Prediction of Reading Ability:

A Cross-Validation Study of the Simple View of Reading

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The Simple View of Reading, as originally articulated by Gough and Tunmer (1986), proposes that reading comprehension ability can be predicted by the product term of two components: decoding and listening comprehension ($R = D \times L$). Based on a longitudinal study evaluating developmental reading in bilingual children, Hoover and Gough (1990) reported results providing initial support for the model. The present study attempted to cross-validate the Simple View of Reading using a sample of children with English as their first language. Results support the idea that reading comprehension ability can be decomposed into decoding and listening comprehension abilities, but they do not support the assumption that all or most of the substantive variance in reading comprehension can be explained by the multiplicative combination of decoding and listening comprehension. They do, however, support a more complicated version of the model, which requires the inclusion of both the linear and the product terms in predicting reading comprehension from decoding and language comprehension ($R = D + L + D \times L$).

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Recently, a theoretically parsimonious model of reading acquisition, the Simple View of Reading, was proposed by Gough and Tunmer (1986) and then empirically tested by Hoover and Gough (1990). The fundamental proposition of the Simple View of Reading is that reading comprehension ability can be decomposed into two factors: "decoding" as measured by tests of phonetic decoding ability or word naming, and language comprehension as measured by listening comprehension. This model also asserts that reading comprehension ability is a function of the product of decoding and listening comprehension. Specifically, the following regression equation is proposed :

$$R = D \times L, \tag{1}$$

where *R* denotes reading comprehension, *D* decoding, and *L* listening comprehension, with *D* and *L* scaled from 0 to 1 (Hoover & Gough, 1990; Gough & Tunmer, 1986).[1] This equation ostensibly reflects the interactive nature of printed-word identification and language comprehension, such that a reader must have adequate facility in both abilities to extract meaning from printed text. In fact, the model signified by the product term is said to account for asymmetries and atypicalities in reading development characterized by selective deficiencies in either decoding print or in comprehending the language represented in print. Thus, children who have difficulty acquiring adequate facility in word identification, but have adequate language comprehension will have difficulty comprehending what they read. Conversely, children who have inadequate language comprehension, but adequate facility in word decoding will also have difficulty comprehending what they read. By extension, those who have both inadequate decoding and inadequate comprehension skills will be the worst comprehenders, and Gough and Tunmer (1986) have called these children "garden-variety" poor readers to distinguish them from children who have specific deficits in either word identification or language comprehension.

The equation defining Gough and Tunmer's Simple View model is also said to account for asymmetries in normal reading development, as exemplified in the case of the beginning reader who is potentially able to comprehend a given passage, but has not yet learned to decode enough of the words in the passage to comprehend its meaning; or in the case of the more advanced reader who can decode all of the words in a passage, but does not have the degree of familiarity with the meanings of enough of the words in the passage to comprehend it. The latter circumstance is handily exemplified in a skilled reader's difficulty in comprehending text in a domain in which he or she does not have the technical and conceptual knowledge required for comprehension. Consider also the more atypical situation in which written words can be decoded reasonably well by virtue of the

1. Following Gough and Tunmer (1986), Hoover and Gough (1990) used the term "decoding" in reference to the process of transforming alphabetic character into a name code. Thus, the term is intended to refer to both word identification and pseudoword naming.

reader's knowledge of letter-sound correspondence rules, but cannot be comprehended because it is literally "foreign" and, thereby, incomprehensible. An example would be a skilled reader of written English who may be able to decode most words written in languages such as Spanish or Italian, because they are alphabetic languages that incorporate most of the same letter-sound correspondence rules as written English.

The Simple View model, in principle, is able to encompass all such instances as well as the asymmetries and atypicalities in poor reading development, because it assumes that comprehension will be nil (mathematically zero) in reading written text unless there is a threshold level of facility in both decoding the words in a passage and in comprehending the message embodied in the passage. Accordingly, Gough and Tunmer (1986) have asserted that a model that places decoding and language comprehension in a multiplicative relationship ($R = D \times L$) will be a more encompassing and ecologically more valid model of reading than one that places these components of reading ability in an additive relationship ($R = D + L$).

The Simple View of Reading initially articulated by Gough and Tunmer (1986) and described in the previous section is, of course, the "strong" version of the model, given that it is based on the putative assumption that the multiplicative combination of decoding and language comprehension can, by itself, account for all of the substantive variance in reading comprehension. However, this assumption would seem to be difficult to validate except in populations consisting exclusively of individuals who have zero facility in either decoding or language comprehension, as in the examples given earlier. It is unlikely to be validated in skilled readers, in normal language comprehenders who are developing normally in reading, or even in impaired readers who have acquired enough facility in decoding to comprehend in written language what they would normally comprehend in spoken language. In such instances, one would not expect to find that the multiplicative combination of decoding and language comprehension would account for all or most of the variance in reading comprehension, while the linear combination of the two components accounts for little variance in reading comprehension.

What is implied here is a "weaker," but more complex version of the Simple View of Reading that stresses the importance of both the linear and multiplicative combinations of decoding and language comprehension in predicting reading comprehension ($R = D + L + D \times L$). According to this version of the Simple View of Reading, the linear combination of decoding and language comprehension would account for substantive variance in reading comprehension, but it is assumed that there may be instances in which the multiplicative combination of the two variables would account for unique variance. To make this point clearer, it helps to think of the linear terms in regression modeling as similar to main effects in an experimental factorial design, whereas the multiplicative term is similar to an interaction effect. In experimental research, there are often instances in which both the main effects and the interaction term are statistically significant.

However, there are rare cases wherein the interaction term is significant, but none of the main effects are significant. The weaker version of the Simple View of Reading assumes that decoding and language comprehension will tend to combine additively in predicting reading comprehension, but under some circumstances, will also combine nonadditively, as when significant main effects and interactions both emerge in experimental research. In contrast, the strong version of the Simple View of Reading assumes that decoding and language comprehension combine nonadditively in predicting reading comprehension, as when the interaction term is significant in experimental research, whereas none of the main effects are significant. The question we address in the present study is whether the strong version of the Simple View of Reading provides a better account of reading ability than does the weaker version of the model.

In an initial test of the Simple View of Reading, Hoover and Gough (1990) evaluated three predictions that they suggested flowed directly from the model. The first was that in predicting reading ability using a multiple regression approach, the product term depicting the assumed interaction between decoding and language comprehension (D × L) will contribute independent variance to the prediction equation over and above that contributed by the linear combination of these variables (D + L). The second prediction was that the correlation between tests of decoding and tests of language comprehension (as measured by listening comprehension) will be negative in samples consisting only of children who are poor in reading comprehension. This prediction was based on the assumption that poor comprehenders will be either poor in decoding or poor in language comprehension, and that a multiplicative model would provide a better account of these alternatives than would an additive model. The third prediction was that in predicting reading comprehension from listening comprehension at different levels of decoding, the regression equation will yield a zero intercept at each level of decoding and increasing slope values with increases of decoding ability. This prediction followed from the assumption that reading comprehension will be nil if language comprehension is nil at any level of decoding, and that an additive model would misrepresent this relationship.

Hoover and Gough (1990) reported results from a longitudinal study using bilingual children, which they offered as seminal support for these three predictions and, thus, for the strong version of the Simple View model. We discuss these results below, and we compare their results with the results of a study that we conducted in an attempt to cross-validate their findings. We should first point out, however, that we find the Simple View of Reading a theoretically and intuitively appealing model of reading and reading development and agree with many of the theoretical assumptions on which the model is based. In fact, we have data that are quite in keeping with certain of these assumptions (Vellutino, Scanlon, Small, & Tanzman, 1991; Vellutino, Scanlon, & Tanzman, 1994). Moreover, in its essential form, the model has practical as well as theoretical importance, because it is a mathematically testable realization of the foundational assumption that reading ability – defined as the ability to extract meaning from written text –

depends on adequate facility in both decoding and language comprehension, and that individual differences in comprehending what one reads is a measurable byproduct of individual differences in decoding and language comprehension ability. Thus, the model allows us to address the following theoretically and practically important questions among others: (a) What should be the relative weights assigned to decoding and language comprehension as determinants of skills in reading (which has been hotly debated in the reading literature – Goodman, 1967; Gough, Alford, & Holley-Wilcox, 1981; Gough & Hillinger, 1980; Liberman & Liberman, 1990; Smith, 1971; Vellutino, 1991)? (b) Do the relative contributions made by decoding and language comprehension ability to reading ability change developmentally, as might be predicted by the Simple View of Reading? (c) What is the degree to which weaknesses in one of these skills can be compensated for by strengths in the other, as suggested by some models of reading ability (Stanovich, 1980)? Given that the Simple View of Reading generates mathematically testable hypotheses, which allow us to address such questions, it provides reading researchers with an important tool for conducting the type of research that will, ultimately, have practical significance.

Nevertheless, in our attempt to cross-validate the three predictions evaluated by Hoover and Gough (1990), we found reason to worry about certain of the interpretations of their results and, thereby, of the generality of their conclusions. We detail our concerns in the following sections.

The following analyses made use of existing data collected in a study recently completed at the Child Research and Study Center at the State University of New York at Albany. We chose this data set for the following reasons: (a) Because the study was designed to investigate components of reading ability in poor and normal readers, a large battery of cognitive and reading tests was administered. As a result, the measurements needed to replicate the three predictions from the Simple View of Reading were available at each grade level. (b) The sample sizes in each reading group were adequate to ensure appropriate statistical power to reduce the probability of committing Type II errors. (c) The children were sampled from middle- and upper-middle-class families with English as their first language, which allowed us to evaluate the generality of the findings with bilingual children in Hoover and Gough's (1990) study.

Subjects and Measurements

Subjects in this study were poor and normal readers in Grades 2, 3, 6, and 7 from schools in suburban areas near Albany, New York. Each subject was administered a battery of tests evaluating intelligence, a variety of reading subskills, language and language-based abilities, and visual abilities. A more detailed description of the sample and the measurements can be found in Vellutino et al. (1991). The original purpose of data collection was to evaluate the components of variance of various reading subskills, including reading comprehension, language comprehension, word identification and pseudoword decoding.

In the present study, reading and language comprehension abilities are measured respectively by raw scores from the reading and listening comprehension subtests of the Spache Diagnostic Reading Scales (Spache, 1981). Phonetic decoding ability was measured by a composite score using two pseudoword pronunciation measures: the Bryant Test of Phonics Skills (Bryant, 1963) and the word attack subtest of the Woodcock-Johnson Test (Woodcock & Johnson, 1977). The sum of raw scores from the two tests was used as the measure of decoding. It should be noted that Hoover and Gough also used pseudoword pronunciation to evaluate phonetic decoding ability.

Hoover and Gough (1990) suggested that decoding ability is most appropriately assessed by pseudoword pronunciation for beginning readers and by word identification (the ability to name isolated real words) for more skilled readers. Accordingly, the present study also used word identification to evaluate decoding. In this study, word identification was a composite of raw scores on the word recognition subtest of the Spache Diagnostic Reading Scales (Spache, 1981) summed across word lists, the letter-word identification subtest of the Woodcock-Johnson Test, and an experimental test evaluating ability to name regular and exception words.

Results and Discussion

The descriptive statistics, including means, standard deviations, and simple correlation coefficients between measures of decoding, listening comprehension and reading comprehension for each grade, are presented in Tables 1 and 2. Table 1 presents results when pseudoword pronunciation was the measure of decoding, and Table 2 presents results when word identification was the measure of decoding. It can be seen that skill in decoding, listening, and reading comprehension all increased with increases in grade level (with the exception of Grade 7), which is consistent with results obtained by Hoover and Gough (1990).

Both Table 1 and Table 2 show that the correlations between decoding and reading comprehension decreased with increases in grade level, regardless of whether decoding was measured by pseudoword pronunciation or real-word naming. Conversely, correlations between listening and reading comprehension increased with increases in grade levels. This pattern of results was not detected by Hoover and Gough (1990), probably because they did not include grades higher than fourth grade. Given that many children in the second- and third-grade samples had minimal fluency in word identification, whereas many children in the sixth- and seventh-grade samples had a high degree of fluency in word identification, it quite likely reflects the fact that facility in word identification is the primary determinant of reading comprehension in beginning readers,

TABLE 1. Means, Standard Deviations, and Intercorrelations of Variables Using Pseudoword Decoding as the Measurement of Decoding

Variables	*1*	*2*	*3*	*4*
		Grade 2 ($N = 163$)		
1. Decoding		.43	.94	.71
2. Listening comprehension			.66	.57
3. Product				.75
4. Reading comprehension				
Mean	29.75	47.55	1484.50	43.13
Standard deviation	16.07	10.71	971.20	13.33
		Grade 3 ($N = 131$)		
1. Decoding		.41	.93	.62
2. Listening comprehension			.70	.68
3. Product				.75
4. Reading comprehension				
Mean	39.51	56.94	2309.50	53.71
Standard deviation	15.15	9.75	1090.30	11.05
		Grade 6 ($N = 129$)		
1. Decoding		.36	.84	.34
2. Listening comprehension			.80	.81
3. Product				.68
4. Reading comprehension				
Mean	55.37	69.92	3923.90	69.66
Standard deviation	11.52	12.84	1269.90	10.04
		Grade 7 ($N = 37$)		
1. Decoding		−.11	.71	.00
2. Listening comprehension			.61	.74
3. Product				.55
4. Reading comprehension				
Mean	54.00	69.58	3792.50	71.25
Standard deviation	11.65	12.81	1040.30	9.92

Note. Total possible scores: reading comprehension, 100; listening comprehension, 100; pseudoword decoding, 76.

TABLE 2. Means, Standard Deviations, and Intercorrelations of Variables Using Word Identification as the Measure of Decoding

Variables	*1*	*2*	*3*	*4*
		Grade 2 ($N = 163$)		
1. Real-word naming		.41	.84	.86
2. Listening comprehension			.82	.57
3. Product				.85
4. Reading comprehension				
Mean	156.00	47.55	7574.90	43.13
Standard deviation	36.95	10.71	2890.30	13.33
		Grade 3 ($N = 131$)		
1. Real-word naming		.47	.83	.73
2. Listening			.88	.68
3. Product				.82
4. Reading comprehension				
Mean	187.30	56.94	10832.80	53.71
Standard deviation	30.40	9.75	3106.10	11.05
		Grade 6 ($N = 129$)		
1. Real-word naming		.50	.62	.46
2. Listening comprehension			.98	.81
3. Product				.81
4. Reading comprehension				
Mean	227.20	69.92	15935.40	69.66
Standard deviation	11.60	12.84	3397.80	10.04
		Grade 7 ($N = 37$)		
1. Real-word naming		.17	.37	.27
2. Listening comprehension			.98	.74
3. Product				.76
4. Reading comprehension				
Mean	229.10	69.58	15956.50	71.25
Standard deviation	9.40	12.81	3120.00	9.92

Note. Total possible scores: reading comprehension, 100; listening comprehension, 100; real-word naming, 250.

whereas facility in language comprehension is the primary determinant of reading comprehension in more advanced readers. Both sets of findings are quite in keeping with the assumption of the Simple View of Reading that reading comprehension depends on adequate facility in both decoding (word identification) and language comprehension across the age/grade continuum. Finally, correlations between decoding and listening comprehension tended to be moderately high, except for that obtained at the seventh-grade level, which was nonsignificant. This near-zero correlation may have been due to a ceiling effect of the decoding measure in our sample, because many of the seventh graders could decode most of the test items.

Prediction 1

Hoover and Gough's (1990) first prediction stated that in predicting reading comprehension using a multiple regression approach, the product term representing the interaction of decoding and language comprehension (D × L) will contribute unique variance over and above their linear combination. Specifically, the following two regression equations were compared in terms of the amount of variance explained in reading comprehension:

$$R = b_0 + b_1D + b_2L \quad (2)$$

and $$R = b_0 + b_1D + b_2L + b_3D \times L. \quad (3)$$

Based on their sample, Hoover and Gough (1990) reported that for Equation 2, the variance explained ranged from .72 at Grade 1 to .85 at Grade 4. For Equation 3, the additional variance accounted for by the inclusion of the product term ranged from .01 at Grade 1 to .07 at Grade 3. (All were all found to be significant at $p < .01$.) Hoover and Gough (1990) asserted that their results supported a modified version of the Simple View model that included the linear terms as well as the product term (R = D + L + D × L), what we call the weaker version of the Simple View of Reading.

To cross-validate Hoover and Gough's (1990) findings, we conducted the same analysis using our sample. Tables 3 and 4 present results when decoding was measured by pseudoword pronunciation and word identification, respectively. In accord with the procedure utilized by Hoover and Gough (1990), we present results showing the proportion of additional variance in reading comprehension accounted for by the multiplicative combination of decoding and comprehension (linear terms followed by the product term) along with results showing the amount of additional variance accounted for by the linear combination of the variance (product term followed by linear terms).

It can be seen that at each grade level, Equation 2 consistently accounted for significant variance in reading comprehension, ranging from .59 to .76. However,

TABLE 3. Summary of Regression Analysis Using Pseudoword Pronunciation as the Measure of Decoding

Variable	*Multiple R*	*R square change*	*p*
Component terms followed by product term			
Grade 2			
Linear	.767	.588	.00
Product	.767	.000	.92
Grade 3			
Linear	.779	.607	.00
Product	.785	.001	.08
Grade 6			
Linear	.806	.650	.00
Product	.807	.001	.49
Grade 7			
Linear	.742	.551	.00
Product	.762	.030	.13
Product term followed by component terms			
Grade 2			
Product	.751	.564	.00
Linear	.767	.024	.01
Grade 3			
Product	.755	.570	.00
Linear	.785	.049	.00
Grade 6			
Product	.682	.465	.00
Linear	.807	.187	.00
Grade 7			
Product	.547	.299	.00
Linear	.762	.282	.00

Note. Linear: $R = b_0 + b_1D + b_2L$. Product: $R = b_0 + b_1D + b_2L + D \cdot L$, where R = reading comprehension, D = decoding measured by pseudoword naming, and L = listening comprehension.

the inclusion of the product term D × L did not add significant unique variance over and above Equation 2 at any grade level. In other words, we failed to detect a significant interaction effect for decoding and listening comprehension in the prediction of reading comprehension, regardless of whether decoding was measured by pseudoword pronunciation or real-word naming. In contrast, when the product term was entered into the equation first, the two linear terms contributed significant unique variance over and above the product term. This pattern was evident at all grade levels when pseudoword pronunciation was the measure of

TABLE 4. Summary of Regression Analysis Using Real-Word Naming as the Measure of Decoding

Variables	*Multiple R*	*R square change*	*p*
	Component terms followed by product term		
	Grade 2		
Linear	.892	.795	.00
Product	.892	.000	.81
	Grade 3		
Linear	.824	.679	.00
Product	.827	.001	.19
	Grade 6		
Linear	.815	.667	.00
Product	.807	.003	.30
	Grade 7		
Linear	.750	.563	.00
Product	.772	.033	.11
	Product term followed by component terms		
	Grade 2		
Product	.847	.717	.00
Linear	.892	.079	.00
	Grade 3		
Product	.823	.767	.00
Linear	.827	.007	.29
	Grade 6		
Product	.814	.662	.00
Linear	.807	.005	.41
	Grade 7		
Product	.756	.571	.00
Linear	.772	.024	.38

Note. Linear: $R = b_0 + b_1 WID + b_2 L$. Product: $R = b_0 + b_1 WID + b_2 L + b_3 WID \times L$, where *R* = reading comprehension, *WID* = real-word naming, and *L* = listening comprehension.

decoding, and it was evident at the second-grade level when real-word naming was the measure of decoding. Thus, results anticipated by Hoover and Gough's (1990) first prediction have not been replicated in our sample.

The following discussion may help to explain why we failed to obtain a significant interaction effect for decoding and listening comprehension in predicting reading comprehension, unlike Hoover and Gough (1990). In recent years, a number of studies have provided documentation that theorized interaction effects are notoriously difficult to detect by the multiple regression method (e.g., Aiken & West, 1991; Jaccard, Turrisi, & Wan, 1990; McClelland & Judd, 1993). The major reason is that the product term is inevitably much more unreliable than each of its components. Unreliability of the product term can cause downward bias in the estimation of the coefficient for the product term (e.g., b_3 in Equation 3), and this may decrease statistical power for detecting an interaction effect. Note also that the reliability of the product term D × L is directly dependent on the reliability of its components D and L In the case in which the correlation between D and L in the population is zero, the reliability of D × L is the product of the separate reliabilities for D and L On the other hand, if D and L are correlated, the reliability of the product term will increase only slightly compared with the case when D and L are independent. To illustrate more concretely, suppose that the reliabilities for decoding and listening comprehension are .8 and .7 in this instance and the reliability for D × L is near .56, which is modest at best. The inclusion of an unreliable variable in the multiple regression equation will certainly make it difficult to add significant predictability. Indeed, McClelland and Judd (1993) concluded that the efficiency of detecting interaction effects using the multiple regression approach is only about 20% of that for optimal experimental methods. It would appear, therefore, that the interaction effect predicted by the Simple View of Reading may or may not emerge when multiple regression is the vehicle for testing the model, which is to suggest that this approach may not always provide a fair test of the model.

A second possible reason that we failed to detect a significant interaction between decoding and listening comprehension, in contrast to Hoover and Gough's findings, is that the subjects used in the two studies came from rather different populations. Whereas Hoover and Gough's subjects were bilingual English- and Spanish-speaking children whose decoding, language comprehension and reading comprehension skills varied greatly (many of the children had low oral English skills), our subjects were monolingual English-speaking children whose skills were ostensibly less variable, especially their language comprehension skills. Thus, the distributions generated by these respective variables could be substantially different in the two samples, and this circumstance could differentially affect the correlations between decoding and language comprehension observed in the two studies. For example, it is possible that, compared with our sample, Hoover and Gough's sample may have had higher concentrations of children with zero listening comprehension and/or zero decoding scores, which, because of wider range in one or both variables, could have produced higher correlations between the two variables than those we obtained. This, of course, could affect the reliability of the product term as we pointed out earlier.

In sum, although Hoover and Gough (1990) obtained a significant interaction between decoding and language comprehension in their study, their results do not support the strong version of the Simple View of Reading ($R = D \times L$). They are more in keeping with the weaker version of the model ($R = D + L + D \times L$), because the inclusion of both the linear and the product terms in the equation accounted for more variance in reading comprehension than either the linear terms or the product term alone. The difference between our findings and those of Hoover and Gough (1990) is that the product term did not contribute unique variance in our sample, and as discussed previously, the unreliability of this term may be the cause of this discrepancy.

Prediction 2

The second prediction from the Simple View of Reading is that for poor comprehenders, the correlation between decoding and listening comprehension will be negative. The rationale generating this prediction is that if reading comprehension is the product of decoding and listening comprehension, children with lower reading comprehension scores will tend to have higher listening comprehension scores at lower decoding levels, and vice versa. Using their sample, Hoover and Gough (1990) demonstrated that with successive reduction of the sample based on deleting subjects with higher reading comprehension scores the correlations between decoding and listening comprehension changed from positive to negative within each grade. To argue that these results were not artifacts, Hoover and Gough showed that good readers had positive correlations between decoding and listening comprehension at each grade level, even after deleting subjects with lower reading comprehension scores.

We performed a similar analysis using our sample. The correlation coefficients between decoding and listening comprehension using Hoover and Gough's sample reduction procedure are presented in Table 5. It can be seen that, for Grade 2, the correlation does become negative when three-fourths of the better readers are excluded. However, with further exclusion, the correlation becomes positive. Moreover, no negative correlation appears for Grade 3. For Grade 6, the correlation becomes negative only when the last six poorer readers remain in the analysis. For Grade 7, all correlations are negative. Because there is no definite pattern across the grade levels to show that the correlation between decoding and listening comprehension becomes negative for poorer readers, the second prediction from the Simple View of Reading is not supported by our data.

A close examination of the correlation coefficients reported by Hoover and Gough (1990) and those obtained from our sample suggest that, quite likely, range restriction plays a major role in the changing of the correlations with successive exclusion of the good readers. The range restriction effect dictates that if a

TABLE 5. Correlations Between Decoding and Listening Comprehension as Sample Reduces Based on Decreasing Reading Comprehension Skill

PCT	*N*	*r*	*p*	*D*	*L*	*P*	*R*
			Grade 2				
100%	162	.426	.000	29.7	47.5	1484.5	43.1
90%	147	.304	.000	27.5	46.2	1309.9	40.8
75%	120	.264	.004	25.2	44.9	1167.9	38.2
50%	75	.102	.383	18.4	42.5	785.8	32.3
25%	41	−.118	.464	14.7	39.2	548.4	23.3
10%	14	.377	.184	12.7	38.8	453.9	17.1
5%	8	.269	.519	12.9	37.8	402.4	14.3
			Grade 3				
100%	131	.408	.000	39.5	56.9	2309.5	53.7
90%	117	.258	.005	37.6	54.8	2087.8	51.4
75%	98	.206	.042	35.3	53.7	1918.7	48.8
50%	64	.180	.155	31.1	52.7	1659.3	45.2
25%	32	.101	.582	26.0	49.3	1291.8	41.0
10%	12	.342	.276	25.3	47.3	1218.8	33.2
5%	6	.405	.425	22.0	46.0	1031.2	27.8
			Grade 6				
100%	126	.363	.000	55.4	70.0	3923.9	70.0
90%	111	.280	.003	54.2	67.7	3700.8	67.6
75%	94	.115	.272	52.6	65.1	3425.6	65.5
50%	63	.000	.999	52.1	60.8	3154.7	61.2
25%	33	.327	.068	53.0	56.4	3018.1	56.3
10%	12	.510	.091	51.6	58.4	3029.5	53.7
5%	6	−.337	.514	50.9	58.7	2834.7	52.8
			Grade 7				
100%	37	−.107	.529	54.0	69.9	3762.5	71.3
90%	33	−.193	.281	53.4	67.7	3607.7	69.7
75%	26	−.331	.098	53.1	64.6	3415.8	67.1
50%	19	−.304	.206	54.5	61.9	3340.2	63.4
25%	9	−.392	.296	55.4	56.6	3083.8	56.4
10%	3	−.999	.016	63.7	51.3	3260.3	53.0

Note. PCT is the percentile score for reading comprehension at each descending level. Children whose reading comprehension score is higher than a given percentile are excluded in the particular regression equation.

narrower range of subjects is used, the correlation will decrease (Cohen & Cohen, 1983; Nunnally, 1978, p. 140). With successive exclusion of the good readers, the subjects remaining in the sample have lower and lower decoding and listening comprehension scores (see the descriptive statistics in Table 5), which is equivalent to using a narrower range of subjects. This explains why correlations between decoding and listening comprehension change from significant positive to near zero. At the time when the correlation is near zero, a few subjects with relatively more extreme scores (e.g., higher decoding with lower listening comprehension or vice versa) may weigh heavily on the correlation coefficient. In the process of successive exclusion, a negative correlation could emerge just because of the existence of some extreme values. Further exclusion of subjects could even produce a positive correlation, as in the present instance.

To further illustrate, Table 6 presents the correlation coefficients between decoding and listening comprehension with successive exclusion of poor readers based on their reading comprehension scores. We see that correlation coefficients between decoding and listening comprehension tend to decrease at each grade level, quite possibly showing the effect of range restriction. When the correlation coefficient reduces to near zero, a few subjects with more extreme scores may change the correlation from positive to negative, as we suggested earlier. In fact, the correlation coefficients become negative for Grades 2, 3, and 6 when only the best readers, whose reading comprehension scores are in the top 95%, remain in the sample. Again the range restriction effect may explain the change of the correlation coefficients presented in Table 6.

Keeping the possible effects of range restriction in mind, let us examine the findings reported by Hoover and Gough (1990). From their Table 3 (pp. 143–144), we see that the correlation coefficients between decoding and listening comprehension for Grades 1, 2, and 3 for the entire sample were positive: .422, .592, and .543, respectively. With successive exclusion of better readers, these coefficients decreased to nonsignificant and then negative values (−.125, −.087, and −.546, respectively). This trend can be explained by the effect of range restriction. Furthermore, the two negative correlations for Grades 1 and 2 (−.125 and −.087) were not significantly different from zero, and the negative correlation (−.546) for Grade 3 was calculated from a sample of only 13 poorer readers. For Grade 4, the negative correlation did not emerge when only 12 poorer readers are left in the sample, which again suggests that the negative correlations obtained in Hoover and Gough's sample may be artifactual.

The foregoing analyses notwithstanding, we should point out that the fundamental assumption on which the second prediction of the Simple View of Reading is based, that poor reading comprehension implies either (or both) poor decoding or poor language comprehension, must be correct and is not in dispute. We nevertheless believe that the sample reduction procedure used by Hoover and Gough is a rather tenuous vehicle for documenting the validity of this assumption. Thus, despite the plausible nature of the second prediction of the Simple View of Reading, that in a population consisting primarily of poor

TABLE 6. Correlations Between Decoding and Listening Comprehension as Sample Reduces Based on Increasing Reading Comprehension Skill

PCT	*N*	*r*	*p*	*D*	*L*	*P*	*R*
				Grade 2			
10%	144	.348	.000	32.0	48.9	1614.4	46.2
25%	121	.323	.000	35.0	50.3	1801.6	50.1
50%	73	.312	.007	40.2	52.7	2149.9	53.5
75%	39	.510	.001	41.6	55.1	2347.9	57.3
90%	14	.544	.050	51.1	60.1	3125.5	64.0
95%	7	−.624	.135	57.0	63.1	3642.8	67.3
				Grade 3			
10%	116	.343	.000	41.2	58.3	2449.2	56.1
25%	93	.263	.011	44.2	59.8	2674.2	58.5
50%	63	.245	.053	48.5	61.7	3014.7	62.4
75%	32	.187	.304	51.9	66.9	3489.8	68.6
90%	12	.096	.766	55.7	76.3	4253.6	73.6
95%	6	−.289	.582	58.0	78.5	4541.6	76.8
				Grade 6			
10%	111	.361	.000	55.9	72.0	4071.0	72.1
25%	94	.379	.000	56.2	74.5	4232.3	74.1
50%	63	.486	.000	58.6	79.3	4693.2	78.1
75%	33	.215	.238	63.5	84.8	5387.8	82.2
90%	11	.042	.903	62.6	86.9	5442.8	86.8
95%	6	−.237	.652	61.2	89.4	5460.2	89.2
				Grade 7			
10%	33	.018	.922	53.0	71.5	3813.1	73.3
25%	27	.037	.854	53.3	74.0	3980.3	76.3
50%	19	.113	.656	53.5	77.6	4208.3	79.1
75%	9	−.032	.935	57.7	83.1	4787.3	82.3
90%	3	.350	.772	63.3	84.7	5364.7	84.5

Note. PCT is the percentile score for reading comprehension at each ascending level. Children whose reading comprehension score is higher than a given percentile are excluded in the particular regression equation.

comprehenders, decoding and listening comprehension should be negatively correlated, the data offered by Hoover and Gough (1990) must be accepted only with some degree of caution. The present findings suggest that the negative correlations obtained between these variables when good readers were excluded may be the result of range restriction.

Prediction 3

The third prediction from the Simple View of Reading is that at different levels of decoding ability, the prediction of reading comprehension from listening comprehension will have (a) a zero intercept at each level of decoding and (b) an increasing slope value with increases of decoding ability, with the slope equal to zero at the lowest decoding skill level. Hoover and Gough (1990) claimed that this prediction effectively distinguishes between an additive model (Equation 2) and a multiplicative model (Equation 1), because an additive model leads to the prediction that (a) the intercept will not be zero except at a zero level of decoding ability and (b) the slopes will be a positive constant value at any level of decoding ability. These two predictions were ostensibly confirmed by Hoover and Gough (1990).

Table 7 presents the intercepts and slopes derived from the measures we used to predict reading comprehension from listening comprehension at various levels of decoding ability, as measured by pseudoword pronunciation. Decoding scores are partitioned into six categories, with one indicating the lowest decoding level and six the highest. Let us first examine the intercepts and their related p values. It can be seen that only 5 out of 17 p values are nonsignificant ($p > .05$), and the 5 nonsignificant p values are all associated with relatively small sample sizes in a given grade. For instance, in Grade 2, the nonsignificant p value is .13 at decoding level 2 ($N = 16$), which has the smallest sample in that grade. It seems likely that the five intercepts turned out to be nonsignificant because of a lack of power resulting from small sample sizes. Thus, part A of the third prediction from the Simple View of Reading has not been cross-validated in our sample.

Our failure to replicate Hoover and Gough's finding of nonsignificant intercepts for reading comprehension at most of the levels of decoding they evaluated is not surprising, given that none of the subjects in our study had grossly deficient oral language skills. Yet, although Hoover and Gough's sample contained sizable numbers of children who did have grossly deficient oral language skills, none of the samples consisted entirely of such children and this is the only condition under which true zero intercepts would be expected to emerge. Thus, the likely reason that more of the intercepts in their study did not achieve statistical significance is lack of power because of small sample sizes.

We hasten to add that we do not dispute the premise that reading comprehension will be nil when either language comprehension or decoding is nil. However, we expect that samples consisting entirely or primarily of individuals who have zero or near-zero language comprehension ability would be rare in reading research, which, of course, means that part A of the third prediction would generally be difficult to validate.

Let us now examine the slopes and the related p values in Table 7. There are 4 nonsignificant p values out of 17. Again, we see that these nonsignificant p values are associated with smaller sample sizes, indicating that the failure to achieve statistical significance may result from low power. We may, therefore, conclude that the slopes should not be zero in the population, which is consistent with results reported by Hoover and Gough. An interesting tendency will be revealed from examining the slope values: with increases in decoding level, the slope tends to increase. This tendency can be seen at each grade level. The interpretation of this tendency is that, at different levels of decoding, listening comprehension predicts reading comprehension differently, indicating that decoding is a moderator variable that significantly affects the relationship between reading comprehension and listening comprehension.[2] Thus part B of the third prediction has been cross-validated in our sample.

Finally, we replicated the foregoing results using real-word naming as a measure of decoding ability. Because the results obtained are similar to those we obtained when pseudoword naming was used as the decoding measure, the findings using real-word naming are not presented.

General Discussion

The basic proposition of the Simple View of Reading is that reading comprehension ability can be decomposed into decoding ability and language comprehension ability, and that facility in comprehending what one reads reflects the combined effects of both abilities. This proposition is, in general, supported by the results of our cross-validation study, given our finding that the variance on a test evaluating reading comprehension ability, which was explained by the linear combination of scores on tests evaluating decoding ability and language comprehension ability (Equation 2), was quite substantial. In addition, we found that the variance explained by the multiplicative combination of decoding and language comprehension was also quite substantial. Both sets of results were obtained when tests of real-word naming were used as the measure of decoding as well as when tests of pseudoword pronunciation were used as the measure of decoding. These results are consistent with results obtained by Hoover and Gough

2. In regression analysis, a moderator variable is a predictor variable that directly influences the relationship between another predictor variable and the dependent variable, such that at different levels of the moderator variable, the relationship between the other predictor and the dependent variable is different. In the present context, decoding ability is a moderator variable, because the relationship between language comprehension and reading comprehension changes across levels of decoding ability. In other words, decoding ability "moderates" the relationship between language comprehension and reading comprehension as follows: At low levels of decoding ability, language comprehension and reading comprehension are weakly related, because linguistic abilities are not allowed to become fully operative as determinants of reading comprehension. As one approaches mastery in decoding, individual differences in language comprehension become increasingly important determinants of reading comprehension and the relationship between language and reading comprehension strengthens. It should be apparent that just as decoding ability can moderate the relationship between language and reading comprehension, so also can language comprehension moderate the relationship between decoding ability and reading comprehension.

TABLE 7. Intercept and Slope for the Linear Relationship Between Reading and Listening Comprehension at Various Levels of Decoding

		Intercept		*Slope*	
Level of decoding	*n*	*Value*	*p*	*Value*	*p*
			Grade 2		
1	55	15.2	.03	.38	.02
2	16	25.5	.13	.34	.33
3	42	35.4	.00	.25	.02
4	28	25.4	.00	.48	.00
5	18	17.3	.01	.71	.00
			Grade 3		
2	10	41.6	.06	.04	.92
3	41	29.8	.00	.37	.00
4	24	15.0	.22	.69	.00
5	31	20.1	.01	.66	.00
6	11	14.5	.14	.79	.00
			Grade 6		
3	13	28.7	.01	.55	.00
4	27	28.0	.00	.58	.00
5	32	26.5	.00	.63	.00
6	54	23.6	.00	.66	.00
			Grade 7		
4	6	51.7	.11	.27	.45
5	9	52.6	.00	.31	.11
6	17	17.4	.03	.77	.00

(1990) and others who have provided independent evidence that the ability to read depends on adequate facility in both decoding and language comprehension (Curtis, 1980; Sticht, 1979; Sticht & James, 1984; Vellutino et al., 1991, 1994).

However, the strong version of the Simple View of Reading also asserts that the product term of decoding and language comprehension can account for all or most of the substantive variance in reading comprehension (first prediction), but neither the findings reported by Hoover and Gough (1990), nor those from the present study unequivocally support this assertion. In contrast to results obtained by Hoover and Gough (1990), we found no evidence of an interaction between decoding and language comprehension in the regression analyses we conducted. More specifically, we found that the term representing the linear combination of decoding and language comprehension accounted for significant variance in reading comprehension at each of the grade levels assessed, and the inclusion of the product term representing the interaction between these two abilities did not add significant unique variance at any of these grade levels. We attributed this outcome to the notorious difficulty encountered by researchers in detecting interaction effects using multiple regression methods (McClelland & Judd, 1993), as well as to sampling differences in our respective studies. Thus, although our findings do not support the strong version of the Simple View of Reading, they do not rule out the possibility that the multiplicative combination of decoding and language comprehension, under some circumstances, may account for unique variance in reading comprehension, and the findings are quite in keeping with a weaker version of the model that incorporates both linear and product terms in predicting reading comprehension. Although they do not distinguish between the strong and the weaker version of the Simple View of Reading, Hoover and Gough (1990), themselves, found that the linear combination of decoding and listening comprehension accounted for significant unique variance in reading comprehension above and beyond that accounted for by the product term representing the interaction of these two variables (see Hoover and Gough's Table 2, p. 141). Thus, the combined results leave the strong version of the model open to question.

The strong version of the Simple View of Reading can also be questioned by our failure to replicate Hoover and Gough's (1990) finding that listening comprehension and decoding were negatively correlated in samples of children consisting only of poor comprehenders (second prediction). Hoover and Gough offered this finding as support for the assumption that decoding and listening comprehension will tend to be negatively correlated in samples of poor comprehenders. Although this assumption is logically coherent and certainly would be an expected outcome in populations consisting primarily or exclusively of poor comprehenders who have inadequate ability in either decoding or language comprehension, our data suggest that the results generated by Hoover and Gough's sample reduction procedure may have been an artifact of range restriction. Thus, additional research will be required to verify it.

We also failed to replicate Hoover and Gough's (1990) finding of zero intercepts at every level of decoding when reading comprehension was predicted by listening comprehension (third prediction). Contrary to results obtained by these investigators, we found that the intercepts for predicting reading comprehension from listening comprehension at several different levels of decoding were significantly different from zero in 12 out of 17 contrasts in Grades 2, 3, 6, and 7. In addition, we found that in those instances wherein the intercepts were not significantly different from zero, our sample sizes were rather small, suggesting that Hoover and Gough's findings may have been due to lack of power associated with small sample sizes. This finding is also at variance with the strong version of the Simple View of Reading and is more in keeping with the weaker version of the model, because the weaker version allows for the possibility that the intercept may not be zero when reading comprehension is predicted by listening comprehension, except in those instances in which decoding ability is actually zero. However, our finding that the slopes for predicting reading comprehension from listening comprehension increased with increases in level of decoding ability is consistent with the related assumption that the prediction of reading comprehension from language comprehension is contingent on the degree of facility one has in decoding (and vice versa). Thus, the combined results add greater weight to our suggestion that decoding ability and language ability may coalesce both additively and interactively under some circumstances.

Of additional interest, relative to the latter assumptions of the Simple View of Reading, is our finding that measures of decoding ability and listening comprehension ability carried different weights in predicting reading comprehension at different grade levels. Whereas in second and third graders, decoding ability accounted for more variance in reading comprehension than did listening comprehension, the opposite pattern was observed in sixth and seventh graders. Similar results have been obtained elsewhere (Curtis, 1980; Sticht, 1979; Sticht & James, 1984), and such findings would seem to be reasonably interpreted as evidence that beginning readers must achieve an adequate level of facility in decoding before language comprehension processes become fully operative. When children have acquired enough facility in decoding to identify all or most of the words they might encounter in material they are expected to read, then language comprehension processes become fully (or almost fully) operative, and facility in language comprehension becomes the primary determinant of reading comprehension. Although Hoover and Gough's article did not explicitly address the question of whether or not decoding and language comprehension carry different weights at different stages of reading development, this assumption is not inconsistent with the essential features of the Simple View of Reading. In fact, Gough, Hoover, and Peterson (1996) have, themselves, provided evidence in support of the assumption. In a recent meta-analysis of relevant studies on reading development, a common pattern emerged in predicting reading comprehension characterized by systematic decreases in the contribution of decoding over time accompanied by systematic increases in the contribution of language comprehension. Thus, with the addition of a similar assumption, the model could quite nicely account for our findings, and those of other researchers.

As pointed out earlier, the pattern of results we obtained when we used a test of pseudoword pronunciation as the measure of decoding ability was essentially the same as the pattern of results we obtained when we used a measure of word identification as the measure of decoding ability, regardless of whether our subjects were closer to the beginning or to the later stages of reading development (i.e., Grades 2 and 3 versus Grades 6 and 7). These outcomes call for some qualification of Hoover and Gough's (1990) suggestion that pseudoword pronunciation would be a more valid measure of decoding ability in beginning readers than would a measure of word identification, whereas a measure of word identification would be a more valid measure of decoding ability in more advanced readers. However, Hoover and Gough did not evaluate children in sixth and seventh grade, nor did they use any measure of word identification to evaluate decoding ability. Thus, it would seem that with children of the ages and grades evaluated here, either a measure of pseudoword pronunciation or a measure of word identification could be profitably used to evaluate decoding ability, although this might not be true when evaluating reading comprehension ability in adult skilled readers.

Finally, as we indicated in the introduction of the this article, the Simple View of Reading, as a model of reading and reading development, represents an important contribution to the reading literature, because it provides researchers with mathematically testable hypotheses, the evaluation of which will, no doubt, have both theoretical and practical significance. Theoretically, testing such hypotheses promises to tell us much about reading as a cognitive ability and the course of reading development, while allowing us to evaluate the relative merits of models of reading such as the "top down" (whole language) models of reading advocated by Goodman (1967) and Smith (1971) compared with "bottom up" (code-oriented) models advocated by Gough and Hillinger (1980) and Liberman and Liberman (1990), about which there has been much debate. Practically, such research promises to give us insight as to the relative effectiveness of the different approaches to reading assessment and instruction that flow directly from these models vis-à-vis developmental and individual differences in decoding and language comprehension as reading subskills. We do not believe that the distinction we have made, in this article, between what we have characterized as the strong versus the weaker versions of the Simple View of Reading, diminishes the potential contribution of the model in any appreciable way. In fact, we believe that the distinction should enhance the model.

In sum, we failed to replicate all of the findings that Hoover and Gough (1990) offered in support of the Simple View of Reading, but we did replicate certain others. Most importantly, we found no evidence to support the central assumption of the strong version of the Simple View of Reading, which suggests that reading ability is a multiplicative function of decoding ability interacting with language comprehension ability. Our findings are consistent, however, with the essential features of the Simple View of Reading and are quite in keeping with a weaker version of the model that combines decoding ability and language comprehension ability additively as well as multiplicatively in determining and predicting reading comprehension ability. In other words, our findings do not rule out the possibility that a product term, reflecting the interaction of decoding and language comprehension, would, under some circumstances, add significant variance to the prediction equation (e.g., in predicting reading comprehension in populations encompassing the extreme ranges in either decoding or language comprehension ability). However, as suggested by the methodology literature, such interactions are difficult to detect using standard multiple regression procedures, and more optimal experimental methods might be a more effective way to evaluate them. It should nevertheless be apparent that the statistical model we advocate is identical to that advocated by Hoover and Gough. And, although it is a more complicated model than that advocated by Gough and Tunmer (1986), it would seem to be more encompassing.

Notes

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