in the ability of their children to accurately recognize and produce stress on derived words, we do not see a gradual shift in parent education across the age groups – nor is there any reason to expect this. In fact, Groups 1 and 2 have very similar parent education profiles, yet we have seen in the experiments that the children in Group 2 often perform better than those in Group 1. Thus, it seems unlikely that parent education is playing much of a role in this study.

Figure 16. Highest level of parent education.



Child and Family History

A total of eight children were reported to have a history of speech, language, or hearing problems: four of the 7-year olds (22%), one 8-year old (6%), and three 9-year olds (21%). The types of problems reported were primarily delayed speech and language, or an articulation problem. Parents' descriptions included early intervention at 8 months (1 child), delayed speech due to frequent ear infections (2 children), late talker (1 child), developmental apraxia (1 child), remediation of a lisp (1 child), and unspecified speech therapy (2 children). Subjectively, these children were not noticeably different than their peers, which would be expected if their problems were treated or had otherwise resolved. Objectively, they all passed the practice criteria for the experiments

previously discussed, and they were judged by their teachers to be performing at grade level.

With respect to family history of speech, language or learning problems, this question was left blank for five of the children. For the remaining children, there was a family history for seven of the 7-year old children (39%), seven of the 8-year old children (44%), and six of the 9-year old children (46%). Averages do not include blank responses. Furthermore, a child was marked as having a positive family history regardless of whether several family members were listed with different disorders for that child; no child was counted more than once. Family histories included incidences of dyslexia (N = 7), learning disabilities (attention deficit = 3, mental retardation = 1, LD unspecified = 3), and speech intervention (N= 6).

Appendix O1: Parent Questionnaire

For purposes of grouping data from different participants, the following information is requested. You are under no obligation to answer any question. Your child may participate even if you choose not to answer these questions, as long as the consent letter is signed. This information will be kept confidential. Thank you for your time.

Please circle the appropriate answer.

1. Does your child read by him/herself at home? Yes No

2. What are some of the books your child likes to read?

3. Please estimate how many books per month your child reads.
 - a. less than one
 - b. one or two
 - c. two or three
 - d. more than three, if so, how many?

4. Please indicate how many years of education completed by you/your spouse.
 - a. less than 12 years
 - b. high school (12 years)
 - c. 1 - 2 years of college
 - d. Bachelor's degree
 - e. Advanced degree, if so what?

5. Does your child have a history of hearing, language, or speech problems? Yes/No
 If Yes, please explain: _____

6. Has anyone in your family ever had a language, speech or learning problem (including you, grandparents, aunts/uncles, or cousins)? Yes No
 If Yes, please explain: _____

Appendix P. Table of perception and production stimuli ordered by Standard Frequency Index (SFI) from Carroll, Davies & Richman (1971).

Perception Derivation	SFI	Total Correct (across groups)	Production Derivation	SFI	Total Correct (across groups)
information	61.3	52	activity	54.3	31
education	56.8	52	vacation	53.5	35
operation	55.1	52	personality	51.6	14
atomic	54.8	43	curiosity	50.9	20
university	53.8	41	celebration	49.7	40
relation	52.2	51	metallic	48.1	5
electronic	52.2	49	artistic	47.7	35
authority	52.2	43	rotation	46.2	40
possibility	49.4	52	execution	45	41
prosperity	46.1	31	microscopic	44.4	37
realistic	44.0	30	nobility	43.2	11
symbolic	42.2	35	alphabetic	37.4	35

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