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ABSTRACT

A study explored word recognition and structural features of words as determinants of reading comprehension. Word recognition scores and comprehension scores for three age groups (6-7 years, 8-9 years, and 10-12 years) representing 1,200 children were used to examine the relationships of structural features of the word recognition task to comprehension performance. Results indicated that the relationship between word recognition and comprehension remained high at all three age levels, dropping only slightly for the oldest children. Results also indicated that the capability to predict comprehension from structural features of the recognized words dropped dramatically for the older children. Findings support a model with the following characteristics: (1) word recognition for younger children is understandable in terms of a small number of structural features of words, which themselves are predictors for each child; and (2) the importance of structural features of words decreases across age levels and indicates that there are developmental characteristics of word recognition that relate to comprehension performance. (One table of data is included.) (RS)

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Relationship of reading comprehension to components of word recognition: Support for developmental shifts

Abstract

Drawing upon models of word recognition, research in word recognition and comprehension relationships, and developmental models of reading positing changes in the functions that word recognition and comprehension play as reading competency emerges, the present study explored word recognition and structural features of words as determinants of reading comprehension. A unique feature of this inquiry was the use of Adams' (1990) model of word recognition to specify structural features of words on a word recognition task that reflected the categories of orthographic, meaning, and phonological processors. Word recognition scores and comprehension scores for three age groups (6 - 7 years, 8 - 10, and 10 - 12) representing 1200 children were used to examine the relationships of structural features of the word recognition task (number of graphemes, consonant blends, consonant digraphs, silent markers, vowel digraphs, r-controlled vowels, morphemes, and syllables) to comprehension performance. Total word recognition score accounted for approximately 79% of the comprehension variance for the 6 - 7 age group, approximately 82% for the 8 - 8 age group, and approximately 63% for the 10 - 12 age group. When predicting comprehension from the individual predicted structural features of words, the total squared multiple correlation was approximately .75 for the 6 - 7 year old group, approximately .49 for the 8 - 10 year old group, and approximately .12 for the 10 - 12 year old group. Of the total squared multiple correlation for structural features for each group, graphemes and morphemes contributed approximately .50 and .15 respectfully for the 6 - 7 year olds; graphemes (.35) and morphemes (.04) contributed the greatest amounts for the 8 - 9 year olds; and consonant blends (approximately .06) and silent markers (approximately .03) contributed the greatest amounts for the 10 - 12 year olds. The results support a model in which for younger children word recognition itself is understandable in terms of a small number of structural features of words. These structural features themselves are predictors for each child. The importance of structural features of words decreases across age levels and indicates that there are developmental characteristics of word recognition that relate to comprehension performance. This suggests a developmental model of reading that can be further supported from several discipline perspectives. As children gain experience and automaticity in using structural features of words to access text, the features are readily accessible in memory, consistent with the recent cerebral blood flow studies of word stem processing.

Relationship of Reading Comprehension to Components of Word Recognition: Support for Developmental Shifts

The contribution of childrer's word recognition capabilities to their reading comprehension performance as they progress through the elementary school reading program has been the focus of research, model building, and debate. Some researchers (Chall, 1983; Samuels, LaBerge, & Bremer, 1978) have posited that developmental changes in word recognition and comprehension occur as children acquire reading abilities, resulting in automatic or capacity free processing for word recognition that enables more capacity being freed for attention to construction of meaning. Other researchers Adams, 1990; Gough, 1984; Juel, 1991) have not focused on the developmental issues of reading acquisition, but have argued that word recognition capabilities are precursors to comprehension, cognition, and continuation of reading development. Regardless of whether one attends to the issues of developmental features of word recognition or to the role of word recognition in reading comprehension, there is sufficient evidence to support the conclusion that skill in word recognition contributes significantly to success in beginning reading and to comprehension in both intermediate grade students and adults (Stanovich & Wilson, in press).

Although the importance of word recognition as a foundation process of reading is well documented by research, many of the experimental tasks utilized to decompose the word recognition process do not focus on lexical aspects as criterion variables. Analyses of syllables, identification of isolated phonemes, phoneme segmentation, and discrimination of sounds are examples of criterion variables used to sort out the role of word recognition in reading development and, in many cases, to generalize to reading comprehension (Adams, 1990; Gough, 1984). Rarely do researchers take as the criterion variable subjects' comprehension performance and explore the relationship of comprehension to word recognition abilities as defined by predictable and anticipated letter strings.

In a synthesis of the research on how readers recognize words, Adams (1990) developed a model of word recognition that provided us a framework for our study. The model is based on three major components, orthographic features, word meaning, and pronunciation. In laying out this model, Adams (1990) stressed that automatic letter recognition within words forms the basis for word recognition. Automaticity is a result of the reader's "bank of associated feature recognizers" (p. 112), which research (McClelland & Rumelhart, 1981) has shown to be represented by the lines, curves, and unique features of letters that enhance rapid and accurate recognition. However, orthographic recognizers alone are not sufficient to evoke recognition of words. Another major component is the association that develops between the sequences and patterns of letters that are frequently seen. This association enables the reader to recognize the word in more of a holistic manner. Adams (1990) believes that because readers have learned the association links between letters, this learning stimulates and provides feedback for the recognition of other letters. Reinforcement of likely and anticipated letters and letter combinations is continuous as long as the reader encounters words that fit well with the associated links that have been developed. Associated links occur within syllables because of the retained predictability of the letters; therefore, in polysyllabic words the reader must chunk them into syllables if they are to be recognized.

The meaning component of the word recognition process is reciprocally related to the orthographic processor. Research by Whittlesea and Cantwell (1987) showed that by associating meaning with a meaningful spelling pattern, recognition of the word is significantly improved over time whether or not meaning is retained. The meaning processor is conceptualized by Adams (1990) to be important in readers' utilization of morphemic information in the recognition of words. However, the utilization of such knowledge may be more advantageous for older more competent readers than beginning or less skilled readers.

The phonological processor of Adams' (1990) model is theorized to be automatic and a direct result of orthographic processing. It is linked not only to the orthographic processor, but to the meaning processor as well. The implication is that activation of meaning for a skilled reader may be as immediate or automatic as activation of phonological features of words. Adams (1990) argues that the phonological processor provides an alphabetic back-up to assist the reader in maintaining speed and accuracy in word recognition and expand on-line memory for individual words, which is necessary for comprehension.

In summary, previous research has established a significant relationship between reading comprehension and word recognition. Several researchers have argued that there are developmental shifts that occur in both word recognition and comprehension as readers become more capable and proficient in interacting with text. A limitation of many of these previous studies is that they have typically focused on word recognition as a one-dimensional variable, such as phoneme segmentation, syllable identification, phoneme blending, and so forth. Although there is some support for the developmental characteristics of word recognition associated with these studies, there is little information about how orthographic, meaning, and phonological features of word recognition contribute to comprehension. There has not been a concentrated focus on whether specific word recognition capabilities contribute to reading comprehension at varying levels of reading development.

Specifically, in the research reported here we used the three components of Adams' model of word recognition to investigate the relationship of graphemic features of words to reading comprehension performance. The theoretical perspective followed in this study was that the presentation of a word for a child to recognize presents a task similar to Adams' (1990) model.

Eight structural features were identified that reflected the association between the sequences and patterns of letters (orthographic) and the meaning features (morphemes) that Adams

(1990) alluded to in her model. These structural features included total number of graphemes, consonant blends, consonant digraphs, silent markers, vowel digraphs, r-controlled vowels, morphemes, and syllables. We theorized that these features are predictable and were valid for inclusion in a reader's bank of associated feature recognizers. Furthermore, the structural features of blends, digraphs, r-controlled vowels, and morphemes were likely and anticipated letters and letter combinations that would be restricted to a syllable. That is, these features could not be split into two separate syllables within polysyllabic words and violate the predictability nature necessary for chunking.

Examining the variation in these structural features in a word recognition task can help understand the complexity of the word recognition task and sort out the relationships between the task and readers' comprehension at varying levels of reading competency.

Method

Subjects

Subjects for this study were 1200 children ages eight to twelve and one-half years. These children were the normative sample of the Kaufman-Assessment Battery for Children (K-ABC). The sample was drawn nationally to mirror the 1980 census with respect to social, gender, and ethnic/racial demographics (Kaufman & Kaufman, 1983). The subjects were split into three age groups intended to reflect developmental and instructional differences in the children's reading: 6 and 7 year olds, 8 and 9 year olds, and

10 through 12 year olds.

Materials

Measures of orthographic, meaning, and phonological elements. The Reading/Decoding subtest from the Achievement Scale of the K-ABC was used as a measure of subjects' utilization of orthographic and meaning processors. Subjects' responded to each word orally by pronouncing the written word for the examiner. The total score is based on the number of words correctly recognized. Internal consistency reliability for this subtest ranged from .89 to .97 for one year age samples from six to twelve and one-half years of age. Validities are all consistent, with correlations between .50 and .75 with other K-ABC achievement tests. The words on the list include a wide range of word frequencies and a balance of common and less common words (Kaufman & Kaufman, 1983) . Both phonetic and nonphonetic pronunciations are represented in the list for the three age levels.

Phonological elements were based upon the correct pronunciation of the words used to assess word recognition capabilities. This measure of the phonological processor was also perceived to be an accurate indicator of the efficiency of the orthographic processor. To correctly pronounce the words the reader must rapidly and accurately resolve the representation of the letter patterns to activate the phonological processor and correctly pronounce the words. Furthermore, if the meaning of the word is derived through morphemic features, then we felt that the phonological processor and orthographic processor would interact with the reader's utilization of meaning features to render a correct identification of the word.

Measures of comprehension

A measure of subjects' comprehension was based on their total score on the comprehension subtest of the K-ABC.

This measure is also an indicator of subjects' use of the meaning and phonological components, where the subjects' understanding of text is clearly dependent on their word recognition competencies. That is, subjects demonstrated comprehension by using gestural, nonverbal responses for the text, which avoids variables such as short-term memory or interpretation of visual symbols (Kaufman & Kaufman, 1983). Subjects had to go directly to meaning after processing the text. As a result, one can assume that they had to utilize their orthographic, meaning, and phonological processors in an instantiated manner to construct a correct interpretation for the text. Internal consistency reliability coefficients for the Reading for Understanding subtest range from .86 to .95 for one year age samples from six and one-half to twelve and one-half years of age.

Independent variables

The eight structural features noted earlier (graphemes, consonant blends, consonant digraphs, silent markers, vowel digraphs, r-controlled vowels, morphemes, and syllables) were used as independent variables. Each of the 28 words on the Reading Decoding subtest was evaluated for the presence and number of occurrences of the eight structural features. Each item was broken down into component parts by the researchers and reviewed independently to obtain full agreement.

Dependent variable

The dependent variable was the total score on the Reading for Understanding subtest of the K-ABC.

Data analysis

The sample was split into three age groups intended to reflect developmental and instructional differences in the children's reading activities: 6 and 7 year olds, 8 and 9 year olds, and 10 through 12 year olds. Parallel analyses described below were conducted with each group.

A two-part analysis was conducted. In the first part word recognition was predicted from the eight structural features using a general linear model within-subject design in which items formed a repeated factor with item score (0 or 1) being the dependent variable. Both logistic regression and general linear model analyses yielded identical results. For each age level a reduced model with fewer than eight features was selected based on statistical significance of each feature (Type I and Type III sums of squares). This model was then assumed to hold for each child, and an individual regression was run for each child to predict word recognition for each child. This analysis is expected to fail only for those children who got all the items correct or those who got them all wrong (fewer than 1%). The best prediction for those children is their observed score.

In the second part of the analysis the predicted word recognition scores based on individual general linear modes were entered as an independent variable in predicting reading comprehension. Also, in a parallel analysis the observed word recognition score was the independent variable in predicting reading comprehension to determine the relative loss in using the predicted word recognition score instead of the observed score.

Results

The primary questions addressed in this study were: (1) whether structural features of words were developmentally related to children's reading comprehension and (2) whether Adam's (1990) model of word recognition based on orthographic, phonemic, and meaning processors was stable across differing levels of reading capabilities. Table 1 summarizes the analysis in which the dependent variable was the comprehension performance score for the three age level groups. The unit of analysis was the age level group score on the Reading for Understanding subtest. The independent variable used in this analysis was total word recognition score derived from correct responses on the word recognition task. Also presented in Table 1 is the percent of variance explained when predicting comprehension from the independent variables for the structural features of the words (total number of graphemes, consonant blends, consonant digraphs, silent markers, vowel digraphs, r-controlled vowels, morphemes, and syllables).

Insert Table 1 about here.

6-7 year olds

The correlation between total word recognition score and total comprehension score was .890 for the 300 children in the 6 to 7 year old group. This represented a squared correlation coefficient of .794. When predicting comprehension from the individual predicted structural features of words, the total squared multiple correlation was .745. Of this, graphemes accounted .501; morphemes, .152; silent markers, .044; r-controlled vowels, .031; and vowel digraphs, .017. The remaining variables of consonant blends, consonant digraphs, and syllables contributed negligible amounts. Thus, almost all of the variance predictable in comprehension by word recognition, approximately 75% of the total of approximately 79%, can be accounted for by four structural features in the words: number of graphemes, number of morphemes, presence of silent markers, and presence of r-controlled vowels.

8-9 year olds

For the 400 children in the 8-9 age group, the correlation between total word recognition score and total comprehension score was .910, representing a squared correlation of .821. When predicting comprehension from the individual predicted structural features, the total squared multiple correlation was .491. Of this, graphemes accounted for .357; morphemes, .040; consonant blends, .014; and r-controlled vowels, .013. The variables consonant digraphs, silent markers, vowel digraphs, and syllables contributed negligible amounts to the total explained variance for structural features of words. For children 8 and 9 years of age, about two thirds of the variance predictable in comprehension by word recognition, just over 80%, is accounted for by three structural features in words: number of graphemes, number of morphemes, and presence of consonant blends.

<u>10-12 year olds</u>

The correlation between total word recognition score and total comprehension score was .790 for the 400 children, representing a squared correlation .626. Individual structural features of words for predicting comprehension had a total squared multiple correlation of .115. Of this approximately 12% of the explained variance, consonant blends accounted for .057; silent markers, .030; and r-controlled vowels, .023. Compared to age groups 6-7 and 8-9 where total number of graphemes was the strongest predictor of comprehension, total number of graphemes contributed a negligible amount. Furthermore, the contributions of consonant digraphs, vowel digraphs, morphemes, and syllables were also negligible.

Discussion

The major finding of this study is that the relationship between word recognition and comprehension remains high at all three age levels, dropping only slightly for the oldest children. The capability to predict comprehension from structural features of the recognized words drops dramatically, however. A model in which younger children's reading comprehension is greatly dependent upon their word recognition capabilities while older children no longer rely to any great extent upon it is consistent with research conclusions of Adams (1990), Chall (1983), Stahl and Miller (1989), and Stanovich (1986). Further, the results support a model in which for younger children word recognition itself is understandable in terms of a small number of structural features of words. These structural features are themselves predictors for each child, although the within-subject error, not reported here, is substantially greater than the between-subject error.

The decrease in the importance of the structural features of words across the three age groups in relation to reading comprehension suggest that there are developmental characteristics of word recognition that relate to comprehension performance. The importance of graphemic features of words decreases at each subsequent age group level from the 6-7 age group. In fact, at the 10-12 age group level, graphemic features contribute a negligible amount of the variance to children's reading comprehension. This suggests a developmental model of reading that can be further supported from several discipline perspectives. As most children gain experience and automaticity in using structural features of words to access text, the features are readily accessible in memory, consistent with the recent cerebral blood flow studies of word stem processing (Wise, Chollet, Hadar, Friston, Hoffner, & Frackowiak, 1991). This would provide an explanation for relatively little predictive variance in comprehension due to structural features of words for children of age 10 and older. Structural features of words for this age group are more likely becoming functions of memory processing rather than conscious activation of orthographic and phonological processors.

The rather great developmental shift observed between age groups 6-7 and 8-9 and 10-12 also is consistent with the nature of reading instruction in American education. Emphasis in the primary grades is typically given to the acquisition of word recognition strategies within the context of meaningful and often redundant text, with oral reading often prominent. Generally by grade four the emphasis shifts to meaning construction for text. This shift in emphasis can be viewed from a child development perspective as the result of long experience with teaching children to read. It has been more recently challenged by certain whole language proponents who support early engagement with more complex text. While the results of this study do not compellingly exclude the possibility that children can leap to such complex processing, cognitive development theory (Stanovich, 1986) supports the requirement for gaining automaticity in the word recognition process prior to success in comprehension of complex task.

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Table 1 **Group and individual analysis of word recognition and structural features of words**

Variable		*% of variance*	
6-7 Age group			
Word recognition	79.4		
Structural features		74.5	
Graphemes			50.1
Morphemes			15.2
Silent markers			4.4
R-controlled			3.1
Vowel digraphs			1.7
8-9 Age group			
Word recognition	82.1		
Structural features		49.1	
Graphemes			35.7
Morphemes			4.0
Consonant blends			1.4
R-controlled			1.3
10-12 Age group			
Word recogniton	62.6		
Structural features		11.5	
Consonant blends			5.7
Silent markers			3.0
R-controlled			2.3