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Phonemes, Rimes, Vocabulary, and Grammatical Skills as Foundations of Early Reading Development: Evidence From a Longitudinal Study

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The authors present the results of a 2-year longitudinal study of 90 British children beginning at school entry when they were 4 years 9 months old (range = 4 years 2 months to 5 years 2 months). The relationships among early phonological skills, letter knowledge, grammatical skills, and vocabulary knowledge were investigated as predictors of word recognition and reading comprehension. Word recognition skills were consistently predicted by earlier measures of letter knowledge and phoneme sensitivity (but not by vocabulary knowledge, rhyme skills, or grammatical skills). In contrast, reading comprehension was predicted by prior word recognition skills, vocabulary knowledge, and grammatical skills. The results are related to current theories about the role of phonological, grammatical, and vocabulary skills in the development of early reading skills.

Reading is a linguistic skill that, with rare exceptions, is learned only after children have acquired considerable proficiency in oral language. The present article explores the importance of oral language skills at school entry as predictors of progress in learning to read in the first 2 years of formal education. In particular, we focus on the roles of different aspects of oral language skill (phonological, grammatical, and vocabulary skills) as predictors of two different components of reading (word recognition and reading comprehension).

There is now a great deal of evidence showing that children's early progress in learning to read depends critically on their oral language skills. Most studies in this area have focused on relationships between early phonological skills and the growth of printed word recognition skills in English-speaking children (for reviews, see Goswami & Bryant, 1990; Rack, Hulme, & Snowling, 1993; Wagner & Torgesen, 1987), though there has recently been increased interest in the possible insights that can be gained from making comparisons with the processes involved in learning to read in other alphabetic (de Jong & van der Leij, 1999; Wimmer, Mayringer, & Landerl, 2000), as well as nonalphabetic, scripts (Ho & Bryant, 1997).

In comparison to the preponderance of studies concerned with the role of phonological processes, there have been fewer studies looking at the importance of other aspects of language development for learning to read. Theoretically, there seems little doubt that two other aspects of language, vocabulary knowledge and grammar, are important for learning to read. It has been argued that vocabulary knowledge (understanding the meanings of individual

words) may be important for both learning to recognize printed words (Nation & Snowling, 1998a; Plaut, McClelland, Seidenberg, & Patterson, 1996) and for the comprehension of text (Nation & Snowling, 1998b). Grammatical skills may also be important in allowing children to benefit from contextual constraints on word recognition (Tunmer, 1989; Tunmer, Herriman, & Nesdale, 1988) as well as contributing to the development of reading comprehension (e.g., Bowey, 1986; Perfetti, 1985).

The Development of Word Recognition in Reading

The close association between phonological skills and the development of word recognition skills in reading is now established beyond doubt (Castles & Coltheart, 2004), but the mechanisms responsible for this association remain controversial. One aspect of this controversy relates to the structure of phonological skills and the possibly distinct influences that different-sized phonological units may exert on the growth of decoding skills at different stages of development. Early studies in this area emphasized that because, in alphabetic languages, letters in printed words typically represent phonemes in spoken words, a child needs to develop an awareness of phonemes in speech in order to learn to read an alphabetic script effectively (Liberman, Shankweiler, Fischer, & Carter, 1974; Savin, 1972). However, in a later study, Bradley and Bryant (1983) showed that a measure of rhyme ability in young children was a good predictor of their subsequent progress in learning to read. Largely on the basis of this study, Goswami and Bryant (1990) developed the argument that awareness of the onset and rime units of a spoken syllable was particularly critical for how easily young children learned to read (in a spoken syllable, the onset corresponds to the consonant or consonant cluster preceding the vowel [the /spr/ in SPRING], whereas the rime corresponds to the vowel and succeeding consonants if any [the /ing/ in SPRING]).

Goswami and Bryant (1990) argued that children who have good awareness of onset–rime units in speech are at an advantage in the early stages of learning to read. This advantage, in turn, was

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explained in terms of a theory of the development of word recognition skills in reading that involved children being able to make orthographic analogies when they encountered printed words that they could not recognize. In this view, if a child encountered an unknown printed word (say, LIGHT) that shared a rime unit with a word the child could read (say, FIGHT), this might allow the child to make an orthographic analogy. A child who realizes that the known word FIGHT can be used as a clue to help him or her read the unknown word LIGHT is making the prediction that the new word (LIGHT) will rhyme with the known word (FIGHT) because they share the same spelling pattern for the rime unit. Critically, however, such analogies are only possible if the child can access phonological representations of the words containing onset and rime units.

This, then, is an explicit theory about the importance of onset-rime awareness as a skill that facilitates learning to read by promoting the use of orthographic analogies in the early stages of learning to read. Goswami and Bryant (1990) argued that the ability to attend to smaller phonological units of speech (phonemes) only develops later, possibly as a consequence of onsets most typically corresponding to phonemes in English (e.g., /d/ in DOCK) and possibly as a consequence of a reciprocal relationship between reading and phonological awareness (Perfetti, Beck, Bell, & Hughes, 1987). However, in another article, Bryant, Maclean, Bradley, and Crossland (1990) argued that sensitivity to rime and sensitivity to alliteration are developmental precursors of phoneme detection, which in turn, plays a role in learning to read. According to this view, rime awareness plays both a direct causal role in learning to read (good rime skills directly facilitate learning to read by promoting the use of orthographic analogies) and an indirect role via the development of phoneme awareness (good rime skills facilitate the development of phoneme awareness, which in turn facilitates reading, possibly by allowing children to use an explicit "sounding out strategy" involving letter-sound correspondences). According to Goswami and Bryant (1990), "The model leads to one main prediction: it is that the relationship between children's awareness of rhyme and reading will hold even after controls for differences in the children's ability to detect phonemes" (p. 111). Assessing this idea is one aim of the present study.

The status of different phonological units as predictors, and potential causes, of the development of word recognition skills remains an issue of intense debate, as evidenced by recent reviews (Castles & Coltheart, 2004; Hulme, 2002; Macmillan, 2002). This debate is of practical significance as it has direct implications for how best to teach children to read. Indeed, Macmillan (2002), who presented a review of many studies of rhyme skills as predictors of reading, argued that the evidence for the importance of onset-rime skills as a predictor of reading is weak, and she questioned its influence on educational practice in both the United Kingdom and the United States (p. 32). On a theoretical level, evidence that phonological processing skills are a *cause* of the development of word recognition skills in reading has been widely accepted (e.g., Torgesen et al., 1999), though this causal hypothesis has recently been severely questioned (Castles & Coltheart, 2004). Arguably, this debate, as an example of how it may be possible to provide support for a theory that postulates a causal link between earlier (spoken language) and later (reading) acquired skills, is an issue with wide implications for developmental psychology generally.

One critical issue is whether measures of phoneme sensitivity and onset-rime sensitivity differ in their importance as predictors of progress in the very early stages of learning to read. There is no doubt that measures of onset-rime sensitivity taken early in development are predictive of variations in the subsequent development of word recognition skills (Bowey, 1995; Bradley & Bryant, 1983; Bryant et al., 1990; Majsterek & Ellenwood, 1995), as are measures of phoneme manipulation ability (e.g., Juel, Griffith, & Gough, 1986). However, what remains at issue is the extent to which, when both phoneme and onset-rime skills are measured before children have made any appreciable progress in learning to read, these measures make differential contributions to predicting reading progress. Statistically, this involves assessing the unique variance in reading skills accounted for by onset-rime and phoneme skills when they are compared directly in the same sample over the relevant developmental period.

Only a small number of studies have directly compared the role of onset-rime and phoneme skills as longitudinal predictors of the development of word recognition skills in reading. These studies have generally found phoneme skills to be better predictors of later word recognition skills than are onset-rime skills (Cardoso-Martins, 1995; Duncan, Seymour, & Hill, 1997; Hulme et al., 2002; Muter, Hulme, Snowling, & Taylor, 1998; Stuart, 1995). The studies by Duncan et al. (1997), Muter et al. (1998), Hulme et al. (2002), and Stuart (1995) found that rhyme skills accounted for no unique variance in later reading scores after phoneme skills had been accounted for, whereas phoneme skills were a unique predictor after rhyme skills were controlled. However, two of these studies had small samples (Muter et al., 1998, $N = 38$; Stuart, 1995, $N = 30$), and it has been argued that the Hulme et al. (2002) study began too late, after the children (age range = 5.14 years to 6.34 years) had made significant progress in learning to read (Bowey, 2002; Bryant, 2002; Goswami, 2002). Goswami and East (2000) argued that the unusual "common units" task used to measure rime awareness by Duncan et al. (1997) involved ambiguous instructions and that the pattern of results may have been an artifact of the way in which the children in the study had been taught to read. The Cardoso-Martins (1995) study involved a sample ($N = 105$) of Portuguese-speaking Brazilian children. In this study, phoneme skills appeared to be stronger predictors of reading than did rhyme skills (though the unique variance in reading attributable to each skill was never directly assessed). However, it might be argued that phoneme awareness will be relatively more important than rime awareness in a comparatively regular orthography such as Portuguese (in which grapheme-phoneme correspondences are consistent) than in an irregular orthography such as English.

In the present study, we sought to confirm the conclusion that phoneme skills are a better predictor of word recognition skills than are onset-rime skills. In order to do this we used multiple measures of phoneme sensitivity and multiple measures of rime sensitivity. Our measures of rime sensitivity included two that we have used previously (Muter et al., 1998) as well as the Bradley and Bryant (1978) rime task (this is the measure that has been used most frequently, and often it was the *only* measure of rime sensitivity in many earlier studies; see Macmillan, 2002). Another critical issue is that this study began in the very early stages of learning to read (average age = 4 years 9 months) when the children had just entered school. By following children from

school entry for 2 years, we were able to chart the interrelationships among phoneme, rime, and reading skills in what theoretically was the developmentally relevant period. By beginning the study at this very early age, we hoped that the majority of the children would not yet be able to read and that this would help to rule out the possible influence of preexisting reading skills on early language skills that may be causal influences on later reading skills (cf. McBride-Chang, Wagner, & Chang, 1997). In addition, we also wanted to explore the relationship between these measures of phonological skill and other language abilities (vocabulary knowledge and grammatical awareness) as possible determinants of children's early reading development. There is evidence, for example, that children's phonological skills (particularly rime skills) may change developmentally as a result of increases in vocabulary size (e.g., Charles-Luce & Luce, 1995; Walley, 1993).

One other skill assessed here, which is a critical influence on early word recognition skills, is letter knowledge. Bond and Dykstra (1967) reported that letter knowledge at the beginning of first grade predicted some 26%–36% of variance in word recognition skills at the end of the year. Theoretically, both letter-sound knowledge and phoneme awareness are necessary for a child to understand the alphabetic principle (the idea that individual letters, or letter clusters [graphemes], represent the sounds [phonemes] of spoken words; Byrne & Fielding-Barnsley, 1989). For effective letter-sound decoding strategies to develop in early reading development, a child must have both access to a phonemic representation of speech and sufficient knowledge of letter sounds. In line with this, Muter et al. (1998) found that both letter knowledge and phoneme segmentation ability measured at school entry were significant predictors of reading (word recognition) skills a year later.

Finally, although phonological skills appear crucial to the development of word recognition skills in reading, it could be argued that the emphasis on phonological skills has tended to detract from the attention paid to the possible importance of other language skills (particularly grammatical skills and vocabulary knowledge; Rego & Bryant, 1993). Tunmer (1989) was one of the first to emphasize the importance of grammatical skills as an independent predictor of the development of word recognition skills in reading. In a longitudinal study, he administered tests of vocabulary knowledge, phoneme segmentation, syntactic awareness (correcting errors of word order in spoken sentences), and reading to 100 children at the end of first grade and again 1 year later. Both phoneme segmentation and syntactic awareness influenced decoding ability (as measured by a nonword reading test) even after the effects of vocabulary knowledge were controlled (presumably this effect was mediated by the effects of syntactic awareness facilitating the development of word recognition skills, which in turn influenced nonword reading). In addition, in this study, syntactic awareness (but not vocabulary knowledge) influenced listening comprehension, which in turn (along with decoding), influenced reading comprehension.

In the present study, we assessed children's grammatical skills using Tunmer's (1989) word order correction task. This task assesses one aspect of grammar (syntax) and may well tap into a range of other skills, including vocabulary knowledge and verbal working memory capacity. In order to broaden our assessment of grammatical skills, we also used a morphological generation task that involved the child supplying a missing word in a sentence that

required a different morphological ending for a word presented in a demonstration sentence (e.g., "Here is a man, here are two . . . [men]"). This task assesses a separable form of grammar (morphology, rather than syntax) and is similar to, but simpler than, a task that has been used previously in studies of reading development (Shankweiler et al., 1995). Shankweiler et al. (1995), in a large-scale study of older children, many of whom had reading difficulties, found that morphological difficulties (but not syntactic difficulties) were predictive of variations in word recognition ability even after the effects of phonemic awareness and listening comprehension had been controlled.

Theoretically, it is also possible that vocabulary knowledge will help to support the development of word recognition skills (Nation & Snowling, 1998a; Plaut et al., 1996) by allowing the creation of mappings between visual (orthographic), phonological, and semantic representations in a child's developing lexical system. In line with this possibility, it is well established that vocabulary knowledge (as typically assessed by receptive vocabulary tests) predicts variations in word recognition skills in reading (e.g., Bryant, Maclean, & Bradley, 1990; Stevenson, Parker, Wilkinson, Hegion, & Fish, 1976). Including such a measure here allowed us to address the extent to which our measures of grammatical skills were separable from vocabulary as predictors of variations in reading development.

The Development of Reading Comprehension

The goal of reading is to understand prose, but there are strong grounds for distinguishing between word recognition and comprehension processes in reading. Logically, word recognition skills are necessary, but not sufficient, for reading comprehension (Gough & Tunmer, 1986). It is reasonable to suppose that grammatical skills and vocabulary knowledge are likely to be important influences on the development of reading comprehension skills. Gough and Tunmer (1986), in their simple model of reading, proposed that the ability to comprehend what was read depended on both word recognition ability (or in their terms, decoding) and language comprehension (assessed by a measure of listening comprehension). Listening comprehension will clearly depend on both vocabulary knowledge and grammatical ability, among other things. We therefore predicted that vocabulary knowledge and grammatical abilities should be predictors of reading comprehension ability (even after accounting for any effects of these variables on word recognition ability).

Developmental Changes in the Role of Different Influences on Reading Development?

The relative importance of different underlying skills (phonological skills, grammatical skills, and vocabulary knowledge) as predictors of reading development may change gradually and in subtle ways during the course of development. Our particular focus in this study was on the first 2 years of formal reading instruction in a school system in which reading instruction begins early (just before children are 5 years old). In the case of phonological skills, it has typically been argued that awareness of large phonological units (syllables, onsets, and rimes) arises earlier than awareness of phonemes (Goswami & Bryant, 1990) and that onset-rime skills are important as predictors of reading early in development,

whereas phoneme skills may develop gradually (in the first year or two of learning to read) and assume greater importance as a driver of reading later in development. It is important to note that the ages of the children at the beginning of the present study (4 years 9 months, with the majority of children having no measurable reading skills) constitute precisely the developmental phase at which onset-rime skills have typically been argued to be of most importance for reading development (Bradley & Bryant, 1983; Goswami & Bryant, 1990). Assessing children's reading, onset-rime, and phoneme skills longitudinally over this period provides the ideal context in which to assess the possible interactions between the development of different aspects of phonological skill (particularly the issue of whether the development of onset-rime skills provides a foundation that is critical for the development of later word recognition and phoneme skills; see Macmillan, 2002).

Possible developmental changes in the roles of grammatical skills and vocabulary knowledge as influences on word recognition and reading comprehension are less well researched. Willows and Ryan (1986) have suggested that children become increasingly sensitive to semantic and syntactic features in reading materials during their elementary school years (see also Flynn & Rahbar, 1998). Thus, grammatical abilities and vocabulary knowledge may become more important predictors of reading from early to middle childhood. Muter and Snowling (1998) were able to demonstrate that grammatical awareness plays a significant role in word identification in context by age 9 years. However, it may have been less important as a predictor in the early phases of the present study (when children were less than 5 years old on average). A recent longitudinal study of French-speaking children found that phonological awareness accounted for the major part of the variance in reading accuracy at age 6.5 years but that by the time the children were 7.5 years old, both phonological awareness and grammatical awareness made significant independent contributions to reading accuracy (Casalis & Alexandre, 2000).

Summary and Predictions

In the present study, we assessed the relative importance of grammatical abilities, phonological abilities, and vocabulary knowledge as predictors of two separable aspects of reading (word recognition and comprehension) during children's first 2 years of learning to read. For word recognition ability, we predicted from previous findings (Cardoso-Martins, 1995; Hulme et al., 2002; Muter et al., 1998) that phoneme sensitivity and letter knowledge would be powerful predictors of later word recognition ability, whereas onset-rime skills would be a relatively unimportant predictor (after the effects of phonemic sensitivity and letter knowledge had been controlled). The present study involved a longer developmental period, a larger sample, and a wider range of measures than previous studies, and by charting progress over the first 2 years at school, we sought to provide evidence on the concurrent and longitudinal relationships among phoneme, onset-rime, letter knowledge, and word recognition skills in this important developmental period. We anticipated that the development of word recognition skills would be only weakly influenced by vocabulary and grammatical skills in this early period of development (Willows & Ryan, 1986).

In contrast to word recognition ability, we did not expect phonological skills to be important predictors of variations in reading

comprehension ability (at least not after their effects on word recognition ability had been controlled). We did, however, expect vocabulary knowledge and grammatical skills to account for variance in reading comprehension skills that would be independent of any (possibly weak) effects these skills exerted on the development of word recognition processes.

Method

Participants

One hundred and one children were recruited from six North London state elementary schools. For 90 of these children (53 girls and 37 boys), complete data were obtained from the three test occasions, and it is these children who form the present study sample. (Of the children lost from the sample, 9 moved and 2 were excluded [1 was found to have moderate learning difficulties, and the other was suspected of having a genetic syndrome]). Their average age at the start of the study (in their first term in school) was 4 years 9 months (range = 4 years 2 months to 5 years 2 months). In this area of the United Kingdom (UK), all children enter school in the term before their 5th birthdays. The children attended school for half a day for the first 6 weeks and attended full time thereafter. Parental occupational status was as follows (*Standard Occupational Classification*, 1991): 14% were classified as Occupational Group 6 (not employed), 1% as Group 5 (unskilled), 1% as Group 4 (partly skilled), 28% as Group 3M (skilled manual), 6% as Group 3N (skilled nonmanual), 38% as Group 2 (managerial/technical), and 12% as Group 1 (professional). Thus, the sample showed a wide range of occupational status, but with higher occupational groups being slightly overrepresented compared with the UK population as a whole.

All children were being taught according to the UK National Literacy Strategy, which provides 1 hour of literacy instruction every day from school entry. Reading is taught using a highly structured approach with a strong emphasis on phonics. Letter sounds and names are taught explicitly in the reception year, with teachers moving on to the teaching of vowel digraph and consonant cluster pronunciations in Year 1. Children are taught to use segmentation and blending skills in the context of learning to decode novel words. Each daily literacy lesson commences with story reading activities, followed by word- and sentence-level work. The children then engage in group-guided reading or writing tasks before the literacy hour is concluded with a whole-class plenary session to summarize what has been covered. The children learned key words usually in the context of a standard reading scheme, they were all given systematic instruction in sound-to-letter relations, and most classes included phonological awareness exercises (predominantly rhyming) and phonemic decoding.

Design and Procedure

All 90 children received a large battery of tests at three equidistant points in time over a 2-year period; the present article reports data from a subset of the tests given. At Time 1, the children were seen shortly after they had started their 1st year of formal schooling (the reception year). Consequently, they had received very little formal exposure to literacy instruction. Children were tested individually in their schools in two sessions, each lasting 35–40 min, during a 4-week period in September and October for Times 1 through 3. The tests were given in the same fixed order for all participants, as is common in correlational/predictive studies, so that correlations between measures were not diluted by variance attributable to order effects.

Tests and Materials

Time 1

Six subtests from the Phonological Abilities Test (Muter, Hulme, & Snowling, 1997) were administered: Rhyme Detection, Rhyme Production, Word Completion – Phonemes (hereinafter referred to as Phoneme Completion), Phoneme Deletion – Beginning Sound, Phoneme Deletion – Ending Sound, and Letter Knowledge. Demonstration items preceded all of these tests. In addition, a test of rhyme oddity was administered.

Rhyme Detection. This subtest required children to indicate which of three words (e.g., *fish*, *gun*, *hat*) rhymed with a target word (e.g., *cat*). There were 10 test items, all of which were accompanied by pictures.

Rhyme Production. This subtest required children to produce words that rhymed with each of two target words (*day* and *bell*). A time limit of 30 s was given for each word.

Phoneme Completion. In this subtest, the examiner supplied the first two phonemes of a single-syllable word that the children were requested to “finish off” with the final phoneme; for example, the examiner supplied the incomplete word “ca_” for which the correct response was /t/ to complete the word *cat*. There were eight test items, all accompanied by pictures.

Phoneme Deletion. In this subtest, children were shown 16 pictures of common objects with single-syllable names. They were asked to delete the initial phoneme from eight words (e.g., “Tin without the [t] says [in]”) and the final phoneme from eight words (e.g., “Tin without the [n] says [ti]”).

Rhyme Oddity. This subtest was based on one developed by Bradley and Bryant (1978, 1983). There were 20 sets of three monosyllabic words, two of which rhymed and one of which did not. The child’s task was to identify the nonrhyming item. For the first 10 sets, the discriminating feature occurred on the final consonant (e.g., *sand*, *hand*, *bank*), whereas for the second 10 sets, the discriminating feature occurred on the medial vowel (e.g., *fun*, *pin*, *bun*).

Letter Knowledge. In this subtest the children were asked to supply either the name or the sound of each of the 26 lowercase letters of the alphabet, which were presented in random order on individual cards.

British Picture Vocabulary Scale II (BPVS II; Dunn, Dunn, Whetton, & Burley, 1997). The first 100 items from this test were used to measure receptive vocabulary.

Hatcher Early Word Recognition Test (Hatcher, Hulme, & Ellis, 1994). This is a test of single-word reading comprising 42 of the most common and simple written words that children encounter during their first 2 years of learning to read. Eight of the words were irregular (e.g., *was*, *you*, *said*), whereas the remaining words were regular or readily decodable (e.g., *cat*, *went*).

Time 2

All of the tests from Time 1 were repeated at Time 2, with the exception of the BPVS II. Three additional tests were given at Time 2.

Word Order Correction Test. This is a measure of syntactic awareness developed by Tunmer (1989). The children were required to supply the correct word order for 24 sentences ranging in length from three to five words that had been uttered in incorrect order by the experimenter. For example, the experimenter said, “Ben throwing was stones,” and the child was expected to respond, “Ben was throwing stones.”

Morphological Generation Task. This test is similar in form to the Grammatical Closure subtest from the Illinois Test of Psycholinguistic Abilities (Kirk, McCarthy, & Kirk, 1968). The test consists of 24 items accompanied by pictures (see the Appendix). For each item, the experimenter uttered two sentences—a stem sentence followed by a second sentence in which the final word was omitted. The child was required to supply the missing word, which demanded a variation in morphological ending from the one used in the stem sentence. The first 10 items required knowledge of plural endings; 5 of the items had regular /s/ endings (e.g., “Here is a tree, here are three . . . [trees]”), and 5 had irregular plural

endings (e.g., “Here is a man, here are two . . . [men]”). The remaining 14 items assessed knowledge of regular and irregular grammatical inflections (e.g., “This girl likes to ride, here she is . . . [riding]”; “The burglar steals the jewels, here are the jewels he . . . [stole]”).

British Abilities Scales II (BAS II) Word Reading Test (Elliot, 1996). The children were asked to attempt to read the first 20 words from this single-word reading test.

Time 3

At the final testing point, the children were readministered the Hatcher Early Reading Test, together with the first 50 words from the BAS II Word Reading Test and a test of prose reading ability.

Neale Analysis of Reading Ability II (NARA II; Neale, 1997). This is a test of prose reading, assessing accuracy (number of words pronounced correctly) and comprehension (number of questions about the meaning of passages answered correctly).

Results

Descriptive statistics for the measures used at Times 1, 2, and 3 together with their reliabilities at each time are shown in Table 1. It is clear that the reliabilities of the measures used are good to excellent, with the exception of that for the Rhyme Oddity task at Time 1 (the poor reliability of this task has been noted before; see Hulme et al., 2002; Schatschneider, Francis, Foorman, Fletcher, & Mehta, 1999). It is also apparent that, as expected, the children showed large improvements in performance on all of the phonological tasks between Time 1 and Time 2. Children’s scores on the phonological tasks at Time 1 were clearly at a low level, and there was a trend toward a floor effect on the phoneme deletion measures at this time. However, there was a considerable range of scores on the phoneme deletion measures at Time 1 (of the 90 children, 49 scored 0, and the remaining 41 obtained scores ranging from 1 to 16 across both tests). Scores on the phoneme completion measure were at a higher level, with fewer children (32) scoring zero. It was clear that there was sufficient variability on these measures to allow us to examine how they related to our other measures of phonological skills and literacy attainment.

To assess the relative power of different longitudinal predictors of reading achievement, we used path analyses (presented below). Before we report these path analyses, it is informative to describe the pattern of concurrent and longitudinal correlations obtained between the measures. Correlations between the measures at Time 1 are shown in Table 2. The three rhyme measures correlated moderately with each other. The two measures of phoneme deletion also correlated moderately with each other but only weakly with phoneme completion. The weak correlations between the measures of phoneme sensitivity appear to be due to trends toward floor effects on these measures at this time. Finally, it is notable that reading skills at Time 1 showed significant concurrent correlations with letter knowledge, the three measures of phoneme sensitivity, rhyme oddity, and vocabulary knowledge (BPVS II).

The correlations between measures at Time 2 are shown in Table 3. These correlations are more uniformly positive than those at Time 1. In particular, the rhyme measures now correlated more strongly with each other, as did the phoneme measures. The correlations between measures of rhyme and phoneme skill also increased in comparison to Time 1, and this increase suggests that there may be a developmental progression toward a more unitary

Table 1

Means, Standard Deviations, and Reliabilities for Measures at Each Testing Occasion

Measure	Time 1			Time 2			Time 3		
	<i>M</i>	<i>SD</i>	Reliability	<i>M</i>	<i>SD</i>	Reliability	<i>M</i>	<i>SD</i>	Reliability
Rhyme Detection (/10)	5.60	3.22	.85	8.20	2.51	.73			
Rhyme Production	1.83	2.30	.76 ^a	5.18	3.34	.86 ^a			
Rhyme Oddity (/20)	9.60	2.94	.59	13.59	3.76	.78			
Phoneme Completion (/8)	2.59	2.88	.91	5.89	2.55	.87			
Beginning Phoneme Deletion (/8)	0.90	2.14	.94	4.31	3.37	.94			
Ending Phoneme Deletion (/8)	1.17	2.16	.89	4.12	3.28	.94			
Letter Knowledge (/26)	10.82	8.94	.96 ^a	23.24	4.25	.89 ^a			
BPVS Vocabulary (/100)	41.10	9.84	.96						
Word Order Correction Test (/25)				17.07	5.40	.84 ^a			
Morphological Endings (/24)				12.68	3.53	.86 ^a			
Early Word Reading Test (/42)	2.48	5.60	.93 ^a	21.44	12.57	.97 ^a	36.52	7.03	.95 ^a
BAS Reading Test (/50)				8.43	6.65		31.76	15.13	.98 ^b
Neale Reading Accuracy (/100)							25.53	15.36	.82
Neale Reading Comprehension (/44)							9.88	5.89	.93

Note. All reliabilities were derived from the study data, with the exception of those for BPVS Vocabulary, BAS Reading, and Neale Reading Accuracy and Reading Comprehension, for which reliabilities were obtained from the respective test manuals. BPVS = British Picture Vocabulary Scale II; BAS = British Abilities Scale II; Neale = Neale Analysis of Reading Ability II. All reliabilities are Cronbach's alpha statistic unless otherwise noted.

^a Split-half reliability with Spearman-Brown correction. ^b Hoyt reliability.

construct of phonological sensitivity between Time 1 and Time 2 (cf. Schatschneider et al., 1999). It is clear that the two measures of grammatical awareness also correlated moderately with each other and with the measures of phonological awareness. The two measures of reading ability at Time 2 correlated significantly with all other measures.

At Time 3, all of the reading measures showed strong positive correlations with each other, as would be expected (see Table 4). It is notable that the two measures of isolated word recognition correlated highly with each other (.87), as did the two measures of prose reading ability (.91), and these correlations tended to be slightly higher than the corresponding cross-skill correlations (.72–.78). This pattern provides some support for seeking to identify separable cognitive precursors for isolated word recognition and text reading comprehension.

Tables 5 and 6 show the longitudinal predictive correlations between measures. Reading ability at Time 2 was predicted at significant levels by all Time 1 measures (except Ending Phoneme

Deletion). Similarly, reading ability at Time 3 was predicted at significant levels by all Time 2 measures.

Modeling Interrelationships Between Measures of Phonological Skill and Word Recognition Ability

Our first interest was to model the longitudinal relationships among measures of phonological ability, letter knowledge, vocabulary, and word recognition skills. Given that we had multiple measures of two key theoretical constructs (rhyme and phoneme) we wished to combine measures to simplify the models and increase reliability. However, it was not appropriate to use latent variables in the longitudinal path models because of the low ratio of participants to free parameters being estimated (Tanaka, 1987). Instead we used structural equation modeling to model the relationships between observed (rather than latent) variables, using aggregated *z* scores to define the observed variables for which we had multiple measures at each time point (Time 1—rhyme, pho-

Table 2

Intercorrelations of the Measures at Time 1

Measure	1	2	3	4	5	6	7	8	9
1. Rhyme Detection	—	.37**	.45**	.02	.12	.01	.23	.39**	.15
2. Rhyme Production		—	.22*	.27**	.12	-.10	.32**	.39**	-.01
3. Rhyme Oddity			—	.22*	.16	.25*	.29**	.46**	.23*
4. Phoneme Completion				—	.15	.16	.32**	.20	.34**
5. Beginning Phoneme Deletion					—	.34**	.35**	.21*	.48**
6. Ending Phoneme Deletion						—	.35**	.03	.32**
7. Letter Knowledge							—	.42**	.54**
8. BPVS								—	.28**
9. Early Reading									—

Note. BPVS = British Picture Vocabulary Scale II.

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

Table 3
Intercorrelations of the Measures at Time 2

Measure	1	2	3	4	5	6	7	8	9	10	11
1. Rhyme Detection	—	.42**	.56**	.29**	.46**	.37**	.29**	.55**	.37**	.41**	.43**
2. Rhyme Production		—	.43**	.16	.45**	.29**	.23*	.47**	.19*	.26**	.30**
3. Rhyme Oddity			—	.31**	.59**	.40**	.24*	.62**	.50**	.46**	.48**
4. Phoneme Completion				—	.39**	.37**	.41**	.32**	.27*	.41**	.42**
5. Beginning Phoneme Deletion					—	.61**	.40**	.59**	.37**	.58**	.61**
6. Ending Phoneme Deletion						—	.32**	.48**	.34**	.54**	.56**
7. Letter Knowledge							—	.34**	.19*	.57**	.50**
8. Word Order Correction								—	.45**	.51**	.50**
9. Morphological Endings									—	.30**	.34**
10. Early Reading										—	.96**
11. BAS Reading											—

Note. BAS = British Abilities Scale II.

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

neme; Time 2—rhyme, phoneme, word recognition; Time 3—word recognition). Using observed (rather than latent) variables greatly reduces the complexity of the models and gives a better ratio of cases to parameters to estimate. Maximum likelihood estimation procedures were used to analyze the variance/covariance matrix of these observed variables. The approach adopted was to estimate models with all possible correlations between measures at Time 1, and with all possible paths from Time 1 variables to Time 2 variables, and from Time 2 variables to Time 3 variables, initially present. Nonsignificant correlations and paths were then dropped to produce a simplified model in which all remaining relationships were statistically significant.

Given the very high correlation ($r = .96$) between our two measures of word recognition (Early Word Reading and BAS Reading) at Time 2, it was obviously appropriate to combine these measures into a composite. A more contentious issue was the extent to which it was justifiable to combine our three measures of rhyme and three measures of phoneme skills to assess these two theoretically separable aspects of phonological sensitivity. As noted earlier, at Time 1 the correlations between the three phoneme measures were weak, particularly between the measure of phoneme completion and the two phoneme deletion measures. Similarly, at Time 1, the correlations between the three rhyme measures, although stronger, were only weak to moderate. In contrast, both the phoneme and rhyme measures form more coherent groupings at Time 2, though the intercorrelations across these two groups of tasks also increased somewhat between Time 1 and Time 2.

Table 4
Intercorrelations of the Measures at Time 3

Measure	1	2	3	4
1. Early Reading	—	.87**	.78**	.75**
2. BAS Reading		—	.78**	.72**
3. Neale Reading Accuracy			—	.91**
4. Neale Reading Comprehension				—

Note. BAS = British Abilities Scale II; Neale = Neale Analysis of Reading Ability II.

** $p < .01$.

In order to justify combining the three phoneme and three rhyme measures into composites, we conducted initial confirmatory factor analyses on these six measures at Time 1 and Time 2 separately. A correlated two-factor (Rhyme and Phoneme) model at Time 1 accounted for 38% of the variance in the rhyme measures and 25% of the variance in the phoneme measures, $\chi^2(8, N = 90) = 21.6$, $p < .01$. The correlation between these two factors at Time 1 was low ($r = .42$), and combining these six measures onto a single latent variable resulted in a significant reduction in fit, $\chi^2(9, N = 90) = 30.17$, $p < .01$, providing a further justification for distinguishing between these two classes of measures. The same picture emerged, more clearly, from comparable analyses conducted at Time 2. A correlated two-factor (Rhyme and Phoneme) model at Time 2 accounted for 48% of the variance in the rhyme measures and 49% of the variance in the phoneme measures, and the overall model provided a good fit to the data, $\chi^2(8, N = 90) = 4.43$, ns . The correlation between these two factors ($r = .81$) was higher than at Time 1 (as would be expected from the more uniformly high correlations between these measures shown in Table 3); however, once again, combining these six measures into a single latent variable resulted in a significant reduction in fit, $\chi^2(9, N = 90) = 13.23$. The factor loadings for the correlated Phoneme and Rhyme factors derived from these confirmatory factor analyses at Time 1 and Time 2 are shown in Table 7.

The simplified path model based on aggregated measures of phoneme and rhyme at Time 1 and Time 2 is shown in Figure 1 and provides a remarkably good fit to the data. The model accounts for a high proportion of the variance in word recognition scores at Time 1 ($R^2 = .52$) and Time 2 ($R^2 = .63$). A number of patterns are evident in this figure. At Time 1, rhyme and phoneme sensitivity are only weakly correlated. Rhyme is moderately correlated with letter knowledge and strongly correlated with vocabulary knowledge. Reading ability at Time 1 (which is at a very low level; see Table 1) correlates highly with letter knowledge and phoneme sensitivity.

The pattern of path weights from Time 1 to Time 2 is arguably of greater interest. The only significant predictors from Time 1 of word recognition at Time 2 (a composite of the Early Word Recognition Test and the BAS II Word Reading Test) were phoneme sensitivity and letter knowledge (these two predictors accounted for 52% of the variance). The only significant predictors

Table 5
Intercorrelations of the Measures at Times 1 and 2

	Time 2 measures									
	Rhyme Detection	Rhyme Production	Rhyme Oddity	Phoneme Completion	Beginning Phoneme Deletion	Ending Phoneme Deletion	Letter Knowledge	Word Order Correction	Morphology Endings	Early Reading
Rhyme Detection	.43**	.34**	.50**	.14	.36**	.27**	.26**	.45**	.23*	.24*
Rhyme Production	.32**	.38**	.37**	.15	.25**	.17	.14	.35**	.33**	.23*
Rhyme Oddity	.23*	.32**	.37**	.06	.30**	.17	.18*	.31**	.30**	.29**
Phoneme Completion	.22*	.22*	.37**	.45**	.34**	.31**	.10	.36**	.41**	.39**
Beginning Phoneme Deletion	.24*	.03	.31**	.08	.34**	.19*	.16	.15	.27**	.29**
Ending Phoneme Deletion	.17	.14	.24*	.20	.37**	.19*	.08	.14	.20*	.13
Letter Knowledge	.44**	.34**	.44**	.24*	.52**	.49**	.41**	.46**	.43**	.71**
BPVS	.36**	.35**	.60**	.16	.38**	.23*	.35**	.49**	.46**	.41**
Early Reading	.22*	.05	.32**	.17	.34**	.32**	.22*	.22*	.39**	.48**
BAS Reading										.51**

Note. BPVS = British Picture Vocabulary Scale II; BAS = British Abilities Scale II.

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

of phoneme sensitivity were earlier phoneme skills and letter knowledge. The absence of any significant influence from rhyme skills at Time 1 is interesting insofar as it has often been argued that rhyme skills are a precursor of phoneme skills in this developmental period (Bryant et al., 1990; Goswami & Bryant, 1990). Rhyme sensitivity at Time 2 was predicted by both earlier rhyme skills and phoneme sensitivity (raising the possibility that the development of rhyme skills is partly a product of early phoneme skills). Finally, letter knowledge was influenced by earlier letter knowledge and also by phoneme sensitivity. It appears therefore, that there was a reciprocal relationship between letter knowledge and phoneme sensitivity at Times 1 and 2. Although early letter knowledge was a predictor of later phoneme sensitivity, it is also the case that early phoneme sensitivity was a predictor of later letter knowledge. This pattern is consistent with suggestions of a close and interactive relationship between these two skills (Burgess & Lonigan, 1998). (It should be noted that at Time 1, 24 of the 90 children were at floor on our composite measure of phoneme sensitivity [formed by summing the two phoneme deletion measures and the phoneme completion measure]. A simplified path model, examining the role of rhyme, phonemes, letter knowledge, early word reading, and BPVS at Time 1 as predictors of word recognition at Time 2, was evaluated after excluding those children at floor on the phoneme sensitivity measure. The pattern of predictors for word recognition at Time 2 in this simplified model was identical for the whole sample to the pattern in Figure 1 [with phoneme sensitivity and letter knowledge as the only predictors]. For the reduced sample [excluding children at floor on the phoneme sensitivity measures], letter knowledge and phoneme awareness again were predictors, but vocabulary knowledge was an additional predictor. Thus the conclusions drawn for the whole sample about the importance of letter knowledge and phoneme sensitivity as predictors of word recognition skills at Time 2 are also supported by the analysis of children with phoneme skills above floor at Time 1.)

It is significant that the error terms for rhyme and phoneme sensitivity, and for word recognition and letter knowledge, at Time 2 are correlated. This is consistent with the idea that each of these pairs of skills is influenced by common processes (such as language experience and print exposure, respectively) that lie outside this model.

At Time 3, word recognition skills are a product of earlier word recognition skills, as well as of letter knowledge and phoneme sensitivity (these three predictors account for 63% of the variance). It should be noted that the significant path from word recognition at Time 2 to the same skill at Time 3 contrasts with the failure to find a significant pathway between word recognition at Time 1 and word recognition at Time 2. This may at least partly reflect the fact that word recognition skills at Time 1 were at a very low level (50 children at Time 1 could not read any word on the Hatcher Early Word Recognition Test—a sensitive test of early word recognition skills). However, there does appear to be sufficient variability in word recognition skills at Time 1 to allow this measure to correlate with a number of other variables measured at the same time (see Table 2). We would speculate that this might reflect important differences between the information-processing skills that are most critical to reading at the different ages assessed here. Children's reading skills at Time 1 (as measured by their recognition of common words from early reading books contained in the Early

Table 6
Intercorrelations of the Measures at Times 1 and 2 With Those at Time 3

Time 1 and Time 2 measures	Time 3 measures			
	Early Reading	BAS Reading	Neale Reading Accuracy	Neale Reading Comprehension
Time 1				
Rhyme Detection	.23*	.26**	.34**	.37**
Rhyme Production	.21*	.27**	.26**	.33**
Rhyme Oddity	.26**	.26**	.31**	.35**
Phoneme Completion	.34**	.42**	.44**	.43**
Beginning Phoneme Deletion	.24*	.31**	.32**	.36**
Ending Phoneme Deletion	.13	.20*	.32**	.30**
Letter Knowledge	.56**	.64**	.66**	.66**
BPVS	.30**	.40**	.50**	.52**
Early Reading	.29**	.39**	.52**	.48**
Time 2				
Rhyme Detection	.41**	.46**	.49**	.50**
Rhyme Production	.30**	.32**	.32**	.43**
Rhyme Oddity	.37**	.49**	.59**	.58**
Phoneme Completion	.42**	.42**	.37**	.34**
Beginning Phoneme Deletion	.55**	.66**	.67**	.65**
Ending Phoneme Deletion	.40**	.53**	.54**	.49**
Letter Knowledge	.61**	.53**	.53**	.51**
Word Order Correction	.54**	.55**	.56**	.61**
Morphological Endings	.18*	.32**	.40**	.39**
Early Reading	.71**	.80**	.80**	.74**
BAS Reading	.66**	.77**	.78**	.72**

Note. BPVS = British Picture Vocabulary Scale II; BAS = British Abilities Scale II.

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

Word Recognition Test) are likely to be heavily reliant on a holistic sight-word reading strategy, whereas the subsequent development of visual word recognition skills during the 1st year of formal education may be critically dependent on the development of alphabetic strategies (i.e., on the development of letter-sound-based reading strategies). This idea is consistent with stage models of reading development (e.g., Frith, 1985) that see early visual or logographic reading skills as being at best weakly related to subsequent progress in learning to read (see also Caravolas, Hulme, & Snowling, 2001).

Comparing the Predictors of Reading Comprehension and Word Recognition at Time 3

The path model presented in Figure 1 shows the predictors of the development of context-free word recognition in children in

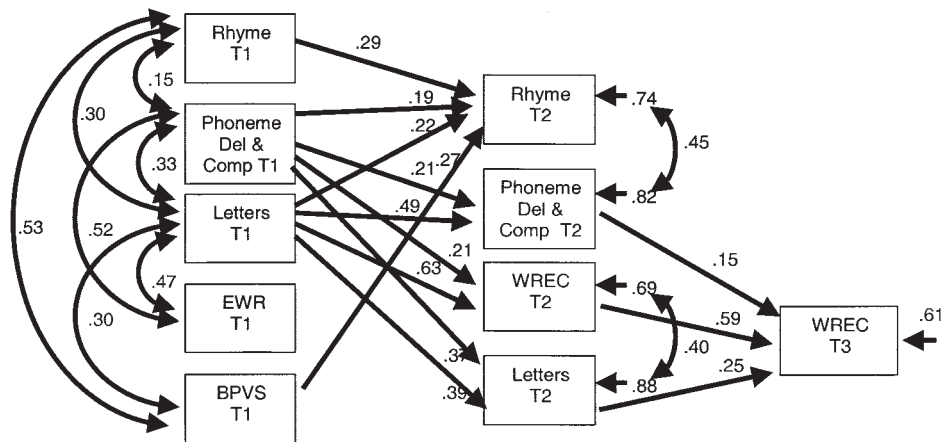
the first 2 years of school. The results of this model are clear in demonstrating the critical importance of letter knowledge and phonemic awareness for the growth of word recognition skills. It seems likely, however, that the development of reading comprehension skills will depend on different underlying skills than the development of word recognition. In particular, we would expect grammatical skills and vocabulary knowledge to be more important as predictors of comprehension ability than of word recognition ability. We decided to explore these issues in some further path analyses, contrasting word recognition with reading comprehension at Time 3 as the outcome measures. In these analyses, we used the three measures from Time 2 (phoneme sensitivity, word recognition, and letter knowledge) that were significant predictors of word recognition skills at Time 3 and added to these predictors measures of vocabulary knowledge (BPVS II measured at Time 1) and grammatical awareness (assessed by syntactic awareness and morphological awareness at Time 2). This allowed us to assess the extent to which these nonphonological language skills (vocabulary knowledge and grammatical skills) were important additional predictors of both word recognition and reading comprehension at Time 3.

Path Model Predicting Word Recognition at Time 3 From Time 2 Measures

Figure 2 shows a path model for word recognition skills at Time 3 predicted from composite measures of phoneme sensitivity (assessed at Time 2 by phoneme deletion [beginning and end] and phoneme completion), word recognition (assessed at Time 2 by the BAS II and the Early Word Recognition Test), letter knowledge,

Table 7
Factor Loadings for the Phoneme and Rhyme Tasks at Time 1 and Time 2

Variable	Time 1	Time 2
Rhyme factor loadings		
Rhyme Detection	.46	.57
Rhyme Production	.78	.69
Rhyme Oddity	.59	.79
Phoneme factor loadings		
Phoneme Completion	.28	.46
Beginning Phoneme Deletion	.57	.89
Ending Phoneme Deletion	.64	.68

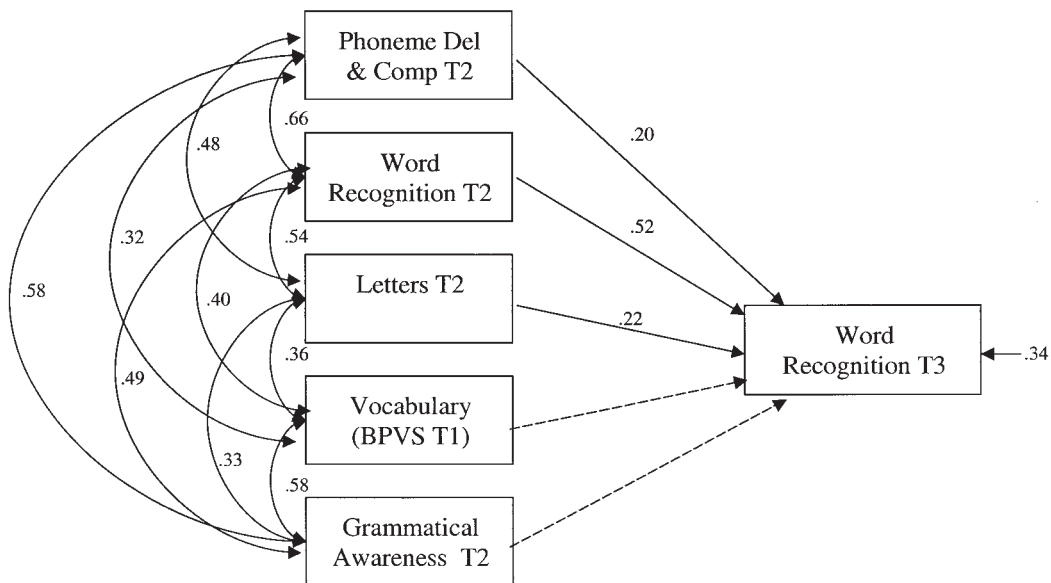


$$\chi^2 (24, N=90) = 28.80, ns, CFI = 0.988, GFI = 0.941, RMSEA = 0.049 (CI_{.90} = 0.000 \text{ to } 0.102)$$

Figure 1. Path analysis for Times 1, 2, and 3 (T1, T2, and T3) word recognition, language, and phonological sensitivity measures. Del = deletion; Comp = completion; EWR = Early Word Recognition Test; BPVS = British Picture Vocabulary Scale II; WREC = word recognition; CFI = comparative fit index; GFI = goodness of fit index; RMSEA = root mean square error of approximation; $CI_{.90}$ = 90% confidence interval.

grammatical awareness (assessed at Time 2 by the syntactic awareness [word order correction] and morphological awareness [morphological generation] tasks), and vocabulary knowledge (assessed at Time 1 by the BPVS II). As before, in the initial path model, all

predictor measures were permitted to correlate with each other, and all paths to word recognition at Time 3 were estimated. Figure 2 shows the simplified path model in which the only two nonsignificant paths (from grammatical awareness and vocabulary



$$\chi^2 (2, N=90) = 0.64, ns, CFI = 1.00, GFI = 0.998, RMSEA = 0.000 (CI_{.90} = 0.000 \text{ to } 0.149)$$

Figure 2. Path analysis predicting Time 3 (T3) word recognition skills from Time 2 (T2) phoneme awareness, word recognition, letter knowledge, and grammatical awareness and Time 1 (T1) vocabulary measures. Del = deletion; Comp = completion; BPVS = British Picture Vocabulary Scale II; CFI = comparative fit index; GFI = goodness of fit index; RMSEA = root mean square error of approximation; $CI_{.90}$ = 90% confidence interval.

to word recognition) have been dropped. The resulting model gives an excellent fit to the data. There are just three significant predictors of word recognition at Time 3: earlier word recognition skills, letter knowledge, and phoneme sensitivity (these three predictors accounted for 88% of the variance in word recognition).

Path Model Predicting Reading Comprehension at Time 3 From Time 1 and Time 2 Measures

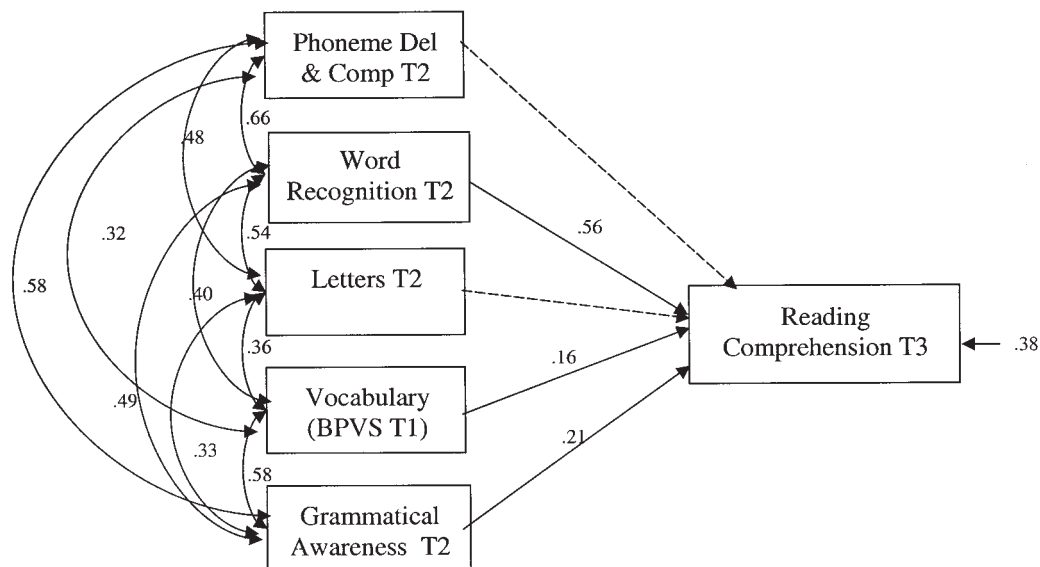
The corresponding model for reading comprehension (assessed by the NARA II at Time 3) is shown in Figure 3. In this case, the paths from vocabulary knowledge, grammatical awareness, and earlier word recognition ability were significant and together accounted for 86% of the variance in reading comprehension ability (however, earlier letter knowledge and phoneme sensitivity were not significant predictors in this model). This analysis confirms that reading comprehension places a greater reliance on vocabulary knowledge and grammatical skills than on context-free word recognition. The finding that earlier word recognition ability was a significant predictor of reading comprehension, as it was for word recognition, is consistent with the idea that a critical determinant of individual differences in reading comprehension skill is reading accuracy, as suggested, for example, by the simple model (Gough & Tunmer, 1986). (It is worth noting that both of our measures of grammatical awareness almost certainly have a significant working memory component. At Time 2, we also had data on a measure of immediate verbal memory span for words. This provided a simple measure of the storage capacity of verbal working memory. However, when the model shown in Figure 3 was supplemented by including verbal memory span as an addi-

tional predictor of reading comprehension, the pattern of predictive relationships was essentially unchanged. Grammatical awareness remained a strong predictor of reading comprehension at Time 3, even after the effects of verbal memory span were controlled. This shows that the relationship between grammatical awareness and reading comprehension found here cannot simply be attributed to variations in working memory storage capacity).

Figures 2 and 3 demonstrate that for the development of word recognition ability and reading comprehension, earlier word recognition skills are of critical importance, but, as predicted, for reading comprehension, vocabulary knowledge and grammatical skills assume a similar level of importance. Broadly, whereas word recognition seems critically dependent on phonological processes (particularly phonemic sensitivity and letter knowledge), reading comprehension appears to be dependent on higher level language skills (vocabulary knowledge and grammatical skills). Hatcher and Hulme (1999) found a somewhat similar pattern, with an effect of vocabulary knowledge on reading comprehension, but not on reading accuracy, in a longitudinal study of a large group of children with reading difficulties.

Discussion

This longitudinal study has shown that the development of two different aspects of reading ability (word recognition and reading comprehension) in the first 2 years of schooling is predicted by different facets of children's underlying language skills. Broadly, the development of word recognition skills appears to be critically dependent on children's phonological skills. More specifically, letter knowledge and phoneme sensitivity are powerful predictors



$$\chi^2(2, N=90) = 3.92, ns, CFI = 0.992, GFI = 0.986, RMSEA = 0.104 (CI_{.90} = 0.000 \text{ to } 0.257)$$

Figure 3. Path analysis predicting Time 3 (T3) reading comprehension skills from Time 2 (T2) phoneme awareness, word recognition, letter knowledge, and grammatical awareness and Time 1 (T1) vocabulary measures. Del = deletion; Comp = completion; BPVS = British Picture Vocabulary Scale II; CFI = comparative fit index; GFI = goodness of fit index; RMSEA = root mean square error of approximation; $CI_{.90}$ = 90% confidence interval.

of variations in word recognition skills, whereas rhyme skills, vocabulary knowledge, and grammatical skills appear relatively unimportant. In contrast, for reading comprehension, phonological skills appear to be relatively unimportant, but higher level language skills (vocabulary knowledge and grammatical skills) are important predictors even after the powerful effects of earlier word recognition skills have been controlled. We discuss the theoretical implications of our findings concerning the development of word recognition and reading comprehension in turn.

The Development of Word Recognition, Letter Knowledge, and Phonological Sensitivity

The development of word recognition, of letter knowledge, and of phonological sensitivity appear so intimately related that it is natural to discuss them together. At the start of the study, the children (average age = 4 years 9 months) had just entered school, where formal reading instruction began. However, even at this early stage of development, most of the children had begun to develop an explicit awareness of the phonological structure of speech, both at the onset-rime and phoneme levels. Like Muter et al. (1998), who studied a smaller sample of children at the same stage in their development, we found that the children's rhyme skills were only weakly correlated with their phoneme skills. Early rhyme skills were strongly related to vocabulary level and weakly related to letter knowledge but not to early word recognition. In contrast, phoneme skills were not predicted by vocabulary level but were related to early word recognition and also, more weakly, to letter knowledge and, very weakly ($r = .15$), to rhyme skills.

The relative independence of rhyme and phoneme skills revealed here (and in our earlier studies; see Hulme et al., 2002; Muter et al., 1998) is somewhat counterintuitive. Theories of phonological development usually assume that rhyme skills are precursors of phoneme awareness (Gombert, 1992; Goswami & Bryant, 1990; Treiman & Breaux, 1982) and therefore would predict some degree of association. The present data are, however, in line with data from a growing number of studies showing developmental dissociations between rhyme and phoneme skills, for example, among children with Down syndrome (e.g., Snowling, Hulme, & Mercer, 2002). The present study, like some others (Bowey & Patel, 1988), has shown strong concurrent and longitudinal relationships between vocabulary knowledge and rhyming skills, whereas phoneme skills appear to be relatively independent of vocabulary knowledge. According to Walley (1993) and Charles-Luce and Luce (1995), during the process of language acquisition, children's representations of spoken words may be globally specified early in development. However, vocabulary growth during the preschool years causes the restructuring of phonological representations so that they become segmentally organized. The finding that preschool rhyme skills are strongly related to vocabulary knowledge suggests that this reorganization may initially have its clearest effects at the level of onset-rime units, rather than at the level of phoneme units, within words.

The present study essentially confirms the conclusions of a number of previous studies (see, e.g., Cardoso-Martins, 1995; Castles & Coltheart, 2004; Duncan et al., 1997; Hulme et al., 2002; Muter et al., 1998; Stuart, 1995) showing the greater importance of early phoneme sensitivity, than of onset-rime sensitivity, as a predictor of the development of word recognition skills in reading.

Between Times 1 and 2, as well as between Times 2 and 3, phoneme sensitivity (but not rime sensitivity) and letter knowledge were independent predictors of later word recognition skills. It is important to note that the present study places these conclusions on a much firmer footing than earlier studies have, given that the present study used a larger sample, used a wider range of measures of onset-rime awareness and language skills, and followed children throughout the theoretically critical period (the first 2 years of formal education, from 4 years 9 months to 6 years 9 months).

How, theoretically, are we to interpret the powerful predictive effect of early phoneme sensitivity on later word recognition skills? Perhaps the most obvious interpretation would be in terms of a causal theory that sees learning to read an alphabetic script as critically dependent on a child's possessing adequate phoneme sensitivity. This viewpoint was advocated on the basis of logic and clinical observation long before the vast majority of studies in this area were conducted (e.g., Savin, 1972). This theory could take a variety of forms. It might be that learning to read an alphabetic script requires an explicit awareness of phonemes in speech and the way in which those phonemes are represented by letters (the alphabetic principle; Byrne & Fielding-Barnsley, 1989). Alternatively, it might be that the child simply needs phonemically structured representations of speech to learn to read effectively but that conscious awareness of those representations is not critical (Snowling & Hulme, 1994). In this view, phoneme awareness tasks may simply be one way of assessing the quality or integrity of the child's phonological representations that underlie the ability to learn to read. In some connectionist models of reading development, learning appears to be facilitated by using a phonemic representation of speech (Hulme, Quinlan, Bolt, & Snowling, 1995; Plaut et al., 1996). These models could be thought of as implementing a learning process that depends critically on phonemic representations but not on conscious access to those representations.

There clearly are alternative accounts of the finding that phoneme sensitivity is highly predictive of variations in learning to read. One alternative view, which also has a long history (Moraes, Cary, Alegria, & Bertelson, 1979), is that phonemic skills only arise as a result of learning to read. More specifically, it has sometimes been suggested that phoneme manipulation tasks may be performed by reference to an orthographic image (Castles & Coltheart, 2004). This possibility does not fit well with our data. Fifty of the children in our sample had no measurable reading skills when first tested with a sensitive test of early word recognition skills, and yet many of these same children did possess some degree of phoneme awareness, and variations in this awareness were predictive of their later reading skills. This seems to refute the idea that phoneme awareness necessarily depends on being able to read.

Another variant of this theory, which is somewhat harder to test, is that phoneme awareness may only arise as a result of being taught letter sounds. In this view, without letter knowledge, phoneme awareness would be impossible. Lundberg (1994) argued persuasively against this view from studies, conducted in Scandinavia (where reading instruction at the time did not begin until children were 7 years old), showing that a minority of prereaders, who also lacked all letter knowledge, could nevertheless perform well on phoneme awareness tasks. Caravolas and Bruck (1993) also reported data from preschool Czech children who were non-

readers with no letter knowledge. On a phoneme isolation task involving identifying the initial consonant in consonant–vowel–consonant nonwords (i.e., segmenting the onset), these children were 56% correct. In the present study, there were just 8 children with no letter knowledge at Time 1 (from 4 years 2 months to 5 years) and of these children, 4 did obtain a score on our composite measure of phoneme sensitivity. It is also apparent (from inspection of letter knowledge and phoneme deletion and phoneme completion scores at Time 1 in the present study) that there is little correspondence between the specific letters known by children and the phonemes that they succeed in manipulating in the phoneme sensitivity tasks. Finally, it is also notable that Lundberg, Frost, and Petersen (1988) trained phoneme awareness in kindergarten using a program that involved no letters or literacy activities and showed that this training was successful in increasing phoneme awareness and the subsequent development of reading. Together, this evidence from a variety of studies demonstrates that it certainly is possible for children to develop phoneme sensitivity in the absence of letter knowledge (though typically these two skills develop at the same time, and many children lacking letter knowledge also lack phoneme awareness).

The present study demonstrates that the three measures of phoneme sensitivity used here (phoneme completion, beginning phoneme deletion, and ending phoneme deletion) are better longitudinal and concurrent predictors of reading skills in the first 2 years of formal schooling than are our three measures of rhyme sensitivity (rhyme detection, rhyme oddity, and rhyme production). However, it has sometimes been argued that stimulus variables and task demands may be critical for explaining relationships between measures of phonological sensitivity and reading ability (e.g., Bryant, 1998). According to this argument, it could be that the measures of phoneme awareness used here just happen to relate more closely to learning to read than do the measures of onset–rime awareness, because of variations in the tasks' psychometric properties or extraneous demands. It should be noted that proponents of this view (see Bryant, 1998) have never provided any empirical support for it, whereas specific versions of this hypothesis (that task instructions may have been misleading) have been tested and refuted (Hulme, Muter, & Snowling, 1998). Nevertheless, given that different tasks were used here to assess phoneme and rhyme sensitivity, it is clearly possible that the superior predictions of reading achieved by the phoneme tasks reflect some unspecified aspect of the tasks used rather than the size of the unit assessed. We would argue, however, that this is not likely.

One way in which rhyme skills might fail to correlate with reading ability would be if the assessment of rhyme had been unreliable. It is worth emphasizing that the present study used three different measures of rhyme awareness and phoneme awareness, whereas the vast majority of previous studies in this area (see Macmillan, 2002) have relied entirely on a single measure of rhyme awareness (the Bradley & Bryant [1983] rhyme oddity task). Because the present study used three different measures of rhyme and phoneme sensitivity, and used composite scores to increase reliability, it is reasonable to argue that it would have been capable of detecting a predictive relationship between rhyme skills and later reading skills if one existed. It is clear that any lack of relationship between rhyme skills and reading ability in the present study cannot be due to low reliability, because if this were the case rhyme skills at Time 1 could not have correlated with other

measures in our path model. In fact, rhyme skills at Time 1 did correlate significantly with a range of concurrent measures (BPVS, letter knowledge, and phoneme sensitivity) and were a longitudinal predictor of rhyme skills at Time 2 (see Figure 1). Such relationships demonstrate that our assessment of rhyme skills at Time 1 showed sufficient reliability and variability to correlate with other measures. In spite of this, however, rhyme skills at Time 1 were not a significant unique predictor of reading skills either concurrently or longitudinally after phoneme sensitivity was controlled.

The most direct way to refute the argument that differences in task demands may lead to artifactual differences in the correlation between reading and phoneme and rhyme sensitivity tasks is to use identical stimuli and identical procedures to assess both phoneme and onset–rime sensitivity. We did this in an earlier study (Hulme et al., 2002) with slightly older children (average age = 5 years 7 months) than in the present study (average age = 4 years 9 months). In that earlier study, phoneme sensitivity was confirmed as the better predictor of reading ability, and onset–rime sensitivity accounted for no additional variance in reading skills after phoneme sensitivity had been controlled. In order to use identical stimuli for all tasks, and to distinguish initial phonemes from onsets, we used stimuli consisting of nonwords with consonant cluster onsets. Such stimuli would likely have proved too difficult for use with the very young children involved in the present study. Nevertheless, this earlier study showed conclusively that uncontrolled task or stimulus characteristics could not explain the superiority of phoneme measures over onset–rime measures as longitudinal predictors of word recognition skills in children slightly older than those in the present study.

We would argue that the present study confirms the conclusion from a number of earlier studies that phoneme skills are better predictors of early reading skills than are onset–rime skills (Cardoso-Martins, 1995; Castles & Coltheart, 2004; Duncan et al., 1997; Hulme et al., 2002; Muter et al., 1998; Stuart, 1995). Given that these different studies have used a range of different tasks and stimuli, the notion that task-specific effects can explain the greater power of phoneme tasks as predictors of early reading skills seems unlikely. We believe that the most plausible explanation for the role of phoneme awareness at school entry as a predictor of later word recognition ability is that phoneme awareness exerts a causal influence on the development of word recognition. This is simply a refinement of the currently dominant theoretical position in this field that early phonological awareness skills are causally related to the development of reading skills. The only way of testing such a causal hypothesis is with a training study. In one such recent study, Hatcher, Hulme, and Snowling (2004) presented children in the first 2 years of formal education with a highly systematic phonically based reading program, which for some groups was supplemented with explicit phonological training involving phoneme, rhyme, or phoneme- and rhyme-level skills. The addition of explicit phoneme-level training was found to be more effective than was rhyme-level training in improving reading attainments in those children deemed to be at risk of reading difficulties. Furthermore, variations in reading skills at the end of the study were predicted by levels of phoneme awareness (but not by levels of onset–rime awareness) that the children had achieved after the training. These results provide support for a causal relationship between early phoneme awareness and later reading skills (at least in a subgroup of children who were at risk of reading difficulties).

Though we have argued against the proposal that phoneme awareness can only develop as a consequence of acquiring letter knowledge or learning to recognize printed words, we do nevertheless believe that there is almost certainly a reciprocal relationship between phoneme sensitivity and the development of literacy in alphabetic writing systems (see, e.g., Perfetti et al., 1987). In the present study (see Figure 1) there is evidence that letter knowledge at Time 1 (4 years 9 months) is a predictor of phoneme sensitivity 1 year later, whereas, conversely, phoneme sensitivity at 4 years 9 months is a predictor of letter knowledge 1 year later. Caravolas et al. (2001) reported a similar reciprocal pattern, and Burgess and Lonigan (1998) also found that both letter-name and letter-sound knowledge, measured at age 5, were unique predictors of phonemic awareness at age 6, even after the effects of oral language skills (grammatical closure and grammatical understanding) and earlier phonological sensitivity were controlled.

This reciprocal view is also consistent with studies showing that people who are unable to read an alphabetic script are typically worse at phoneme awareness than are comparable individuals who can read an alphabetic script (see, e.g., Morais et al., 1979; Read, Zhang, Nie, & Ding, 1986). More recently, Castro-Caldes, Petersen, Reis, Stone, and Ingvar (1998) produced evidence, from a study of literate and illiterate Portuguese speakers, for the neural basis of the changes in phonological processing that arise from learning to read. Illiterate adults showed a selective deficit in their ability to repeat nonwords, as compared with words, and this deficit was paralleled by selective differences in patterns of brain activation revealed by positron emission tomography when repeating nonwords.

Our study also allowed us to test the hypothesis put forward by Goswami and Bryant (1990) that early rhyme skills have both direct and indirect longitudinal effects on later word recognition skills. (It is important to note that our assessment of rhyme skills included the measure on which this theory was based [the rhyme oddity task of Bradley & Bryant, 1978, 1983]). It is noteworthy that in Figure 1 there are no significant longitudinal paths from Time 1 rhyme skills to Time 2 phoneme skills or word recognition skills. This is inconsistent with the model of reading development put forward by Goswami and Bryant (1990; see also Bryant, 2002; Bryant et al., 1990) that postulates that early rhyme skills (measured before children have learned to read) have two separable effects on the development of later reading: a direct longitudinal effect of rhyme on later reading and an indirect longitudinal effect of rhyme on reading that is mediated by phoneme skills. The present study could have detected both of these postulated longitudinal mechanisms if they were operating, because we measured both rhyme and phoneme skills in children prior to their having learned to read and again 1 year later. It should be noted that at Time 1 there was a weak correlation between rhyme and phoneme skills and a slightly stronger correlation between rhyme and letter knowledge. These correlations between simultaneously measured variables are ambiguous in terms of direction of causation, though they might be interpreted as representing indirect effects of rhyme at Time 1 on word recognition at Time 2 (via phoneme and letter knowledge at Time 1). However, arguably, such a causal interpretation is weakened by the absence of any longitudinal prediction from rhyme at Time 1 to word recognition at Time 2, and it is such longitudinal relationships that are postulated in the Goswami and Bryant (1990) theory. It remains possible, however, that rhyme

skills might have an effect on reading at a later point in development when children become sensitive to the way in which commonly occurring rime units in spoken words are represented orthographically (as suggested by Duncan et al., 1997).

It also remains possible that, had we assessed children when they were even younger (say at age 3 years), rudimentary rhyme skills would be predictive of the subsequent development of phoneme skills. Carroll, Snowling, Hulme, and Stevenson (2003), in a short-term longitudinal study of children between the ages of 3 years 10 months and 4 years 9 months (i.e., in a study that finished at the age at which the present study started), found that both awareness of large speech segments (assessed by rime and syllable tasks) and accuracy of articulation were predictive of the emergence of phoneme awareness skills at age 4 years 9 months. However, it should be noted that this study did not identify a specific role for rime awareness on later phoneme awareness, because rime awareness was highly correlated with syllable awareness and was combined with this measure into a single latent variable. Interestingly, in this study, early letter knowledge failed to have a direct effect on later phoneme awareness.

In the present study, children's grammatical skills (as assessed by their performance on tests of word order correction and on the test of grammatical morphology) and vocabulary skills failed to predict the growth of word recognition skills at Time 3. These findings suggest that in the first 2 years of formal education (from age 4 years 9 months to 6 years 9 months), the growth of word recognition abilities is relatively uninfluenced by vocabulary and grammatical skills. This finding is broadly in line with the findings of Casalis and Alexandre (2000), who found that phonological awareness accounted for the major part of the variance in reading accuracy at age 6.5 years but that by the time the children in their study were 7.5 years old, both phonological and grammatical awareness made significant independent contributions to reading accuracy. A previous study (Shankweiler et al., 1995) showing inflectional morphology to be impaired in children with reading difficulties, and to be predictive of variations in word recognition abilities, also involved much older children (7.5 to 9.5 years). The data from the present study, along with those from previous studies, are therefore in line with the idea that vocabulary and grammatical skills become more important as facilitators of word recognition skills later in development when the range of words children encounter in print increases (Share, 1995) and as reading materials become linguistically more complex.

The Development of Reading Comprehension

In contrast to our findings relating to the development of word recognition, vocabulary knowledge and grammatical awareness were significant predictors of reading comprehension (even when the effects of early word recognition, phoneme sensitivity, and letter knowledge were controlled). These findings add to the large body of evidence that reading comprehension depends on skills outside of the phonological domain (the so-called "outside-in skills" of Whitehurst & Lonigan, 1998).

As we argued in the case of word recognition earlier, we suspect that the importance of nonphonological language skills as determinants of reading comprehension may increase at later stages in development. In line with this suggestion, Gough, Hoover, and Peterson (1996) conducted a meta-analysis of studies examining

the correlations among reading comprehension, listening comprehension, and decoding skills over a wide range of ages. They found that from early to later grades, the correlation between reading comprehension and decoding decreased (i.e., reading comprehension became less influenced by variations in decoding skill) whereas the correlation between reading comprehension and listening comprehension increased. Such findings suggest that reading comprehension will become more heavily dependent on semantic and syntactic language skills (as assessed by listening comprehension) as children get older.

Summary, Conclusions, and Limitations

We have investigated the development of language and reading skills in the first 2 years of formal education. Our results are clear (a) in demonstrating the critical roles of phoneme sensitivity and letter knowledge for the development of early word recognition skills and (b) in demonstrating that for reading comprehension, as might be expected, vocabulary knowledge and grammatical skills play additional significant roles. We argue that it is important for future studies to focus in more detail on the immediate precursors of reading skills (particularly phonemic skills and letter knowledge and their interrelationships). Training studies may be particularly helpful in unraveling the apparently interactive relationships between these two skills that appear, from the present study, to form the foundation for the growth of children's early word recognition skills. It is also important to chart more precisely, and over a longer developmental period, the role of vocabulary knowledge and grammatical skills in the development of word recognition and reading comprehension, as it seems likely that such skills will assume greater importance at later stages of development than the ones studied here.

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Appendix

Items for the Morphological Generation Task

1. Here is a banana. Here are three . . . (bananas)
2. Here is a dog. Here are three . . . (dogs)
3. Here is a tree. Here are three . . . (trees)
4. Here is a flower. Here are three . . . (flowers)
5. Here is a hand. Here are two . . . (hands)
6. Here is a knife. Here are three . . . (knives)
7. Here is a leaf. Here are three . . . (leaves)
8. Here is a man. Here are two . . . (men)
9. Here is a mouse. Here are three . . . (mice)
10. Here is a foot. Here are two . . . (feet)
11. This boy likes to climb. Here is the rock he . . . (climbed)
12. This boy likes to dig. Here he is . . . (digging)
13. This girl likes to drink. Here she is . . . (drinking)
14. This man likes to paint. Here he is . . . (painting)
15. This girl likes to ride. Here she is . . . (riding)
16. Santa carries his sack. Here is the sack Santa . . . (carried)
17. The girl sees the birds. Here are the birds she . . . (saw)
18. The burglar steals the jewels. Here are the jewels he . . . (stole)
19. The man brings the flowers. Here are the flowers he . . . (brought)
20. This boy likes to write. This is what he . . . (wrote)
21. This man found something. Here he is pointing to what he . . . (found)
22. The lady went to buy the shopping. This is what she . . . (bought)
23. The lady falls on the banana skin. Here is the banana skin on which she . . . (fell)
24. This girl keeps pets. Here is a puppy she . . . (kept)

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New Editor Appointed for *Journal of Occupational Health Psychology*

The American Psychological Association announces the appointment of Lois E. Tetrack, PhD, as editor of *Journal of Occupational Health Psychology* for a 5-year term (2006–2010).

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Manuscript submission patterns make the precise date of completion of the 2005 volume uncertain. The current editor, Julian Barling, PhD, will receive and consider manuscripts through December 31, 2004. Should the 2005 volume be completed before that date, manuscripts will be redirected to the new editor for consideration in the 2006 volume.