Reading and Writing: An Interdisciplinary Journal **13:** 313–336, 2000.

The transient role of explicit phonological recoding for reading acquisition

RALPH WESSELING & PIETER REITSMA
PI Research, Amsterdam, The Netherlands

Abstract. This study explores early stages of reading acquisition, specifically the relation of phoneme blending and letter recoding to individual differences in word decoding. The hypothesis was that facility in letter recoding and accuracy of phoneme blending are substantial components of word decoding in beginning readers but not for skilled reading and that reliance on phoneme-sized decoding of words would dissipate as reading proficiency increased. In four studies we examined the ability to recode letters, blend phonemes and decode words in four groups of Dutch children (early Grade 1, N = 130, older Grade 1, N = 81, Grade 3, N = 54 and a group of children with a reading lag, N = 356). Phoneme blending was only related to the reading ability of beginning Grade 1 children. By the end of Grade 1 ability to blend phonemes did not differentiate reading capacity, nor for older children in Grade 3 and reading disabled children. Letter recoding was related to word decoding in all four studies, although the strength of that relation did dwindle as reading skill level increased. The results of the study appear consistent with self teaching hypothesis and other theories that imply a transient role of explicit phonological recoding in word identification.

Keywords: Early reading acquisition, Phoneme blending, Phonological recording, Word decoding

Introduction

The ability to identify printed words is a central task in learning to read (Gough & Tunmer 1986; Juel, Griffith & Gough 1986; Share 1995; Stanovich 1986). Although contextual cues and analogy assist the beginning reader, the most important route for deriving the lexical referent of a printed word is decoding, i.e., recoding written symbols into a sound based representation (Frith, Wimmer & Landerl 1998; Torgesen & Morgan 1990; Wagner & Torgesen 1987). This has been variously termed as phonetic reading (Torgesen, Wagner & Rashotte 1997), phonological decoding (Olson, Wise, Ring & Johnson 1997) and phonological recoding (Share 1995). The importance of learning to decode words in early reading acquisition has been established (Bradley & Bryant 1983; Byrne & Fielding-Barnsley 1989, 1991; Demont & Gombert 1996; Foorman, Francis, Fletcher, Schatschneider & Mehta 1998; Rack, Snowling & Olson 1992; Stanovich 1986), however, there remain many unanswered questions regarding early reading development (Bowers & Wolf 1993). In a series of studies we examine the early word decoding of Dutch children and the role of grapheme recoding and phoneme blending. The issue is what role phoneme blending and letter-sound knowledge have for word decoding throughout the initial stages of learning to read?

Awareness of the phonological structure of spoken language is widely regarded as crucial for reading acquisition (Lewkowicz 1980; Lovett, Borden, DeLuca, Lacerenza, Benson & Brackstone 1994; Perfetti, Beck, Bell & Hughes 1987; Torgesen, Morgan & Davis 1992; Wagner & Torgesen 1987; Williams 1980). Although awareness of phonemes is obvious for most adults this is not the case for prereading children, because phonemes are abstract and difficult to isolate from the speech stream (Morais, Cary, Alegria & Bertelson 1979). Tasks that measure phoneme awareness include blending phonemes, segmenting words into phonemes (phoneme segmentation), and deleting phonemes in a word. Some phonological tasks seem to be important for later reading acquisition whereas other phonological tasks can only be accomplished by individuals who have some reading ability. Phoneme blending is an example of a phonological task that children tend to be able to do before they are able to manage other phonological tasks (Torgesen & Morgan 1990). Perfetti, Beck and Hughes (reported in Perfetti 1985: 220) conducted a longitudinal study in which the relationships between reading, phoneme blending and phoneme analysis (word segmentation) were examined. The results showed that phoneme blending ability at the start of Grade 1 was the best predictor of reading at the end of Grade 1. Their conclusion was that phoneme blending is required for reading whereas other phonological skills such as phoneme analysis are a consequence of reading acquisition.

Another important aspect of early word decoding is converting graphemes to phonemes (Lovett, Warren-Chaplin, Ransby & Borden 1990; Torgesen, Wagner & Rashotte 1997; Vellutino & Scanlon 1987). Correlational studies show that knowledge of grapheme to phoneme correspondences (GPC) is a good predictor of later reading success. Research has also demonstrated that training letter-sounds improves decoding ability (Ball & Blachman 1988, 1991; Bradley & Bryant 1983; Juel 1988) and that training of grapheme knowledge independently contributes to reading development, over and above phoneme awareness training (Bryant & Impey 1986; Cunningham 1990; Treiman 1984). In a study by Foorman, Francis, Fletcher, Schatschneider and Mehta (1998) three different classroom reading programs were trialed with 285 children. The three conditions varied in the amount of direct instruction given in letter-sound correspondences. The children receiving direct instruction showed greater gains in initial reading acquisition than children who were given less direct instruction or implicit instruction. Providing children with the basic tools of decoding appears to give them a better start at reading than when children are left to discover these tools for themselves.

Research findings show that there is an association between both phoneme blending and letter recoding, and the successful development of word decoding ability. However, what is the longitudinal relationship between these three factors? In a comprehensive review of the literature Stanovich (1986) puts forward a theory of a developmentally limited relationship between phonological awareness and reading. Being phonemically aware accounts for variance in reading ability only in the beginning stages of reading development, in later stages of reading development other variables differentiate between readers. Stage and Wagner (1992) reported that their measure of phonological awareness (a sound categorisation task) accounted for most of the variance in decoding ability in Grade 1 but this was surpassed by other variables when retested in Grade 2. Thus, one could hypothesise that during the development of reading ability, a previously strong relationship between phoneme blending and word decoding levels off to a weaker relationship or no relationship.

A developmentally limited relationship between the importance of letter-sound knowledge and reading has also been proposed. Ehri (1995) argues that there are four distinct phases that occur in the development of word decoding, in two phases single grapheme-phoneme correspondences play a role. In a pre-alphabetic phase a child uses salient features of a word to aid recognition. The second phase comprises the use of partial letter-sound information to decode words. In a third stage the child starts using grapheme to phoneme correspondences for all letters in the word. Finally, with experience, a child will start using letter clusters and associated phoneme blends for more efficient and rapid decoding. Thus, single letter-sound correspondences are theoretically only important for a limited span of time (phases two and three) for the acquisition of reading skills.

The hypothesised transitory relationship of letter-sound knowledge is also present in the theory of self-teaching mechanisms for reading acquisition proposed by Jorm and Share (1983), and further developed by Share (1995). The self-teaching hypothesis implies that children use explicit grapheme to phoneme rules and blending skills to allow self-teaching of more complex implicit correspondences between orthography and the phonological representations of words. The child uses the rudimentary skills of letter-sounds, basic phonemic awareness and knowledge of context to determine pronunciation. Successful decoding experiences ensure that simple letter-sound correspondences can be modified in “light of lexical constraints imposed by a growing body of orthographic knowledge”. Familiar words can be decoded using larger units yielding faster rates of reading (e.g., Ehri & Wilce 1983).

Some direct (empirical) evidence for a transient relationship between letter knowledge and word decoding was reported by Walsh, Price and Gillingham (1988). They found that letter naming is related to word decoding in Kindergarten but by Grade 2 this relationship is gone. Their hypothesis was that knowledge of letter names indicates that the person has a lexical referent for that item, that allows other information such as letter-sounds to be stored. In their study 35 kindergarten and 42 Grade 2 children were tested on their speed and accuracy at naming 10 letters (mixed upper and lower case). The results show a positive correlation between speed of accurate letter naming in kindergarten children and reading achievement. However, this relationship was not apparent in the Grade 2 children. Walsh et al. (1988) suggest that the relation between letter naming and reading achievement is best described by a curve of diminishing returns that flattens out during Grade 1. In kindergarten a curve of diminishing returns accounted for 58% of the variance in reading, as opposed to a linear regression that accounted for 54%.

The Walsh et al. study, however, may not allow conclusive insight into the developmental relationship between letter knowledge and reading acquisition. One possible drawback was that letter naming was tested and although letter names may be a proxy for letter-sounds, this was not tested. Letter sound knowledge can be argued to be more directly related to reading than letter naming. Second, they used a combination of ten upper and lower case letters. Beginning readers are generally less familiar with upper case letters as words are usually not written using uppercase letters. Also, the number of letters tested was restricted to ten making it difficult to answer questions regarding how *much* letter knowledge is required for reading acquisition. The conclusions of the Walsh study may also be based on a misinterpretation of the results. The results show that kindergarten children scored on average less than 75% correct on the letter naming task, whereas in Grade 2 the average was almost 100% with negligible deviation, therefore the disappearance of a relationship between letters and word decoding in Grade 2 could be a statistical artifact caused by a restriction of range due to a ceiling effect. To correct this, the letter naming test should have included more letters. Finally, the conclusion that a curve of diminishing returns offers the best description of the relationship between letter knowledge and reading from kindergarten through to Grade 2 is seriously undermined by the omission of a Grade 1 group. The study by Walsh et al. (1988) alludes to a transition point without actually measuring or identifying the actual phenomenon.

In the present four studies we examine the contribution of grapheme recoding and phoneme blending to regular word decoding in early reading acquisition of Dutch children. What is the relationship or function of letter recoding and phoneme blending skills as word decoding ability improves? For this study the period of early reading acquisition is defined as non-fluent reading, i.e., when a reader can decode 20 to 30 words in a list per minute. We ask the question how much competence in grapheme recoding and phoneme blending does a beginning reader need to achieve a good start in acquiring decoding skills? Is it possible to find a transition point, or threshold, where further improvements in phoneme blending and/or grapheme recoding have no consequences for word decoding performance? In a written language with a regular orthography, like Dutch, it is possible to decode most words using simple grapheme to phoneme correspondences (GPCs). It is possible that in a regular orthography the use of GPCs remains an important method of decoding words. On the other hand the importance of efficient grapheme recoding and phoneme blending may be temporary as beginning readers learn other, more efficient methods to decode words, e.g., by analogy, or item specific orthographic information (Reitsma 1990, 1997; Share 1995).

In a first study with first graders we measured facility in letter recoding, skill in phoneme blending, and word decoding. To search for thresholds we examine correlations between the variables and if an initially strong correlation significantly weakens or disappears then the point at which this change occurs is a threshold point. However, if there are *no* thresholds we would expect that facility in either letter recoding or phoneme blending will continue to relate to individual differences in word decoding, even when the reader has achieved a high level of proficiency in word decoding. The specific questions examined in the first study are: Is word decoding in beginning readers substantially related to the ability to recode letters and to blend phonemes? Is there a threshold point where the relationship between the component skills and decoding ability no longer holds?

Study 1

Method

Participants. In total 130 Grade 1 subjects from four primary schools participated. The schools had children with comparable social and economic background. Permission was obtained from the four primary schools and information was sent home to parents of the children. The mean age was 6 years 8 months (71 to 96 months, SD = 4.89). At the time of testing the children had received about 10 weeks of formal reading instruction. Reading instruction in the Netherlands has a sizeable phonics component in it (Reitsma & Verhoeven 1990) and by the end of Grade 1 children are expected to read regular one and two syllable words fluently.

Materials and procedure

One minute test of word decoding (part A and B). Each part of the decoding test consisted of a list of 36 regular CVC words, placed on A4 page one below the other in three columns. The first 15 words were constructed from letters that are taught in the first 3 months of reading instruction in Dutch schools (e.g., *poot*, *bos*), however, none of the words are used in any of the initial readers used for reading instruction. The number of words correctly read in one minute is noted. A few children could read the 36 words in less than 60 seconds, in this case time was recorded. Later scores were scaled to show what each child would have read if they had continued for the full 60 seconds. Performance on part A of the test correlated 0.72 with part B of the test. For analysis the average of the two tests is used as the measure of word decoding.

One minute letter recording test (part A and B). Each part of the recoding test consisted of the 36 graphemes and digraphs commonly used in the Dutch language (e.g., *a, b, z,* and digraphs such as *ij, oe, ui, eu*). The graphemes were arranged pseudo randomly on an A4 page in 4 columns, the more common graphemes were bunched towards the beginning of the test. Part A and B differed in the order of graphemes. The child was asked to sound out the graphemes and directed to begin at the top left corner and follow the column down, and then proceed with the next column. The raw scores were scaled to indicate the number of letters recoded correctly within one minute. Scores for part A and B of the test correlated 0.81. For purposes of statistical analysis the average number of correctly sounded letters on the two tests was used.

Phoneme blending task (part A and B). Both part A and B consisted of 10 fully segmented CVC words. The words used in the test are known by more than 90% of six year old children in the Netherlands (Kohnstamm, Schaerlaekens, de Vries, Akkerhuis & Froonincksx 1981). The segmented words were recorded at a studio with the help of a speech therapist. Examples of words used include /d/ /ie/ /f/ (thief), /b/ /oo/ /t/ (boat) and /m/ /e/ /s/ (knife). The two parts of the test were placed on audio cassette. The 10 words in each test are successively presented one phoneme per second. The time between items was just over 1 second, allowing sufficient time for pressing and releasing the pause button. Following each word the tape is paused by the experimenter until the children responds. There are no articulatory cues to help the child. For a response to be considered correct, the child must combine all phonemes and say the entire word out loud. A correlation calculated between scores on part A & B resulted in $r = 0.67$. For statistical analysis the average number of correct responses on the two tests was used.

Testing was done in a one on one interview style, each child being removed from the classroom for approximately ten minutes. The tests were presented in the order of decoding part A, letter recoding part A and the phoneme blending test part A, then the order would be repeated for version B.

Statistical analysis. To search for thresholds we will apply three statistical procedures to the data. The first analysis is to ascertain how well the relation between word decoding and either letter recording or phoneme blending can be described using a linear regression. Then we will conduct two analyses to try and locate possible thresholds. As stated earlier our definition of a threshold is the point at which there is a significant change in the magnitude of the relationship between two variables. This can be described as a sharp bend in a regression line, in that case two separately fitted linear regressions would offer a better description of the data. To do this we use a piecewise regression analysis detailed in Neter, Wasserman and Kutner (1990). However, the relation of either letter recording or phoneme blending may not weaken suddenly but perhaps more gradually in which case a curve of diminishing returns will be a better description of the relationship. We will use an S curve ($Y = e^{(b0+b1/x)}$), specified in the SPSS 6.0 users guide (Norusis 1993: 374), as a curve describing the characteristics of diminishing returns.

Results and discussion

In this study we tested 130 beginning readers after 10 weeks of reading instruction on their word decoding, letter recoding and phoneme blending ability, and examined the inter-relationships. Displayed in Table 1 are the means and standard deviations of the three tests administered. The average number of correctly read CVC words out of context in a list was 10.8 in 1 minute. The average that may be expected at this age according to norms set for Dutch children (Struiksma, Van der Leij & Vieijra 1991) is about 7.5 to 10 words in one minute, so relatively speaking the children in this sample are doing quite well. Even after only 10 weeks of reading instruction and practice these first graders were able to decode relatively simple but unfamiliar words correctly. Good decoding skills, in beginning readers, are not unusual in countries with a shallow or regular orthographically. For example, a study by Wimmer and Goswami (1994) found that after a short period of reading instruction German children were much more adept at decoding then matched English children.

Ten weeks of reading instruction is not sufficient to teach children in the Netherlands all graphemes used in the Dutch writing system. However, the

Table 1. Observed means, standard deviations and range for Study 1 (early Grade 1)

N = 130	Mean	SD	Min.	Max.
Word decoding test	10.83	5.41	2.50	43
Decoding accuracy (% correct)	85%	13%	36%	100%
Letter recoding test	27.01	7.89	9.50	57.00
Recoding accuracy (% correct)	78%	8%	56%	99%
Phoneme blending test (max. possible 10)	7.11	2.03	1	10

average number of letters recoded correctly (27) in one minute was high with some children recoding almost one grapheme per second. The accuracy of word decoding and letter recoding was on average very high, although the minimum accuracy for word decoding (36%) indicates that some children had difficulty with decoding words correctly.

A Pearson's correlation was calculated revealing strong relationships between all three efficiency tests, all correlation coefficients were significantly different from zero ($p < 0.001$). Word decoding correlates 0.71 with letter recoding and 0.39 with phoneme blending. Letter recoding and phoneme blending correlate 0.39.

To examine the development of word decoding in relation to phoneme blending and letter recoding three types of regression analyses, detailed in the method section, were conducted (see Table 3 for an overview). The best least squares approximation for a description of the data for letter recoding and word decoding was an S curve, $R^2 = 0.55$ (significantly more than the ordinary correlation, a linear regression, $p < 0.05$). The best least squares approximation for a description of the relationship between phoneme blending and word decoding was also a curve of diminishing returns, $R^2 = 0.19$ (significantly more than a linear regression, $p < 0.05$). A piecewise regression analysis was done, however, no thresholds were found.

The results of this study show that individual differences in both letter recoding and phoneme blending are related to individual differences in word decoding. There was no indication of a threshold point, although the best regression for letter recoding seems to suggest that there is a relationship of diminishing returns. The finding of a curve of diminishing returns as the best description of the relationship between both phoneme blending and letter recoding for word decoding is consistent with the findings of Walsh et al. (1988). In the Walsh study the best fitting curve, through letter knowledge versus reading, accounted for 58% of the variance, this is similar to the 55% of the variance accounted for by the best fitting curve in the present study.

A curve of diminishing returns indicates that as word decoding increases the relationship with phoneme blending and letter recoding will decrease. However, the range of scores in this study do not reveal when the significance of phoneme blending and letter recoding for word decoding cease.

Study 2

In the first study we found that increases in letter recoding and phoneme blending both covary with increases in word decoding. Although a curve of diminishing returns offered the best description of the results the relation between word decoding and both phoneme blending and letter recoding did not reach a level of proficiency where they ceased predicting word decoding ability. To further test the possibility of finding a threshold point, it was decided to try with a different group of children and extend the range of ability. There were two options considered to examine the possibility of extending the range of ability. The first option was to re-examine the same group of children at a later stage in reading development. Perhaps at a later point a threshold could be found. However, it is difficult to gauge the appropriate moment when to retest, too early and nothing new is found, too late and most of the children may have passed the point providing little extra information. Our choice was to go for a second option, namely to study older children with a reading lag, who were on average slightly ahead in word decoding ability than children from Study 1. Children with a reading lag make an interesting contrast to the Grade 1 children in the first study. Whereas the Grade 1 children had all received about the same amount of reading instruction a group of poor readers will have widely varying amounts of instruction and remedial instruction. The greater variability in reading experience will afford a broader range of scores on the three tests allowing more detailed analysis of the interrelationships along the continuum of ability.

The aims of the second study are the same as those for the previous study. The first is to see whether phoneme blending and grapheme recoding are predictors of word decoding ability. A second question is to see if there is evidence of thresholds in the relation between the subskills and word decoding. We will use the same methods described in Study 1 to search for possible threshold points or transitions.

Method

Participants. In total 356 children participated in this study after first receiving the permission from schools and parents. The children came from

32 different special education schools situated in and around Amsterdam. The age of the children selected was on average 8 years 9 months (106 months, SD = 9.71) but ranged from as young as 83 months up to 138 months. The children were all preselected by the teachers at the schools based on criteria that we had stipulated. The criteria were that the child was able to only read approximately 10 to 30 words on a standardised one-minute-decoding test (Brus & Voeten 1973) and that the participants were identified as having an abnormal delay specific to reading not attributable to sensory dysfunction or general learning difficulty. Because this level of word reading should be attained normally by almost all children at the end of Grade 1, the children in the current study are on average 2 years behind in expected reading ability.

Materials and procedure

The materials and procedure used were the same as in Study 1. Correlations between the two parts of each test were recalculated, the word decoding test part A & B correlated 0.85 and the letter recoding test 0.78. A correlation between part A and B of the phoneme blending task resulted in a relatively low correlation $r = 0.35$.

Results and discussion

The results from Study 2 are displayed in Table 2. The accuracy on all tests was very high, averaging around the 90% on all three tests. The average score correct on the phoneme blending test was 8.64, clearly approaching ceiling levels, explaining the low correlation between parts A & B. The average amount of words decoded is almost twice that of the Grade 1 children in Study 1. The average scores on letter recoding and phoneme blending are also higher than the test scores for Grade 1 children. Most children could accurately recode about 1 letter every 1.25 seconds, but the distribution was very spread out.

In Table 3 the results are presented of various regression analyses between reading and phoneme blending and between reading and letter recoding. There was no relationship between phoneme blending and decoding ability (0.06, n/s), and only a small but statistically significant correlation between phoneme blending and grapheme recoding (0.11). Although a relation between phoneme blending and word decoding was not present for the entire range of scores, our expectations were that in the lower range a linear relationship would exist and that it would cease as word decoding increased beyond a certain level. We attempted to fit a piecewise linear regression line, however, no significant amount of variance could be accounted for. A similar analysis for phoneme blending revealed no significant relationship between blending phonemes and word decoding.

Table 2. Observed means, standard deviations and range for Study 2 (reading disabled)

N = 356	Mean	SD	Min.	Max.
Word decoding test	21.73	8.41	8	47
Decoding accuracy (%)	89%	7%	57%	100%
Letter recoding test	48.89	12.58	16.50	90.50
Recoding accuracy (%)	93%	5%	71%	100%
Phoneme blending test (max. possible 10)	8.64	1.08	4.50	10.00

Table 3. Results of various regression analyses for the four studies

Study	Decoding	Regression	Letter recoding	Blending (CVC)	Blending (complex)
1	CVC	*Linear*	R^2 = 0.50*	R^2 = 0.15*	N/A
		S curve	R^2 = 0.55*	R^2 = 0.19*	
		Piecewise	–	–	
2	CVC	*Linear*	R^2 = 0.30*	R^2 = 0.00	N/A
		S curve	R^2 = 0.36*	–	
		Piecewise	–	–	
3	CVC	*Linear*	R^2 = 0.62*	R^2 = 0.00	R^2 = 0.17*
		S curve	–	–	–
		Piecewise	–	–	R^2 = 0.21*
	Complex	*Linear*	R^2 = 0.49*	R^2 = 0.03	R^2 = 0.23*
		S curve	–	–	–
		Piecewise	–	–	–
4	CVC	*Linear*	R^2 = 0.19*	R^2 = 0.01	R^2 = 0.02
		S curve	–	–	–
		Piecewise	–	–	–
	Complex	*Linear*	R^2 = 0.18*	R^2 = 0.01	R^2 = 0.00
		S curve	–	–	–
		Piecewise	–	–	–

Note: Linear regressions are always shown (*$p < 0.05$ for difference from zero). Further regression analyses are only shown if significantly more variance was accounted for than a linear regression.

There was a strong correlation between word decoding and letter recoding (0.55) for the entire range of scores. A curve diminishing returns was fitted to the data that accounted for 35.6% of the variance in word decoding, this is significantly ($p < 0.05$) more than the best fitting linear curve (30.2%). A piecewise regression was also conducted but revealed no threshold point. The spread in letter recoding scores suggest that efficient and fast recoding of letters to sound is beneficial for word decoding.

Study 3

The findings of the previous two studies suggest that knowledge of phoneme blending is necessary for word decoding, but that improvements in efficiency beyond a rudimentary acquisition of phoneme blending ability is not related to further increases in word decoding skill. A shortcoming of the phoneme blending task used in Studies 1 and 2 was that in Study 2 the test scores approached ceiling level. Because the children in Study 2 were able to perform at such a high level on the phoneme blending task it suggests that they had either passed the hypothetical threshold value or that a restriction of range masks the existence of a threshold point. To test these possibilities a more demanding phoneme blending task needs to be administered. The findings in Studies 1 and 2 support a view that letter recoding is a significant predictor of word decoding.

The participation of reading disabled children in Study 2, to examine the role of letter recoding and phoneme blending for word decoding, may have presented a misleading picture of normal reading development. If reading disability is not a developmental lag but has an alternative etiology, then the findings in Study 2 would not apply to normally developing readers. Therefore, in Study 3 we examine Grade 1 children (different from those in Study 1) who are more advanced readers than the Grade 1 children from Study 1. The present group of Grade 1 children will be tested after 20 weeks of reading instruction, 10 weeks more than the children in Study 1. We will adjust the tasks to make them more demanding. A more complex phoneme blending task will be added and a word decoding task with structurally more complex words. By introducing a more complex word decoding task greater variance in reading scores can be anticipated thereby removing to some extent the possibility that a finding of a “null” relationship between word decoding and either phoneme blending and letter recoding is due to statistical restriction of range.

The questions remain the same. Are phoneme blending and letter recoding substantially related to word decoding ability and are any found relationships developmentally limited with word decoding?

Method

Participants. In total 81 Grade 1 subjects from two primary schools participated. The schools had children with comparable social and economic backgrounds. Permission was obtained from the primary schools and information was sent home to the children's parents. The mean age was 6 years 11 months (75 to 95 months, SD = 4.15). At the time of testing the children had received 20 weeks of formal reading instruction.

Materials and procedure

One minute test of word decoding Version 2 (part A and B). Part A remained largely unchanged, except that we increased the number of items from 36 to 43. We refer to part A as the simple test of word decoding. For part B, referred to as the complex test of word decoding, a standardised test of word decoding was used (Brus & Voeten 1973). The first 43 items of the entire test were included for the version in this experiment. The test starts off with single syllable CVC words but quickly progresses onto two and three syllable words. The correlation coefficients between parts A & B was $r = 0.87$.

One minute letter recoding test (part A and B). This test remained unchanged and was administered in the same manner as for Studies 1 and 2. The correlation coefficient between Parts A & B resulted in a $r = 0.76$.

Phoneme blending task (part A and B). Part A of the phoneme blending test was the same as that used in Study 1 and 2 except that the number of items was increased to 15, this was done by including a number of items from part B of the blending tests used in Studies 1 and 2. Part A is referred to as simple phoneme blending. For Part B, complex blending, we used a standardised test of phoneme blending. This is a 15 item test that starts with VC and CV items (e.g., /ui/ /t/ = out) and progresses in difficulty through to (C)CVC(C) items (e.g., /s/ /t/ /e/ /r/ /k/ = strong). Because of the high scores on Part A of the phoneme blending test (not much variation) the Pearson's product moment correlation between parts A & B was relatively low, $r = 0.48$.

Results and discussion

The results for Study 3 are summarised in Table 4. The average number of CVC words read was 23, twice the amount that children in Study 1 scored and comparable with poor readers in Study 2. Fewer words were read in 60 seconds on the complex word test (part B) reflecting the inclusion of more demanding word structures. The average number of letters that were recoded in 1 minute was approximately 54, which is also twice the number

Table 4. Observed means, standard deviations and range for Study 3 (older Grade 1)

N = 81	Mean	SD	Min.	Max.
Simple CVC word decoding test (part A)	22.92	10.61	4	47.31
Decoding accuracy part A (%)	90%	12%	44%	100%
Complex word decoding test (part B)	14.05	5.44	4	30
Decoding accuracy part B (%)	84%	13%	38%	100%
Letter recoding test (average part A and B)	53.95	18.89	19.50	103.80
Recoding accuracy (%)	92%	5%	81%	100%
Simple phoneme blending test (Part A)†	11.33 (76%)	2.40	1	15
Complex phoneme blending test (Part B)†	7.96 (53%)	3.10	1	15

† The percentage correct is presented between parentheses to allow comparison with results from Studies 1 and 2.

that children in Study 1 could manage. The accuracy of word decoding and letter recoding was very high. More errors were made on the standardised word decoding test than on the relatively simpler CVC test of word decoding. Most children were able to successfully blend the majority of simple CVC items, but the more complex phoneme blending items in Part B were a greater challenge. This group of children is comparable in reading ability to the poor readers in Study 2 in terms of accuracy and total words attempted.

In Table 3 the results of the various regression analysis for Study 3 are presented. As in Study 2 simple phoneme blending (Part A) did not correlate with word decoding. Part B of the phoneme blending task was more demanding and did account for variance in both word decoding tests. A linear regression analysis with simple decoding as the dependent variable and complex phoneme blending as the independent variable resulted in $R^2 = 0.17$ ($p < 0.01$). A piecewise analysis with these same variables revealed a threshold point where the two regression lines accounted for the optimum amount of variance (21%). This point lay at 8 successful items blended that corresponds with CCVC and CVCC level of difficulty. The regression function above the threshold point did not account for significant amounts of variance, in other words scoring higher than 8 did not differentiate between readers.

A second linear regression analysis was calculated with complex decoding as the dependent variable and complex phoneme blending as the independent variable, the variance accounted for by best fitting line was 23%. A piecewise analysis with the same variable failed to discover any threshold points.

There was a substantial relationship between letter recoding and both simple and complex word decoding. The best fitting regressions were linear and accounted for 62% of variance in simple word decoding and 49% of variance in complex word decoding. Subsequent piecewise regression analysis revealed no threshold point in the relationship between letter recoding and either variant of the word decoding tests.

The results of Study 3 are relatively straightforward, letter recoding and phoneme blending still account for significant amounts of variance in word decoding. Individual differences in letter recoding explain substantial variance in word decoding, with no indication of a threshold point. The slope and intercept of the linear regression between word decoding and letter recoding is identical to Studies 1 and 2 (see Figure 1). It is clear that letter recoding differentiates the children in Studies 3 and 2 from the young Grade 1 children in Study 1. But it is not possible to predict whether a child participated in Study 2 or 3 based on letter recoding scores.

Only complex phoneme blending still differentiates between readers. If we examine Figure 2 (see Study 4) we see that the reading level of children in Studies 1, 2 and 3 cannot be predicted from phoneme blending ability. It seems that phoneme blending may be a requirement for very early reading acquisition but as reading skills progress the importance of being able to blend phonemes diminishes. This supports the findings by Torgesen and Morgan (1990) and Perfetti (1985: 220) who suggested that phoneme blending is an important skill only at the beginning of reading acquisition.

Study 4

In Study 3 word decoding ability was related to letter recoding ability (50–60% of variance) and to a less extent with phoneme blending (approximately 20% of variance). The hypothesised thresholds did not eventuate. The role of phoneme blending seemed to be a diminishing one as by the end of Grade 1 (Study 3) only the more demanding version of the blending task correlated with reading ability. If letter recoding and phoneme blending are components of early reading and not of skilled reading we should not expect to find significant relationships with word decoding within an older group of skilled readers.

Based on the findings from the previous three studies we would predict that phoneme blending is not related to skilled reading. Skilled readers do not continue to decode words by blending phoneme sized units (Torgesen & Morgan 1990). Based on the trends discussed in the previous studies it is possible that at least two alternatives exist for the relationship between letter recoding and word decoding. First, skilled readers will recode letters rapidly and individual differences in letter recoding will not be related to word decoding. However, alternatively, we may find that letter recoding continues to differentiate between older skilled readers. This could be because the ability to recode individual letters is still important for attacking unfamiliar words, thus the efficiency of this process would still relate to efficiency of word decoding. In this fourth and final study the same relationships are examined in an older group of Grade 3 children with normal reading ability and of similar age as the reading disabled children of Study 2. The question remains the same, are letter recoding and phoneme blending substantial components of word decoding.

Method

Participants. In total 54 Grade 3 subjects from one primary school participated. The mean age was 8 years 11 months (99 to 122 months, SD = 5.40) this is comparable to the age of the children in Study 2. However, whereas the children in Study 2 lagged behind their expected reading level the group participating in Study 4 were reading at a level consistent with their age and the amount of reading instruction they have received (approximately 25 months).

Materials and procedure

One minute test of word decoding (part A and B). Part A, simple decoding, the number of items was increased to 65. For Part B, complex decoding, the first 65 items of the standardised test of word decoding test (Brus & Voeten 1973) were included for the test. The correlation between part A & B was r = 0.72.

The rest of the tests and the procedure used remained unchanged from that in Study 3. The inter-correlation for letter recoding was r = 0.80, and for phoneme blending r = 0.55.

Results and discussion

The results of the present study are presented in Table 5. The average score on the CVC word decoding test is almost 75 which is 3.5 times the average number of words that the age matched poor readers in Study 2 could manage. The facility at recoding letters is similar to the children in Study 3 who are two years younger than these children. The range in scores on the letter recoding test overlaps that of the children in Study 2 and Study 3. It is important to note that the superior word decoding ability of the Grade 3 group is not attributable to greater facility in letter recoding. The Grade 3 children are comparable in accuracy on the letter recoding task to the children in both Study 2 and Study 3. Phoneme blending has topped out at ceiling level, few children have any difficulty with even the complex items presented in Part B of the phoneme blending test.

Table 5. Observed means, standard deviations and range for Study 4 (Grade 3)

N = 54	Mean	SD	Min.	Max.
Simple word decoding test (part A)	74.78	15.49	41.00	108.33
Accuracy part A (% correct)	98%	3%	90%	100%
Complex word decoding test (part B)	54.79	13.61	32.00	112.94
Accuracy part B (% correct)	97%	3%	87%	100%
Letter recoding test (average part A and B)	46.07	13.69	17.00	80.55
Accuracy letter recoding task (% correct)	95%	6%	78%	100%
Simple phoneme blending test (part A)[†]	14.13 (94%)	1.36	7	15
Complex phoneme blending test (part B)[†]	13.98 (93%)	1.16	10	15

[†] The percentage correct is presented between parentheses to allow comparison with results from Studies 1 and 2.

The analyses conducted in the previous studies were also applied to the present data and are presented in Table 3. No significant relationship was found between either phoneme blending task (A or B) and the two reading tasks (simple or complex). A piecewise regression analysis did not provide a range of scores where word decoding was related to phoneme blending. In Figure 2 two phoneme blending versus word decoding regressions are displayed. Figure 2 provides an overview of the relations for phoneme blending and word decoding for all four studies. The length of each regression line covers approximately 90 percent of all values of the predictor variables in that study. There was a significant relationship between letter recoding and word decoding. The correlation between letter recoding and simple word decoding was 0.40 and between letter recoding and complex word decoding $r = 0.39$. The best fitting regression function for the data remained linear for both simple and complex word decoding and accounted for 19% and 18% respectively. In Figure 1 the best fitting linear regressions for letter-recoding and word decoding are depicted. It is clear that in all four studies the most proficient letter recoders tend to be the best word decoders.

The results show, as was hypothesised, that word decoding ability of Grade 3 children is not predictable from phoneme blending ability. However, individual differences in word decoding can to a small extent be accounted for by facility in letter recoding ability.

General discussion

In four studies the relationships between word decoding, phoneme blending and letter recoding were examined. The results clearly demonstrate that letter

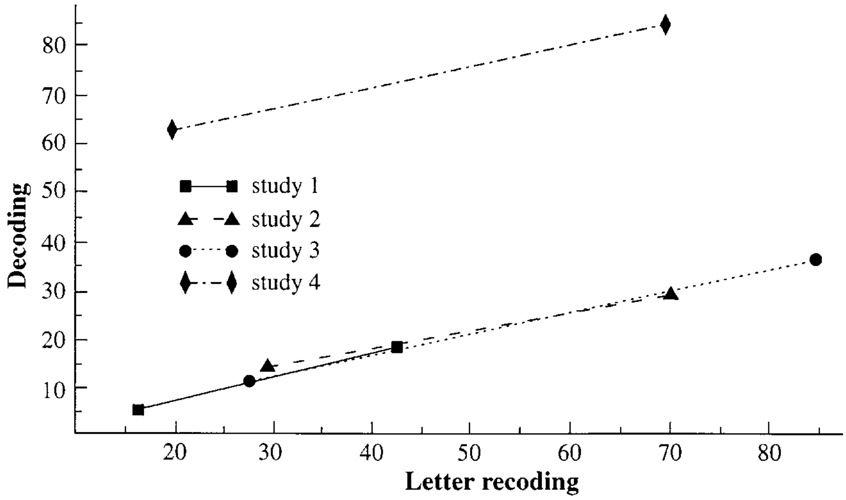

Figure 1. CVC word decoding vs letter recoding.

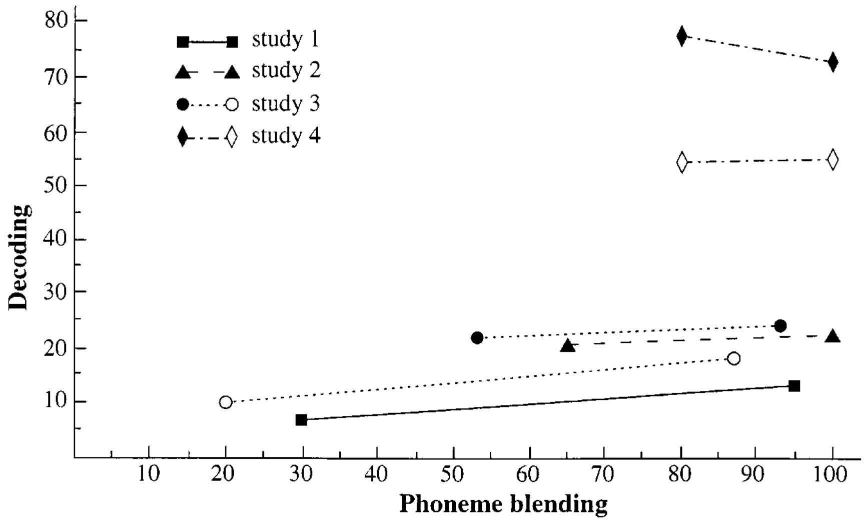

Figure 2. CVC word decoding vs phoneme blending.

recoding and phoneme blending are substantial components of initial word decoding ability but not for skilled reading.

Ability to blend phonemes is a requirement for word decoding in Grade 1 (Study 1 & Study 3) where the most adept children tended to be the best word decoders. However, in Grade 3 phoneme blending did not differentiate between children. The initial relationship of phoneme blending with reading is linear but beyond a certain competency level the relationship disappears, supporting findings by Stanovich (1986) and Stage and Wagner (1992). That level appears to be reached towards the end of Grade 1 as children are by that stage fairly proficient at blending phonemes.

It could be argued that the null relation between phoneme blending and word decoding in Grade 3 is due to ceiling effects which may be masking a relation between phoneme blending and word decoding. If the phoneme blending task was made more difficult, by perhaps introducing multi-syllable words, a correlation may possibly be found. However, this increase in difficulty is likely to differentially tax memory components to a greater extent than skill in blending phonemes. We argue that the tasks as they are indicate which children can or cannot blend phonemes.

The developmental trajectory of letter recoding seems more complicated. A threshold, as defined in the introduction, between letter recoding and word decoding was not located. The results show that letter recoding predicts the reading ability of not only Grade 1 beginning readers (Study 1 & Study 3) but also Grade 3 readers (Study 4) and children with reading problems (Study 2). However, it is not possible to predict whether a child is an advanced Grade 1 reader (Study 3), disabled reader (Study 2) or a Grade 3 reader, based on their letter recoding ability, as the range of scores for all three groups overlap to a considerable extent. The results do indicate that children who are scoring below 30 letters successfully recoded in 1 minute are likely to be beginning readers. Letter recoding accounts for individual differences *within* each group studied but not *between* the four groups. This issue is addressed below in more detail.

Although efficiency of letter recoding has a relationship with word decoding in all four studies there is a trend that indicates that the role of letter recoding for word decoding is decreasing in importance. The amount of variance in word decoding accounted for by letter recoding and word decoding drops from 50–60% in the two Grade 1 studies to 18% in Grade 3.

The continued relationship between word decoding and letter recoding does not support the conclusions reported by the Walsh et al. (1998) study. In their study the efficiency of *naming* of mixed upper and lower case letters was related to reading ability in Kindergarten but not in Grade 2. The best description of the relationship between speed of letter naming and word decoding in Kindergarten was afforded by a curve of diminishing returns. The disappearance of a relationship between letter name knowledge in Grade 2 reported by Walsh et al. (1988) was not found in the present study. We did initially report a curve of diminishing returns as the best description of the relation between word decoding and letter recoding, however, the inclusion of more groups showed this conclusion to be misleading. In all four studies grapheme-to-phoneme knowledge continued to account for variance in word decoding. There are a number of factors that could explain this finding. First in our study we measured letter-sound knowledge which is perhaps more directly related to word decoding than letter naming. Second, a total of 36 graphemes were tested twice as opposed to ten letters thereby increasing the variation in scores. Finally, it is also possible that the regularity of the Dutch written language and the phonics reading instruction used in the Netherlands is in part responsible for these outcomes.

One striking collective outcome from the four studies is that the superior reading ability of the Grade 3 children is not predictable from skill of letter recoding or phoneme blending. For example, whereas the relationship between letter recoding and word reading within studies 1, 2 and 3 are all compatible, in that there is a single regression line for all three groups, the results of Study 4 with Grade 3 children are "out-of-line". The slope of the regression line within the latter group is fairly similar to the slopes in the other studies, however, the intercept is clearly different. Thus, while there exists a relationship between letter recoding and word decoding within Grade 3 children, the ability in word decoding cannot be explained by skill in letter recoding which is at a similar level to that of subjects within studies 1, 2 and 3. Thus, the difference in word decoding between these four groups must be explained by other factors.

One possible explanation could be that the Grade 3 children utilise orthographic knowledge of clusters and syllables, instead of single graphemes, to allow for rapid and efficient word decoding (Share 1995; Ehri 1995). The use of larger orthographic units can explain why the intercept of the regression line in Study 4 lies so much higher than that for the other three studies. However, although the intercept lies higher than that for the other studies the slope of the regression line is very similar, suggesting that while the total proportion of word decoding accounted for by letter-sound knowledge has decreased it remains related.

The self-teaching-hypothesis by Share (1995) predicts that beginning readers will blend phoneme sized chunks into sound based representations using letter-to-sound correspondences. Confirmation of the identity of the printed word creates an opportunity to learn something specific beyond the single letter-sound level. Even exception words can be quickly learned using such a method. For example, "island" could be incorrectly decoded by an inexperienced reader as /is/ /land/, two well-known morphemes. However, using context or external feedback the reader may realise that "is" should be pronounced /ai/. This mechanism could theoretically increase the store of "sight" words and frequently occurring grapheme clusters, e.g., "ght" or "and". Frequently encountered grapheme strings will become familiar allowing more efficient decoding of words containing these grapheme units.

For example, the string "and" occurs in many words, whence this unit is familiar it will no longer be necessary to recode the individual symbols.

The results may also be interpreted using Ehri's (1995) description of reading phases for decoding words (see introduction). The children in Grade 1 recode all letters in a word for identification, whereas the Grade 3 children show consistencies with a consolidated alphabetic phase that allow familiar letter strings to be connected to phoneme blends as a more efficient manner decoding. The Grade 3 children are able to read words without conscious attention to the task of decoding itself. The Study 2 poor readers seem to require much mental attention to the task of recoding the letters into a sound based representation, this lack of automaticity may be what is holding back improvement in reading (Ehri 1995; LaBerge & Samuels 1974; Share 1995).

The poor reading ability of the children in Study 2 does not appear to be directly related to an overt deficit in either letter-sound knowledge or phoneme blending. It is possible that their primary deficit lies in phonological processing but that the phonological awareness tasks (two phoneme blending tasks) used within this study are insufficient to bring that to light. Although the children in Study 2 were as competent at the phoneme blending task as Grade 3 children (Study 4) their phonological dysfunction may be more subtle. If this is the case then it raises the question whether or not phonological awareness, per se, is causally related to reading ability. Where does phonological awareness develop from? One possible explanation may be found in theories of lexical representation (Fowler 1991; Elbro, Nielsen & Petersen 1994). Fowler suggests that lexical representations are refined from a holistic to a phonological level of representation as a natural process of language acquisition demanded by the requirements of storing increasing amounts of lexical items. Elbro et al. (1994) argue that perhaps the problems of many poor readers is that phonological representations that they create by recoding the letters into phonemes do not resemble the lexical representations stored in the lexicon. This is speculation and further theorising on this topic is beyond the immediate scope of this article and should be the subject of separate investigation.

In summary letter recoding and phoneme blending share a developmentally limited relationship with word decoding, although neither phoneme blending nor letter recoding are sufficient to ensure good word decoding they are a requirement for the successful development of reading ability. For normally developing readers there seems to be a transition from reliance on letter-by-letter recoding to some other method, possibly orthographic decoding. Evidence suggests that poor readers possibly continue to decode words using the letter-by-letter method without being able to make the transition to orthographic decoding. An important question therefore remains open, why are children with reading difficulties unable to advance to automatic and efficient reading levels?

References

Ball, E.W. & Blachman, B.A. (1988). Phonological segmentation training: Effects of reading readiness, *Annals of Dyslexia* 38: 208–225.

Ball, E.W. & Blachman, B.A. (1991). Does phoneme awareness training in kindergarten children make a difference in early word recognition and developmental spelling? *Reading Research Quarterly* 26: 49–66.

Bowers, P.G. & Wolf, M. (1993). Theoretical links among naming speed, precise timing, mechanisms and orthographic skill in dyslexia, *Reading and Writing: An Interdisciplinary Journal* 5: 69–85.

Bradley, L. & Bryant, P.E. (1983). Categorising sounds and learning to read: A causal connection, *Nature* 301: 419–421.

Brus, B.T. & Voeten, M.J.M. (1973). *Een minuut test: Verantwoording en handleiding* (*One minute test: Manual*). Nijmegen: Berkhout.

Bryant, B. & Fielding-Barnsley, R. (1989). Phonemic awareness and letter knowledge in the child's acquisition of the alphabetic principle, *Journal of Educational Psychology* 81: 104–111.

Byrne, B. & Fielding-Barnsley, R. (1991). Evaluation of a program to teach phonemic awareness to young children, *Journal of Educational Psychology* 83(4): 451–455.

Cunningham, A.E. (1990). Explicit versus implicit instruction in phonemic awareness, *Journal of Experimental Child Psychology* 50: 429–444.

Demont, E. & Gombert, J.E. (1996). Phonological awareness as a predictor of recoding skills and syntactic awareness as a predictor of comprehensive skills, *British Journal of Educational Psychology* 66: 315–332.

Ehri, L.C. (1995). Phases of development in learning to read words by sight. Special issue: The contribution of psychological research, *Journal of Research in Reading* 18: 116–125.

Ehri, L.C. & Wilce, L.S. (1983). Development of word identification speed in skilled and less skilled beginning readers, *Journal of Educational Psychology* 75: 3–18.

Elbro, C., Nielsen, I. & Petersen, D.K. (1994). Dyslexia in adults: Evidence for deficits in non-word reading and in the phonological representations of lexical items, *Annals of Dyslexia* 44: 205–226.

Fowler, A.E. (1991). How early phonological development might set the stage for phoneme awareness. In: S. Brady & D. Shankweiler (eds.), *Phonological processes in literacy. A tribute to Isabelle Y. Liberman* (pp. 97–118). Hillsdale, NJ: Erlbaum.

Frith, U., Wimmer, H. & Landerl, K. (1998). Differences in phonological recoding in German- and English-speaking children, *Scientific Studies of Reading* 2: 31–54.

Foorman, B.R., Francis, D.J., Fletcher, J.M., Schatschneider, C. & Mehta, P. (1998). The role of instruction in learning to read: Preventing reading failure in at-risk children, *Journal of Educational Psychology* 90: 37–55.

Gough, P.B. & Tunmer, W.E. (1986). Decoding, reading and reading disability, *Remedial and Special Education* 7: 6–10.

Jorm, A.F. & Share, D.L. (1983). Phonological recoding and reading acquisition, *Applied Psycholinguistics* 4: 103–147.

Juel, C. (1988). Learning to read and write: A longitudinal study of 54 children from first through fourth grades, *Journal of Educational Psychology* 80: 437–447.

Juel, C., Griffith, P.L. & Gough, P.B. (1986). Acquisition of literacy: A longitudinal study of children in first and second grade, *Journal of Educational Psychology* 78: 243–255.

Kohnstamm, G.A., Schaerlaekens, A.M., de Vries, A.K., Akkerhuis, G.W. & Froonincksx, M. (1981). *Nieuwe streeflijst woordenschat voor 6-jarigen* (*New word vocabulary list for six year olds*). Lisse: Swets & Zeitlinger.

Laberge, D. & Samuels, S.J. (1974). Toward a theory of automatic information processing in reading, *Cognitive Psychology* 6: 293–323.

Lewkowicz, N.K. (1980). Phonemic awareness training: What to teach and how to teach it, *Journal of Educational Psychology* 72: 686–700.

Lovett, M.W., Warren-Chaplin, P.M., Ransby, M.J. & Borden, S.L. (1990). Training the word recognitions skills of reading disabled children: Treatment and transfer effects, *Journal of Educational Psychology* 82: 769–780.

Lovett, M.W., Borden, S.L., DeLuca, T., Lacerenza, L., Benson, N.J. & Brackstone, D. (1994). Treating the core deficits of dyslexia: Evidence of transfer of learning after phonologically- and strategy-based reading programs, *Developmental Psychology* 301: 805–822.

Morais, J., Cary, L., Alegria, J. & Bertelson, P. (1979). Does awareness of speech as a sequence of phones arise spontaneously? *Cognition* 7: 323–331.

Neter, J., Wasserman, W. & Kutner, M.H. (1990). *Applied linear statistical models*. Boston, MA: Irwin.

Norusis, M.J. (1993). *SPSS for Windows base system user's guide release 6.0*. USA: SPSS Inc.

Olson, R.K., Wise, B., Ring, J. & Johnson, M. (1997). Computer-based remedial training in phoneme awareness and phonological decoding: Effects on the posttraining development of word recognition, *Scientific Studies of Reading* 1: 235–253.

Perfetti, C.A. (1985). *Reading ability*. New York: Oxford University Press.

Perfetti, C.A., Beck, I., Bell, L. & Hughes, C. (1987). Phonemic knowledge and learning to read are reciprocal: A longitudinal study of first grade children, *Merrill-Palmer Quarterly* 33: 283–319.

Rack, J.P., Snowling, M.J. & Olson, R.K. (1992). The nonword reading deficit in developmental dyslexia: A review, *Reading Research Quarterly* 27: 29–53.

Reitsma, P. (1990). The acquisition of orthographic knowledge. In: P. Reitsma & L. Verhoeven (eds.), *Acquisition of reading in Dutch* (pp. 43–63). Dordrecht: Foris Publications.

Reitsma, P. (1997). How to get friends in beginning reading. In: C.K. Leong & R.M. Joshi (eds.), *Cross-language studies of learning to read and spell: Phonological and orthographic processing* (pp. 213–233). Dordrecht: Kluwer.

Reitsma, P. & Verhoeven, L. (1990). *Acquisition of reading in Dutch*. Dordrecht: Foris Publications.

Share, D.L. (1995). Phonological recoding and self-teaching: Sine qua non of reading acquisition, *Cognition* 55: 151–218.

Stage, S.A. & Wagner, R.K. (1992). Development of young children's phonological and orthographic knowledge as revealed by their spellings, *Developmental Psychology* 28: 287–296.

Stanovich, K.E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy, *Reading Research Quarterly* 21: 360–407.

Struiksma, A.J.C., Van der Leij, A. & Vieijra, J.P.M. (1991). *Diagnostiek van technisch lezen en aanvankelijk spellen* (*Diagnostics of reading and beginning spelling*). Amsterdam: VU Uitgeverij.

Torgesen, J.K. & Morgan, S. (1990). Phonological synthesis tasks: A developmental, functional, and componential analysis. In: H. Lee Swanson & B.K. Keogh (eds.), *Learning disabilities: Theoretical and research issues* (pp. 263–276). Hillsdale, NJ: Erlbaum.

Torgesen, J.K., Morgan, S.T. & Davis, C. (1992). Effects of two types of phonological awareness training on word learning in kindergarten children, *Journal of Educational Psychology* 84: 364–370.

Torgesen, J.K., Wagner, R.K. & Rashotte, C.A. (1997). Prevention and remediation of severe reading disabilities: Keeping the end in mind, *Scientific Studies of Reading* 1: 217–234.

Treiman, R. (1984). On the status of final consonant clusters in English syllables, *Journal of Verbal Learning and Verbal Behavior* 23: 343–356.

Vellutino, F.R. & Scanlon, D.M. (1987). Phonological coding, phonological awareness, and reading ability: Evidence from a longitudinal and experimental study, *Merrill-Palmer Quarterly* 33: 321–363.

Wagner, R.K. & Torgesen, J.K. (1987). The nature of phonological processing and its causal role in acqusition of reading skills, *Psychological Bulletin* 101: 192–212.

Walsh, D.J., Price, G.G. & Gillingham, M.G. (1988). The critical but transitory importance of letter naming, *Reading Research Quarterly* 23: 108–122.

Williams, J.P. (1980). Teaching decoding with an emphasis on phoneme analysis and phoneme blending, *Journal of Educational Psychology* 72: 1–15.

Wimmer, H. & Goswami, U. (1994). The influence of orthographic consistency on reading development: Word recognition in English and German children, *Cognition* 51: 91–103.

Address for correspondence: R. Wesseling or P. Reitsma, PI Research, P.O. Box 366, 1115 ZH Duivendrecht, The Netherlands

Phone: +31 20 690-2777; Fax: +31 20 690-5327; E-mail: RFJQ.Wesseling@psy.vu.nl *or* P.Reitsma@psy.vu.nl