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ABSTRACT

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Technical Report No. 536

THE DEVELOPMENT OF KNOWLEDGE OF DERIVATIONAL SUFFIXES

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Abstract

Knowledge of morphology--the ability to gain information about the meaning, pronunciation, and part of speech of new words from their prefixes, roots, and suffixes--is an important component of skilled reading. As part of a larger program of research on morphology, a study explored the development of students' knowledge of common English suffixes. Two aspects of knowledge about suffixes were investigated: The ability to use the suffix on a new word to determine that word's part of speech and its appropriate use in a sentence, and the ability to distinguish between true suffixed words (e.g., *swimmer*) and nonsuffixed words that contain the orthographic form (but not the meaning) of a root word and suffix (e.g., *mother*). A battery of tasks measuring knowledge of morphology was administered to 720 fourth-grade, seventh-grade, and high school students. Knowledge of common English suffixes was found to continue to develop after fourth grade; even in high school, some students had serious problems with these suffixes. Knowledge of morphology appears to be a distinct component of verbal ability, although it is significantly related to standardized measures of reading ability in seventh grade and high school. The instruments developed in the study identified students who have particular difficulties with English suffixes, and thus have potential as diagnostic tools.

THE DEVELOPMENT OF KNOWLEDGE OF DERIVATIONAL SUFFIXES

Skilled reading depends not just on knowing many words but on being able to deal effectively with new ones. The nature of our language is such that one cannot expect to have prior knowledge of all the words one will encounter in a text. Nagy and Anderson (1984) estimated that the average fifth grader, in the course of a year's reading, may encounter more than 10,000 new words, that is, words the student has not previously encountered in print. It is clear that no program of vocabulary instruction, however ambitious, could attempt to cover all the new words a student will read. What students need, then, is not just knowledge of many words (although this is certainly helpful), but strategies for handling new words in text (Mason, Herman, & Au, 1990).

In the initial stages of learning to read, most of the new words students encounter in print are already in their oral vocabularies. For this type of new word, the student can rely on knowledge of spelling-sound correspondences. After third grade, on the other hand, students encounter increasing numbers of words in print that are not in their oral vocabularies; decoding strategies alone will not provide information about their meaning. However, the majority of new words in text are related to more familiar ones through prefixation, suffixation, or compounding (Nagy & Anderson, 1984; White, Power, & White, 1989). In the course of a year's reading, a reader will encounter numerous words such as *uncourteously*, *queenlike*, or *playfellow*. These are long, rarely occurring words; yet they are not necessarily difficult words, if the reader can recognize the familiar parts and understand how these parts fit together. Hence, students' knowledge of morphology--that is, the ability to gain information about the meaning, pronunciation, and part of speech of new words from their prefixes, roots, and suffixes--determines in part how effectively they will be able to deal with new, long words.

It is well known that word length is associated with text difficulty (Davison & Green, 1988; Klare, 1984). However, it has been argued that word length per se is not a cause of difficulty for all readers (Anderson & Davison, 1988). The vast majority of long words have some discernable morphological structure; it is difficult to find a word of more than eight letters that does not contain some recognizable prefix, stem, or suffix that gives at least partial information about its meaning and pronunciation. Anderson and Davison hypothesize that word length is a source of difficulty for those younger and less able readers who cannot analyze a long word such as *sleeplessness* into its component parts. This hypothesis is consistent with Baker's (1989) findings that third graders were more likely to identify longer rather than shorter nonwords as problematic, whereas fifth graders were not influenced by word length. Word length influences third graders' judgments of the difficulty of reading the words in isolation, and also of the difficulty of understanding sentences containing the words. The particular difficulty that long words pose for younger and less able readers was also confirmed by a reanalysis of data reported in Nagy, Anderson, and Herman (1987), which showed that word length had an independent negative effect on learning from text only for students in the bottom third of a sample of middle-grade readers.

Just and Carpenter (1987) argued that if the burden of decoding a long word is too great, readers will not have sufficient capacity in working memory to store and process the entire sentence. Although Baker (1989) did not examine the possible role of morphological knowledge in the difference between third and fifth graders, it is reasonable to assume that the ability to chunk the letters in a long word into meaningful morphemes would facilitate the processing of new words, and that this ability increases between third and fifth grades. Hence, differential knowledge of morphology may account, at least in part, for the relationship between word length and text difficulty, and for the problems that long words pose for younger and less able readers.

Considerations such as the above have served to highlight morphological knowledge as an important component of vocabulary growth and skilled reading. In addition, there has been shown to be a relationship between general verbal ability and the use of morphology in learning new words (Freyd & Baron, 1982) and in the comprehension of sentences containing suffixed words (Tyler & Nagy, 1990).

The potential benefits of instruction in morphology are considerable (White, Power, & White, 1989). The need for instruction is also clear; upper-elementary and middle-school students do not appear to make anything close to full use of the help that morphological relatedness among words should provide in word learning (Freyd & Baron, 1982; Wysocki, & Jenkins, 1987). Morphology does receive a fair amount of attention in most reading programs, generally under the label "structural analysis" (Winsor, Nagy, Osborn, & O'Flahavan, in preparation). What is not clear is the quality or effectiveness of such instruction.

Current instructional practice operates largely in a theoretical vacuum. There has been little research done to test whether instruction on word parts has any effect (see Graves, 1986), and none that we know of on the relative effectiveness of different instructional approaches. One reason for the paucity of instructional research on morphology is the lack of a foundation in basic research. Any attempt to formulate an effective method of instruction must be based on accurate information about what students already know about morphology, and how they use this knowledge in reading and word learning.

Aspects of Morphological Knowledge

Since Berko's (1958) pioneering study, a number of researchers have examined children's acquisition of knowledge about morphology (e.g., Condry, 1979; Derwing & Baker, 1979; Freyd & Baron, 1982; Selby, 1972; Shepherd, 1973; Sternberg & Powell, 1983; Tyler & Nagy, 1989, 1990; Wysocki & Jenkins, 1987). For there to be a solid research basis for making decisions about instructional practice, however, progress is necessary on two fronts. First, there is still need for more detailed information about what children know about morphology, when they learn it, and how they use it. Second, a framework must be developed that allows the diverse and sometimes seemingly inconsistent information about children's acquisition of morphology to be put together into a coherent picture. Such a framework must distinguish between, and explicate the relationships among, different aspects of morphological knowledge.

Different Types of Word Parts

An essential beginning step in gaining an understanding of children's acquisition of morphological knowledge is recognition that such knowledge is not monolithic. We will, therefore, lay out here some of the distinctions that must be recognized in gaining a comprehensive picture of this topic.

First, one must distinguish between different kinds of morphological structures--between prefixation, suffixation, and compounding, and between inflectional and derivational suffixes. Inflectional suffixes are those that create different forms of the same word, for example, the endings for tense (*walk, walked, walking*) or number (*frog, frogs*). Derivational suffixes create different words, typically with different parts of speech (*refine, refinement*). Children pretty well master inflections in oral language in their preschool years (Berko, 1958). They largely learn other types of word formation processes later (Derwing & Baker, 1979).

Although it is difficult to rank compounding, prefixation, and suffixation in any absolute scale of difficulty or age of acquisition, it is clear that these are qualitatively different processes. One dimension along which they differ is the meaningfulness of their parts. Compounds typically consist of elements that are words in their own right. Prefixes and suffixes are bound morphemes; they are not words in themselves, and their meanings or grammatical functions are often difficult to articulate (it is not easy, for example, to express in simple terms what the *a* in *asleep* or the *ive* in *progressive* means). The simple fact that prefixes come at the beginning of words and suffixes at the end may also have implications for how readers process these word parts.

Another important distinction that must be made is between bound and free stems. Free stems, such as the *teach* in *teacher*, are words in themselves. Bound stems are stems such as the *proach* in *reproach* and *approach*, the *ceive* in *receive, deceive,* and *perceive*, or the *petro* in *petrochemical*, which do not appear in isolation. Shepherd (1973) found that unlike free stems, bound stems appeared to play little role in the vocabulary knowledge of college students. Presumably they would play still less of a role for younger students. Some studies, however, have shown a measurable increase in knowledge and use of bound stems between high school and college (Nagy & Scott, 1990; Sternberg & Powell, 1983).

Among bound stems, one might want to make a further distinction between Latin roots such as *ceive* or *fer* that are almost entirely void of meaning in current English, and Greek roots such as *geo, thermo,* or *graph*, which often make a discernable contribution to the meaning of the words in which they occur.

Different Types of Knowledge about Word Structure

Thus, there are several different types of word structure, which may function somewhat differently in the language. One cannot assume that knowledge of one type would automatically transfer to the other. One must also distinguish between different types of knowledge about word structure. Four different types of knowledge about word structure can be identified:

1. **Recognition of morphological relatedness.** Perhaps the most basic level of knowledge about morphology is the recognition that two words are related--for example, seeing the *thanks* in *Thanksgiving*. This basic insight presumably develops relatively early. Tyler and Nagy (1989) found no gain in the ability to recognize that a novel word contains a known stem after fourth grade.

2. **The ability to distinguish stems from pseudo-stems.** The child who learns to see the *agree* in *agreement* might also find the *sea* in *season*. The ability to distinguish between these two kinds of cases is a second aspect of morphological knowledge, one that presumably grows as the child begins to appreciate the systematic nature of morphological relationships among words. Derwing and Baker (1979) found that young children were more likely to rely on the spelling of a word, relative to its meaning, than adults were, in making judgments about relationships among words. Instruction encouraging students to look for "little words in big words" may encourage this kind of confusion. Any instructional approach to morphology must make some provision for dealing with this possible misconception.

3. **Knowledge of individual word parts.** A child may well learn to recognize *-ness* as an English suffix before *-ship*. One type of growth in knowledge of morphology is therefore the learning of particular prefixes, roots, and suffixes. Much of the growth in morphological knowledge between high school and college found by Nagy and Scott (1990) and Sternberg and Powell (1983) might be attributed to growth in knowledge of particular stems and affixes.

4. **Knowledge of structural meaning.** Another aspect of what students know about morphology is structural knowledge, that is, knowledge not just of the meanings of individual word parts, but how the meanings of these parts fit together to make up the meaning of the whole word. There is a variety of evidence to suggest that this type of knowledge is relatively late to develop, and strongly related to verbal ability.

Gleitman and Gleitman's (1970) research on the ability of adults to interpret complex (i.e., three-part) compounds illustrates this point. Compounding appears to be one of the first word formation processes to be acquired; children are certainly able to understand, and to generate, novel compounds before they enter school (Clark, Gelman, & Lane, 1985; Derwing & Baker, 1979). However, Gleitman and Gleitman found substantial differences associated with verbal ability and educational background in adults' ability to interpret the meaning of novel complex compounds. In their experiment, the correct interpretation of the compounds depended not on recognizing the component parts, but on determining their relationship. For example, the subjects would have to decide whether a *bird house foot* was more likely to mean the foot belonging to a house for birds, or the foot of a bird who lived in a house. What is striking about these results is the existence of ability related differences, among adults, in the knowledge of structural meaning for a linguistic structure that must have been acquired much earlier. (To some extent, the interpretation of complex compounds depends on knowledge about the way things are in the world [Kuhara-Kojma & Hatano, 1991]. However, the differences in ability to interpret compounds that Gleitman and Gleitman [1970] found could not be attributed to any large extent to difference in background knowledge; rather, they seem to reflect differential ability to utilize cues provided by linguistic structure.)

Likewise, there is evidence that knowledge of the structural meaning of derivational suffixes is not well developed among school-age children. Investigating students' ability to define simple and suffixed words, Freyd and Baron (1982) found that all the students they tested, including the high-ability group, tended to ignore or misinterpret the suffix when defining a word; that is, if asked to provide a definition for the word *expansive*, they would generally provide a definition that would be appropriate for *expand*. Wysocki and Jenkins (1987) obtained similar results; when fourth-, sixth-, and eighth-grade students were asked to provide a definition of a derivative, they most frequently responded with the definition for its stem.

Tyler and Nagy (1989) investigated the relative order of acquisition of different aspects of knowledge about derivational suffixes. As mentioned above, they found no increase in students' basic recognition of morphological relatedness--the ability to see the familiar stem *butter* in the novel derivative *butterless*--after fourth grade. They also attempted to measure students' knowledge of the syntactic function of suffixes, that is, what the suffix contributes to the meaning of the derivative as a whole, and found substantial growth in this knowledge after fourth grade.

Tyler and Nagy (1990) investigated the relative contribution of these two aspects of morphological knowledge to high school students' comprehension of complex sentences containing suffixed words. They found that high school students did not differ substantially in their recognition of morphological relatedness, but did find a significant relationship between general verbal ability and the students' use of the syntactic information provided by the suffix.

Effects of Task and Stem Familiarity

The extent to which students demonstrate knowledge of morphology is likely to depend on the nature of the task they are asked to perform. One distinction that must obviously be made is that between recognition and production tasks. Another task dimension that may influence students' ability to demonstrate knowledge of morphology is the familiarity of the stems involved. When the task involved seeing the relationship between a derivative and a familiar stem (e.g., seeing the *agree* in *agreement* or the *butter* in *butterless*), second graders (Condry, 1979) and fourth graders (Tyler & Nagy, 1989) were found to perform quite adequately. On the other hand, in the task posed by Freyd and Baron, eighth graders failed to perceive or utilize the relationship between novel stems and derivatives (e.g., *skaf* = "steal," *skaffist* = "thief").

Tyler and Nagy (1989) directly compared students' ability to utilize the syntactic information in suffixes with two types of words: possibly familiar words with known stems, and suffixed words with nonsense stems. The task, illustrated by the item in Table 1, was to choose which suffixed word best fit in a sentence context. Strictly speaking, this task required no knowledge of the meaning of the stem; the correct answer depends entirely on the suffix. However, students consistently performed better on the real-word version than on the nonsense-stem version.

[Insert Table 1 about here.]

There are two possible reasons for this difference in performance. One is that some students did not, in fact, know the syntactic value of the suffixes. They were able to answer correctly on the real-word items because they knew the particular words involved, as unanalyzed wholes. That is, they knew (implicitly at least) that *intensify* is a verb (and hence fits the sentence context) and that *intensity* is a noun (and hence does not) in the same way that they know *rejoice* to be a verb, and *joy* to be a noun, without any help from a suffix.

The other is that students may have had some knowledge of suffixes, but were less able to apply this knowledge in the case of the nonsense-stem items, perhaps because of the additional demands of trying to choose among nonsense words. These two accounts are, of course, not mutually exclusive.

Study Goals

The research reported here investigated students' acquisition of familiar English derivational suffixes between fourth grade and high school. In particular, it focused on the syntactic function of these suffixes--how the suffix affects the meaning, and more specifically, the part of speech, of the suffixed word.

There are several reasons why we chose this particular topic. Most important, this appears to be a late-developing aspect of knowledge about suffixes. Both Freyd and Baron (1982) and Wysocki and Jenkins (1987) found that students as old as eighth graders showed no apparent knowledge of what a suffix contributed to the suffixed word. Tyler and Nagy (1989) did not find consistent evidence that fourth-grade students possessed this type of knowledge, but did find it in sixth graders and older students. Even in high school, Tyler and Nagy (1990) found significant ability-related differences in students' tendency to utilize the syntactic information provided by suffixes.

Another reason for looking at students' knowledge of the syntactic function of suffixes is that this knowledge is important for writing. Suffixed words are more common in written than in oral language (see Chafe & Danielewicz, 1987), and the writer must have a grasp of how the suffixes work in order to use these words correctly.

It is likely that the studies by Freyd and Baron (1982) and Wysocki and Jenkins (1987) underestimated students' knowledge of the syntactic function of suffixes (as Wysocki and Jenkins noted), because students' knowledge was measured in terms of their ability to provide definitions for derived words. Providing an adequate definition for a derived word, say an abstract noun like *cancellation*, or an adjective like *responsive*, is difficult enough for lexicographers, let alone for students. Abstract noun definitions often resort to phrases such as "the act or process of," and derived adjectives are sometimes given definitions starting with "of or pertaining to." It is not surprising, then, that elementary and middle school students were not able to articulate definitions of derived words that expressed their part of speech. The type of items used by Tyler and Nagy (1989) to measure students' knowledge of the syntactic function of suffixes avoided this problem, but, as we will discuss later, such items have other weaknesses. One of these was a confounding of knowledge of suffixes with other aspects of reading ability.

Our primary goal in the present study, therefore, was to develop a paper-and-pencil task that would enable us to accurately measure students' knowledge of the syntactic function of suffixes, in a way that would allow us to assess the relationship between this knowledge and measures of general verbal ability in a meaningful way.

The suffixes we investigated were chosen from among the most frequently occurring suffixes in English (using data from Harwood and Wright, 1956). We also limited our choice of suffixes to neutral suffixes (see Tyler & Nagy, 1989), that is, suffixes that are added only to free-standing words, and that make only minimal changes in the spelling and meaning of the words to which they are added. These suffixes were chosen so that we could be relatively sure that errors by students reflected problems with using the syntactic information provided by the suffix, rather than lack of recognition of the suffix.

We were also interested in finding out whether students' knowledge of the syntactic function of suffixes is related to other aspects of morphological knowledge. We therefore included in this study a questionnaire to assess students' self-reported reliance on morphology (and other word-level strategies) when they encountered new words and a test designed to measure students' ability to distinguish between true roots (e.g., the *swim* in *swimmer*) and pseudoroots (e.g., the *moth* in *mother*).

Method

Subjects

Subjects were 700 students from schools in middle-sized midwestern towns--236 fourth graders from four elementary schools, 125 seventh graders from two junior high schools, and 339 students from two high schools. There were 120 tenth-grade students from one high school (High School A). Students from another high school (High School B) were drawn from 12 reading and literature classes selected to provide a variety of ability levels; each class contained students from different grade levels. Altogether, among the 219 subjects from High School B, there were 70 students in ninth grade, 81 in tenth, 39 in eleventh, and 29 in twelfth.

Different standardized test scores were available for different grade levels, and for the two high schools. Thus, it is not possible to determine fully how much of the differences between grade levels might reflect truly developmental effects and how much they might be due to differences in the make-up of the classes that were tested.

Suffix Function Test

The focus of this study was students' knowledge of the syntactic function of derivational suffixes. Since derivational suffixes serve primarily to mark changes in part of speech (e.g., *happy/happiness*), we constructed a test to measure students' knowledge of how these suffixes affected use of the suffixed word in sentences.

We made several improvements on the items Tyler and Nagy (1989) used to measure students' knowledge of the syntactic function of suffixes. The intent was to provide an item that could be answered correctly only if one recognized the syntactic function of the suffixes. The first item in Table 1 fulfills this requirement, with one qualification: A person might know the part of speech of each of the choices (*intensify, intensification, intensity, intensive*), but only know these words as unanalyzable units. That is, the person might know these words without any knowledge of what the suffix contributes to the part of speech, in the same way a person knows the part of speech of the words *joy, friend, sick,* and *think*.

Tyler and Nagy employed a second type of item to circumvent this problem. This type of item used suffixed words with nonsense stems. Therefore, it was only by knowing the part of speech conveyed by the suffix that a person could get the item right. However, a person might fail to get such an item right for other reasons, in particular, because the presence of a nonsense stem might be confusing. Hence, a person might get an item of the first type right without knowing anything about the part of speech conveyed by a suffix, and fail to get an item of the second type right even if he or she had some knowledge of the function of the suffix.

Another problem with these items is that the person's ability to answer the item reflects not only a knowledge of suffixes, but an ability to read and interpret the sentence context.

For the present study, we constructed a new type of measure to assess students' knowledge of the syntactic properties of suffixes. We used novel (or very low-frequency) but well-formed suffixed words with high-frequency stems. For example, the word *butterless* is extremely rare, so students would be unlikely to have encountered it before; if they recognize it, it is because they analyze it into a familiar stem plus a suffix. On the other hand, the stem itself is familiar.

For each suffixed word a multiple-choice item was created to assess the students' knowledge of how the suffix governed the use of that word in the sentence. We will refer to these as "derivative items." Table 2a gives a sample derivative item. For each such item, a corresponding "stem item" was constructed using a frequent, non-suffixed word of the same part of speech that made sense in the same sentence contexts. Table 2b gives a sample stem item.

[Insert Table 2a and Table 2b about here.]

The Derivative version of the item measures the students' ability to determine the syntactic function of a novel suffixed word. The Stem version of the item measures everything else that contributes to a students' performance on such an item--ability to understand the context sentence, test taking skills, possible effects of the order of choices, and so on. Thus, the Stem version of the item provides us with a baseline against which to evaluate students' performance on the Derivative version. The only difference between the two types of items is that the Derivative items require specifically morphological knowledge. When Stem-item performance is controlled for statistically, students' performance on Derivative items gives us a rather pure measure of their ability to use their knowledge about suffixes to figure out the part of speech of a novel suffixed word.

If a student were able to make full use of the information provided by suffixes, the score on Derivative items should be as high as that on Stem items. In fact, one might even expect the score for Derivative items to be higher: Although *powderize* is a novel word, it is explicitly marked by the suffix for part of speech--it is obviously a verb. On the other hand, most non-suffixed English words are at least potentially ambiguous as to their part of speech. *Smash*, for example, is typically a verb, but it is sometimes used as an adjective (a smash hit), and could conceivably be used as a noun (it was a real smash/the smash of the pumpkin on the sidewalk). To the extent that students score lower on Derivative items than Stem items, then, this can be taken as an indication that they are failing to use the syntactic cues provided by the suffixes.

Twenty rare suffixed words were selected: *rescuable, powderize, roarer, echoful, activeness, weaponist, parentism, butterless, cheesish, cutely, mirrorize, barkless, orangeness, froggish, snappable, evilly, greaseful, profitism, herdist,* and *repairer*. The stems of these words range in frequency from 8.8 to 37.2 occurrences per million words of text, and can be assumed to be familiar to most students. The suffixes were also chosen to represent common English suffixes. However, the particular stem+suffix combinations are very rare: Only two of the suffixed words themselves occurred in Carroll, Davies, & Richman (1971), *evilly* and *roarer*. These two words are found very infrequently, occurring less than once in 10 million words of text. It was assumed that most students would not previously have seen any of the suffixed words as units, and would therefore have to analyze them into stem and suffix to understand them.

Two versions of a multiple-choice test were constructed, with each version containing 10 derivative and 10 stem items in a random order. Any given subject saw only one version of an item.

Stem Discrimination Test

Another aspect of knowledge of suffixes is reflected in students' ability to discriminate between stems and pseudostems--that is, to recognize that there is not a *moth* in *mother*, at least not in the same way that there is a *bath* in *bather*. It is likely that at some point in their acquisition of concepts like *root word*, *suffix*, and *prefix*, some students develop misconceptions, and do not distinguish true rootwords from pseudostems.

A test was constructed to measure students' ability to discriminate stems from pseudostems. Students were given a brief explanation of the concept "root word," emphasizing the distinction between root words and simply finding little words in big words (such as the *fat* in *father*). They were then instructed to circle all the root words they could find and to leave words without roots uncircled.

The test consisted of 64 words, printed in two columns on a page, double spaced and with spaces between the letters to facilitate circling. Half of the words contained genuine root words, and half did not. Of the 32 words without true root words, 12 had no apparent roots at all (*common*, *simple*, *guess*) and 20 had pseudoroots (*needle*, *season*, *corner*). (We had originally thought that some of the words in this second group belonged to the first group, but students surprised us by circling the *had* in *shade*, the *me* in *meal*, and the *kit* in *kitchen*, which we had not originally seen). Of the 32 words that did contain genuine root words, 17 were common suffixed words (*thirsty*, *selfish*, *wonderful*), and 15 were novel suffixed words with familiar stems (*jumpsome*, *bounceful*, *clownish*).

Three versions of this test were constructed, differing only in the order of the items.

New Word Strategy Questionnaire

A questionnaire was constructed to obtain self-report measures about what students do when they encounter new words. The questions included are listed in Table 3.

[Insert Table 3 about here.]

For the first question, the possible choices were (a) about one in every sentence, (b) a few in every paragraph, (c) two or three on a page, (d) one or two a day, and (e) I know almost every word I read. For the remaining questions, the choices were (a) always, (b) most of the time, (c) about half the time, (d) once in a while, (e) almost never, and (f) never.

As self-report data, the answers to questions such as these would not necessarily be a very accurate reflection of what students do, or how often they do it, when they encounter unfamiliar words. On the other hand, such a questionnaire does provide some information about what students think they do, and about the relative reliance they think they place on different strategies.

Standardized Measures of Reading Ability

For most subjects, standardized test scores for reading comprehension and vocabulary were obtained from school files.

For some fourth graders, we were able to obtain Reading Total scores on the SRA Level 3S, Form Q, expressed in terms of national percentiles. These tests had been administered the preceding year. Other fourth graders were in schools that would not release information on students' test scores.

For seventh graders, we obtained Reading Comprehension scores on the Stanford 7 Plus test, again expressed in terms of national percentiles.

For High School A, we obtained scores from the Stanford 7 Plus test, Reading Comprehension, expressed in terms of national percentiles. For High School B, we were able to obtain students scores from the Stanford Diagnostic Reading Test (Blue level). The scores we used were Reading Comprehension (total), Vocabulary, Word Parts, and Structural Analysis. These were raw scores.

The Reading Comprehension (total) score was the sum of scores from two subtests that measured literal and inferential comprehension. The Word Parts subtest required students to choose the best synonym for an underlined word part. For example, in the word *caustic* the student might have to choose between (a) throw (b) burn (c) hinder (d) cover.

The Structural Analysis subtest items consisted of four groups of one or more letters, three of which could be reordered and assembled to form a word. However, for some items, no word could be formed. The student was to answer by choosing the one part that did not fit, or else to respond "no word." The word parts were not morphemes, that is, not meaningful parts of words. For example, an item might look like this:

a) sk
b) ba
c) ad
d) et
e) no word

Results and Discussion

Suffix Function Test

Means for students' performance on the Suffix Function test are given in Table 4. As can be seen from the table, subjects did better on the Stem version of items than on the Derivative version, meaning that they were not utilizing all the information provided by the derivational suffixes. The gap between the Stem and Derivative versions is greater in fourth grade than in the higher grades, suggesting that fourth graders have acquired somewhat less knowledge of suffixes than the older students. On the other hand, at all grade levels, subjects performed significantly above chance on the Derivative version, showing that they do have substantial knowledge of the syntactic properties of common suffixes.

[Insert Table 4 about here.]

Another way of representing the results from the Suffix Function test is in terms of a scatterplot comparing students' scores on the Derivative items with their scores on the Stem items. Such a scatterplot is given in Figure 1. The Y-axis represents students' proportion correct for Derivative items, corrected for guessing. (Scores less than zero have been set equal to zero.) The X-axis represents students' proportion correct on Stem items, also corrected for guessing. The scatterplot in Figure 1 includes data from all students at all grade levels. Preliminary scatterplots done separately for fourth grade, seventh grade, and high school all showed the same pattern.

[Insert Figure 1 about here.]

It is clear from Figure 1 that performance on Stem and Derivative items is correlated, $r = .67, p < .001$. (Correlations for individual grade levels are about the same--for fourth grade, $r = .59$, for seventh grade, .59, and for high school, .70.) However, the figure tells us more than just the fact that these two variables are correlated. What is clear, beyond the correlation, is that there are very few students above the diagonal, but quite a few below it.

The lack of points above the diagonal is not surprising; to be above the diagonal, a student would have to have done better on the Derivative items than on the Stem items. Since the Derivative items measure knowledge of the syntactic properties of suffixes plus all the knowledge and skills required for doing the Stem items, this is expected.

The relatively large number of points below the diagonal shows that ability to answer the Stem items may be a necessary condition for answering the Derivative items, but it is not a sufficient condition. There are many students who demonstrate a high level of facility with the Stem items, but who are not able to demonstrate any knowledge of suffixes. This indicates that some subjects have a specific problem with suffixes.

Students' performance on the Derivative version of items on the Syntactic Function test serves as a measure of their knowledge of the syntactic function of suffixes, when their performance on the Stem version of items is used as a covariate. It turned out to be somewhat complicated to remove variance associated with performance on the stem items, because of curvilinearity of this measure, and because of slight differences in difficulty of the stem items in the two versions of the test. Therefore, to best measure subjects knowledge of the syntactic function of suffixes, we included in a regression equation (functioning as covariates) subjects' performance on the stem version of items, a dummy variable representing test version, and the interaction of these last two variables. To deal with curvilinearity, we also included the square of the subjects' stem version score.

This regression model was used to compute a residual difference score, representing in effect subjects' performance on the Derivative items of the Syntactic Function test, when their performance on the Stem items has been used as a covariate. We take this residual difference score, which we shall henceforth call the Suffix Function score, to be the best measure of students' ability to use their knowledge about the syntactic properties to predict the syntactic function of novel suffixed words.

It should be stressed here that by defining the Suffix Function score in this way, we have removed all variance associated with test taking skills and with knowledge of the vocabulary and sentence structures used in the context sentences of the Suffix Function test. This leaves us with a relatively pure measure of students' knowledge of the syntactic contribution of suffixes. It also means that correlations between the Suffix Function score and standardized measures of reading ability represent a very conservative estimate of the relationship between these constructs.

For Table 4, Suffix Function scores were computed for all subjects using a single regression model, to allow for a comparison of students' knowledge of the syntactic function of suffixes across grade levels. One-way analysis of variance using the Suffix Function score as the dependent measure revealed that there was a significant difference among the three groups, $F(2,629) = 11.4, p < .001$. Post hoc Tukey tests indicate that the only significant difference is between fourth grade and high school. For other analyses, Suffix Function scores were computed using the regression model for each group individually.

Stem Discrimination Test

Three variables were computed to represent subjects' performance on the Stem Discrimination test.

Proportion of true roots circled is the proportion of words with true roots for which the subject in fact circled the root. *Proportion of pseudoroots circled* is the proportion of words with pseudoroots for which the subject circled the pseudoroot. (In the case of these first two variables, instances of other types of erroneous circling, for example, circling nonword subparts of words, were excluded from the calculation.)

These first two variables were found to be correlated, $r = .22, p < .001$. This suggests that the first variable reflects two components--first, the ability to identify root words, and second, a tendency to circle word parts, whether true or pseudoroots. To help distinguish between these two factors, a third variable, stem discrimination, was computed.

Stem discrimination is the proportion of circled word parts that were in fact true roots. (In calculating this proportion, other types of erroneous circling, e.g., circling of nonword subparts of words, were included in the denominator.) If a subject circled only true roots, this variable would have a value of 1.0; if a subject circled true roots and pseudoroots equally often, it would have the value .615 (since there were 20 possible pseudoroots to circle, and 32 true root words). If a subject were to circle only pseudoroots and no true roots the variable would have a value of zero. Means for these three variables are given in Table 5.

[Insert Table 5 about here.]

These scores reveal that the majority of subjects were able to discriminate between true roots and pseudoroots. However, at all grade levels, there were some subjects who did not consistently discriminate.

One-way analysis of variance showed a significant difference among the three groups of subjects for Proportion of True Roots Circled, $F(2,624) = 32.6$, $p < .001$, Proportion of Pseudoroots Circled, $F(2,624) = 4.9$, $p < .01$, and Stem Discrimination, $F(2,624) = 9.4$, $p < .0001$. Post hoc Tukey tests revealed that for Proportion of True Roots Circled, the mean for fourth grade was lower than the means for the other two groups. For Proportion of Pseudoroots Circled, seventh-grade students had a lower mean than the other two groups; for Stem discrimination, seventh-grade students had a higher mean than the other two groups. The surprising superiority of seventh graders over high school students might be due to overall differences in ability between these two groups. However, as will be discussed below, this effect probably reflects the conditions under which some of the high school students were tested rather than differences in the students' knowledge of morphology.

Knowledge of the Syntactic Function of Suffixes and Standardized Ability Measures

Table 6 gives the correlations for each group of subjects between standardized ability measures and the variables from the Suffix Function Test. Correlations were computed separately for High Schools A and B, because of differences in the standardized ability measures available for these two schools. Several things are apparent from this table. For one, it is clear that computing the Suffix Function Score using the Stem score as a covariate reduces, but does not totally remove, the correlation between performance on the Derivative items and standardized ability measures. For the seventh-grade subjects, and those from High School B, there is a substantial correlation between the Suffix Function Score and standardized ability measures. As noted above, because of the use of the Stem score as a covariate in computing the Suffix Function Score, this correlation is a very conservative estimate of the relationship between reading ability and students' knowledge of the syntactic function of suffixes.

[Insert Table 6 about here.]

For the students in High School B, we were able to obtain scores for several subtests of the Stanford Diagnostic Reading Test: The Reading Comprehension Total, Vocabulary, Word Parts, and Structural Analysis. As can be seen from Table 9, the Word Parts subtest was the one most strongly related to students' knowledge of the syntactic function of suffixes.

In subsidiary regression analyses, the effect of the Word Parts subtest was found to be significant whether this variable was entered before, $F = 21.1$, $p < .001$, or after, $F = 10.0$, $p < .01$, students' Total Reading Comprehension score had been entered. The effect of the latter variable was also significant, $F = 10.6$, $p < .01$, but only if it was entered before the Word Part subtest score. On the one hand, this is not a surprising result: Both the derivative items in the current study and the Word Part subtest of the Stanford Diagnostic Reading Test purport to measure students' knowledge of word parts. On the other hand, there are several differences between the two tests. Of the 30 items on the Word Part subtest, only one specifically involves a suffix. The nature of the tasks is also different; in the Word Part subtest, students are asked to choose the answer closest in meaning to a particular underlined word part; there is no context sentence involved in the items, and part of speech plays no role. Our results show, however, that despite their differences, these two tasks appear to tap a similar ability to deal with word parts, which cannot be reduced to general reading ability or vocabulary knowledge.

The Structural Analysis subtest, on the other hand, deals with students' ability to manipulate non-morphemic word parts. Hence it is not surprising that performance on this subtest is not as strongly related to subjects' Suffix Function knowledge.

Stem Discrimination and Standardized Ability Measures

Table 7 gives the correlations between standardized ability measures and the three variables derived from subjects' performance on the stem discrimination test.

[Insert Table 7 about here.]

As can be seen from the table, proportion of true roots circled is significantly related to ability only in fourth grade. This suggests that for fourth graders, identifying the roots of derivatives is still developing; in later grades, subjects have reached a ceiling on this task. For older subjects, discriminating between true roots and pseudoroots is still an issue, and hence highly related to ability measures.

The high correlation between Stem Discrimination and reading comprehension ability for seventh graders is striking, especially considering that the seventh graders appear to be close to a ceiling on the stem discrimination task.

Summary of Correlations Among Measures

Table 8 gives a summary of correlations among the different measures explored in this study.

[Insert Table 8 about here.]

Students' Suffix Function scores (the residual difference between their scores for Derivative and Stem items on the suffix function test) were significantly correlated with standardized measures of general reading ability only for subjects in seventh grade, and in High School B. The correlation between suffix function scores and general reading ability was highest in seventh grade. In High School B, where scores for several subtests of the Stanford Diagnostic Reading Test were available, the highest correlation was with the Word Parts subtest, suggesting that the suffix function score and the word parts subtest both measure some aspect of knowledge of morphology, even though the two tests are quite different in nature.

Stem Discrimination, reflecting the ability to distinguish true roots from pseudoroots was significantly related to standardized ability measures for every group but fourth grade. In seventh grade, there was an especially strong relationship between Stem Discrimination and a standardized measure of reading comprehension, $r = .56, p < .001$.

New Word Strategy Questionnaire

Correlational analyses were done to look for relationships between students' answers to the second question (how often the student reported using word parts to figure out the meaning of a new word) and other variables explored in this study. No significant correlations were found between reported use of word parts and any of the experimental or standardized ability measures.

This result, though disappointing, is consistent with Nagy and Scott's (1990) finding that self-reported reliance on morphology was not significantly related to actual use of morphology in experimental tasks for seventh- or tenth-grade students (although they did find a significant correlation in the case of college undergraduates).

The lack of any significant relationship between reported reliance on morphology and other variables may simply reflect the limited validity of this kind of self-report data. On the other hand, this result may reflect a real lack of relationship, rather than simply a weakness in measurement. Question 2 on the questionnaire measures a very general level of awareness about word parts, one that is likely to be attained by most students before fourth grade. A student encountering a word such as *windowless* for the first time does not necessarily have to reflect on the morphological structure of the word, or on the effect of the suffix on its part of speech. A student's awareness of the use of word parts may therefore be determined to a large extent, not by that student's proficiency in using word parts, but by the number of unfamiliar words the student encounters, and the difficulty the student experiences in using word parts.

The lack of correlation between reported use of word parts and other measures of morphological knowledge and reading ability suggests that general exhortations to use word parts are unlikely to have much impact.

General Discussion

Knowledge of Syntactic Function of Suffixes

One purpose of our study was to get a more accurate picture of students' developing knowledge of the syntactic function of suffixes. From the results of Tyler and Nagy (1989), it appeared fourth graders were barely able, if able at all, to demonstrate knowledge of the syntactic function of suffixes in the case of novel suffixed words. In the present study, using an improved measure, it is clear that fourth graders are able, to some extent, to determine what a suffix contributes to a novel suffixed word, although there is also measurable improvement in performance after fourth grade.

On the other hand, although there is some knowledge of the syntactic function of suffixes at all grade levels tested, this knowledge was not complete; subjects' scores for the derivative versions of items are on the average from 10% to 20% lower than their scores on the stem versions of items. Comparison of the scores for Derivative and Stem items also allows the identification of subjects who have particular trouble with suffixes. Hence, this kind of test is potentially a useful diagnostic tool.

A follow-up analysis was performed to explore the possibility that other factors, not directly controlled in the main study, might have contributed to differences in knowledge of the syntactic function of suffix. From the data for High School B, 32 students with the lowest Suffix Function scores were identified, and paired with 32 other students who had high Suffix Function scores. Each pair was matched for performance on the Stem version, and as far as possible on the Reading Comprehension subscore of the Stanford Diagnostic Reading Test. This procedure results in what could be called a High Suffix Knowledge group and a Low Suffix Knowledge group, the two groups being otherwise equivalent. A teacher familiar with these students was then asked to categorize a randomized list of these 64 students by gender, race, and status as a native vs. nonnative speaker of English. None of these factors was found to relate significantly to suffix knowledge scores.

Stem Discrimination

Only in fourth grade was there much variation in students' ability to identify the roots of suffixed words. There was more variation in students' tendency to identify pseudoroots as root words.

Performance on the stem discrimination task seems to be most clearly related to the extent to which the written instructions were carefully explained to the class. In post hoc exploration of the data, the fourth-grade classes were divided into three groups: One group consisted of the first two classes in which the experiment was administered, in which students were individually handed the experimental task booklets, briefly informed about the nature of the task, and asked to read the instructions on their own. After administering the test to these two classes, it was realized that this level of instruction would not be adequate.

The second group consisted of the bulk of the fourth-grade classrooms, for whom the instructions were read aloud, with some emphasis and repetition of the most important points. The third group consisted of the two last fourth-grade classes in which the study was conducted, in which the instructions were both read aloud and explained, and students were questioned to insure a high level of comprehension. The means for Proportion of Pseudoroots Circled for these three groups were .25, .14, and .10, respectively.

Differences in performance among the high school students tested also appear to indicate that performance on the Stem Discrimination task reflected the manner in which the instructions were given. Students in High School A were tested in a single large group in the school cafeteria; they were asked to read the test instructions silently. In High School B, students were tested in classrooms, and the instructions for the Stem Discrimination task were read out loud and explained to them. Although the test instructions for the Stem Discrimination task explicitly discussed the difference between roots and pseudoroots and gave examples, it is likely that a substantial proportion of the students in High School A did not pay careful attention to these instructions. When means were computed separately for the two high schools, there were significant differences found for both Proportion of Pseudoroots Circled and Stem Discrimination. In fact, the performance of students in High School A was similar to that of those fourth-grade students who were asked to read over the instructions on their own. It is clear, then, that performance on the Stem Discrimination task is highly sensitive to the manner in which instructions are given.

We believe, however, that variation in performance on this task may reflect not just failure to follow written instructions but also some level of misconception about the use of morphology in reading. That is, the fact that some students are willing to circle the *car* in *carbon* or the *pump* in *pumpkin* may be a consequence of their familiarity with activities in which the object is simply to find words within longer words or within arbitrary strings of letters without regard to meaning. Such activities may have some value, but they certainly run the risk of fostering or confirming misconceptions about morphological structure. Many fourth graders can distinguish between true roots and pseudoroots in familiar words when given thorough instructions; but this does not mean that they will keep such a distinction in mind when they encounter new words while reading.

Conclusion

Our findings suggest that there is a specific component of morphological knowledge related to, but distinct from, more general measures of reading ability. In the data for High School B, the two experimental measures, Suffix Function Score and Stem Discrimination, correlate more highly with the Word Part subtest of the Stanford Diagnostic Reading Test than with any other the other subtests, even though the Word Part subtest and our two experimental tasks had extremely little in common, in terms of the nature of the test items used, beyond the fact that they all involved morphology in some way.

In general, students were able to perform at high levels on our experimental tasks, demonstrating that they possessed, and were able to apply, several types of knowledge about familiar English suffixes. Thus, the inability of students to accurately represent the distinctive contribution of suffixes in their definitions of derived words observed by Freyd and Baron (1982) and Wysocki and Jenkins (1987) can be attributed largely to the difficulty of conveying this type of information through verbal definitions. This result may also, at least indirectly, call into question the common practice of *teaching* the content of derivational suffixes via definitions.

On the other hand, there were substantial individual differences in students' knowledge of morphology, which were significantly correlated with standardized measures of reading ability. Our measures allowed us to identify students who had a particular deficiency in their knowledge of suffixes. Even in High School B, which showed the best overall performance on the Syntactic Function of Suffixes test, a sizable proportion of students (18%) got at least three fewer of the derivative items correct than of the stem items, indicating that these students had a substantial gap in their knowledge of suffixes.

Our results also indicated that the ability to distinguish true roots from pseudoroots, although clearly present in the fourth-grade students, continued to be significantly correlated with reading ability through high school. Even some high school students showed a tendency to find "little words in big words" despite the lack of semantic relationship between the pseudoroot and the word in which it was embedded. This indicates a fundamental misconception, either about the nature of word structure in general, or about the nature of the task students thought they were being asked to perform. Such results suggest that instruction in morphology must address specific misconceptions or gaps in knowledge of students at various age and ability levels. The present study constitutes an attempt to develop a test for the identification of specific difficulties that students might have in dealing with morphologically complex words.

The study focused only on one type of word structure--suffixation--and in particular, only the most frequent neutral suffixes. Thus, although the findings give us some insight into students' acquisition of knowledge about English morphology, they cannot be generalized automatically to other kinds of morphological structure. Further research is needed to explore students' knowledge of non-neutral suffixes, as well as prefixation and compounding, and how that knowledge is applied in word learning tasks.

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Table 1

Items Measuring Syntactic Knowledge of Suffixes Used by Tyler & Nagy (1989)

a) **Real word item**

You can _______ the effect by turning off the lights.

a) inteusify
b) intensification
c) intensity
d) intensive

b) **Nonsense stem item**

I wish Dr. Who would just _______ and get it over with.

a) transumpation
b) transumpative
c) transumpate
d) transumpatic

Table 2

Sample Syntactic Function of Suffix Item

a) Derivative version of the item

Which sentence uses the word *powderize* most correctly?

a) First they had to find a powderize rock
b) First they had to powderize find the rock
c) First they had to find a powderize for the rock
d) First they had to find a way to powderize the rock

b) Stem version of the item

Which sentence uses the word *smash* most correctly?

a) First they had to find a smash rock
b) First they had to smash find the rock
c) First they had to find a smash for the rock
d) First they had to find a way to smash the rock

Table 3

Questions from New Word Strategy Questionnaire

1. When you are reading, how many of the words don't you know?
2. When you come across a word you don't know, how often do you use *word parts* to figure out what the word means?
3. When you come across a word you don't know, how often do you use *a dictionary or glossary* to find out what the word means?
4. When you come across a word you don't know, how often do you just *skip the word*?
5. When you come across a word you don't know, how often do you *use the context* to figure out what the word means?
6. When you come across a word you don't know, how often do you *ask someone what the word means*?
7. When you come across a word you don't know, how often do you *sound out the word to see if you know what it means*?
8. When you come across a word you don't know, how often do you use a *dictionary or glossary* to find out *how to pronounce* the word?
9. When you come across a word you don't know, how often do you try to *break the word into syllables or parts* to find out *how to pronounce* the word?

Table 4

Performance on the Suffix Function Test: Means for Stem and Derivative Item Versions

	Stem Version	Derivative Version	Suffix Function Score
Fourth Grade (n = 210)	.67 (.29)	.40 (.34)	-.048 (.21)
Seventh Grade (n = 118)	.83 (.25)	.62 (.33)	-.003 (.20)
High School (n = 311)	.82 (.25)	.67 (.33)	-.002 (.17)
All Subjects (n = 639)	.77 (.27)	.57 (.35)	.000 (.19)

Note: Values for Stem Version and Derivative Version are mean proportion correct, corrected for guessing; standard deviations are in parentheses.

Table 5
Means for the Stem Discrimination Test

	Proportion of True Roots Circled	Proportion of Pseudoroots Circled	Stem Discrimination (Relative Proportion of True Roots Circled)
Fourth Grade (*n* = 221)	.83 (.17)	.13 (.20)	.86 (.15)
Seventh Grade (*n* = 118)	.91 (.10)	.08 (.14)	.93 (.10)
High School (*n* = 286)	.92 (.10)	.15 (.23)	.89 (.15)
All Subjects (*n* = 639)	.88 (.13)	.13 (.20)	.88 (.14)

Note: Standard deviations are in parentheses.

Table 6

Correlations Between Standardized Ability Measures and Subjects' Performance on the Suffix Function Test

	Stem Score	Derivative Score	Suffix Function Score
Fourth Grade (n = 83)	.56**	.44**	.16
Seventh Grade (n = 93)	.54**	.60**	.34**
High School A (n = 76)	.26*	.35*	.17
High School B (n = 140)			
Reading Comprehension	.49**	.53**	.28**
Vocabulary	.38**	.35**	.14
Word Parts	.30**	.45**	.33**
Structural Analysis	.20*	.31**	.25*

Note: *$p < .01$ **$p < .001$

Table 7

Correlations Between Standardized Ability Measures and Subjects' Performance on the Stem Discrimination Test

	Proportion of True Roots Circled	Proportion of Pseudoroots Circled	Stem Discrimination
Fourth Grade (*n* = 83)	.32*	-.18	.25
Seventh Grade (*n* = 93)	.17	-.48**	.56**
High School A (*n* = 76)	.13	-.33*	.40**
High School B (*n* = 140)			
Reading Comprehension	.05	-.41**	.43**
Vocabulary	.04	-.38**	.43**
Word Parts	.08	-.45**	.48**
Structural Analysis	-.04	-.22*	.25*

Note: $^{*}p < .01$ $^{**}p < .001$

Table 8

Summary of Correlations Among Experimental and Standardized Measures

a) Fourth Grade

	Suffix Function Score	Stem Discrimination	Ability
Suffix Function Score	1.00	.22	.16
Stem Discrimination	.22	1.00	.25
Ability	.16	.25	1.00

b) Seventh Grade

	Suffix Function Score	Stem Discrimination	Ability
Suffix Function Score	1.00	.18	.34**
Stem Discrimination	.18	1.00	.56**
Ability	.34**	.56**	1.00

Note: $^{*}p < .01$ $^{**}p < .001$

Table 8 (Continued)

c) **High School A**

	Suffix Function Score	Stem Discrimination	Ability
Suffix Function Score	1.00	.18	.17
Stem Discrimination	.18	1.00	.40**
Ability	.17	.40**	1.00

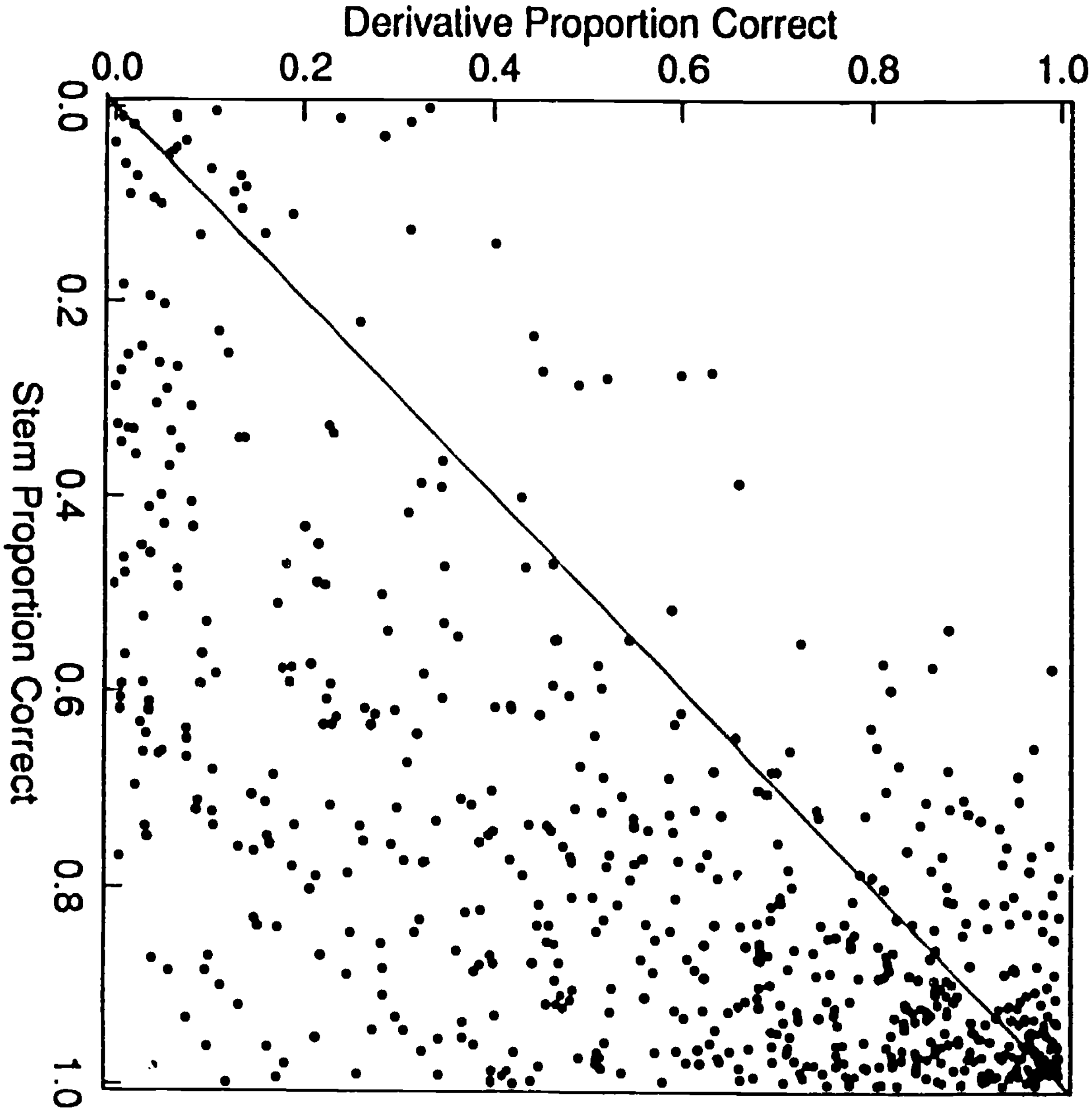
d) **High School B**

	Suffix Function Score	Stem Discrimination	Reading Comprehension	Vocabulary	Word Parts	Structural Analysis
Suffix Function Score	1.00	.30**	.21*	.14	.33**	.25*
Stem Discrimination	.30**	1.00	.43**	.43**	.48**	.25*
Reading Comprehension	.21*	.43**	1.00	.59**	.62**	.19*
Vocabulary	.14	.43**	.59**	1.00	.62**	.31**
Word Parts	.33**	.48**	.62**	.62**	1.00	.29**
Structural Analysis	.25*	.25*	.19*	.31**	.29**	1.00

Note: *$p < .01$ **$p < .001$

Figure Caption

Figure 1. Proportion correct on Derivative items as a function of proportion correct on Stem items.


Derivative Proportion Correct
0.0
0.2
0.4
0.6
0.8
1.0
Stem Proportion Correct
0.0
0.2
0.4
0.6
0.8
1.0