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Deficits in phoneme segmentation are not the core problem of dyslexia: Evidence from German and English children

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ABSTRACT
A widely held assumption about dyslexia is that difficulties in accessing the constituent phonemes of the speech stream are responsible for specific reading and spelling difficulties. In consistent orthographies, however, the acquisition of accurate phonological recoding and phonemic awareness was found to pose much less difficulty than in English, and even dyslexic children were found to exhibit high levels of performance in phonemic segmentation (Wimmer, 1993). Nevertheless, using a rather complex phonological awareness and manipulation task (spoonerisms: MAN–HAT → HAN–MAT), Landerl, Wimmer, and Frith (1997) found support for the original position on phonological awareness deficit, as both German and English dyslexic children showed poor performance. In the present studies, the spoonerism responses of Landerl et al. were reanalyzed such that children were given credit for partially correct responses (e.g., a response of HAN for MAN–HAT). Such partially correct responses were taken to indicate full segmentation of both stimulus words at the onset–rime level. The effect of this rescoring was that the error rate dropped from 76% to 26% for the English dyslexic children and from 63% to 15% for the German dyslexic children. Even higher performance levels, although not perfect as for the age-matched control children, were found on a nonword spelling task in both groups. A second study examined the segmentation of consonant clusters in younger German dyslexic children and found performance levels of about 90% correct when memory problems were ruled out. We argue that, at least in the context of a consistent orthography (and a phonics-based teaching approach), deficits in phoneme awareness are only evident in the early stages of reading acquisition, whereas rapid naming and phonological memory deficits are more persistent in dyslexic children.

The field of dyslexia research is dominated by the phonological deficit explanation, which Stanovich (1994) summarized quite succinctly:

> most cases of reading disability arise because of difficulties in the process of word recognition. These difficulties are, in turn, due to deficiencies in processes of phonological coding whereby letter patterns are transformed into phonological codes. The precursor to the phonological coding difficulty appears to be a deficit

> in segmental language skills sometimes termed phonological awareness or phonological sensitivity. (p. 585)

The terms “phonological awareness” or “phonological sensitivity” here cover the various phonological segments (syllable, onset–rime, phoneme) and the plethora of manipulations (from phoneme counting to pig latin) that have been used in studies of phonological awareness deficits in dyslexic children.

However, in the original formulation of the phonological deficit explanation of dyslexia by the Haskins group in the 1970s (Shankweiler & Liberman, 1976), there is a particular segmental level of language – the phoneme level – that is of critical importance for learning to read an alphabetic orthography and that poses particular difficulties for conscious access. It does so because of a basic characteristic of human language (i.e., the coarticulation of word-distinguishing phonemes into syllables and words), which allows the fluency of speech production. It is the biological specialization for language that allows this coarticulation and the corresponding perceptual ability to recover the phonemes embedded in coarticulation. In the words of Liberman and Liberman (1992), “the speech specialisation causes a word like ‘bag’ to be coarticulated in a single, seamless piece of sound. . . . given the automaticity of that specialisation, the constituent phonemes do not ordinarily rise to the level of awareness” (p. 351). However, acquiring the ability to bring the phonemes to consciousness is a critical step in learning to read. It is a step that goes against the natural inclination of the biological language faculty, leading to the implication that “reading is hard just because listening is easy” (Liberman, 1989, p. 197). That young children, indeed, have little inclination to map letters onto phonemes and infer the alphabetic principle was elegantly demonstrated by Byrne (1998). In stage models of reading acquisition, insight into the alphabetic principle is seen as the major early achievement and as the major stumbling block of the dyslexic child (Frith, 1985; Seymour, 1986).

Given the theoretical importance of the phoneme level of speech within the phonological perspective on learning to read and on dyslexia, one would expect that the bulk of the evidence would be concerned with the phonemic awareness deficits of dyslexic children and adults. In their recent review, Share and Stanovich (1995) concluded from the existing evidence that “it is indisputable that poor readers display large deficits on a variety of different tasks that require the complete segmentation of a word or nonword into phoneme units” (p. 10). However, a closer inspection of the studies cited by Share and Stanovich shows that only a few of them used well-defined samples of dyslexic children and assessed phonemic awareness in a straightforward fashion. By “straightforward” we mean that few extra task complexities were involved in the assessment of phonemic awareness. That these extra complexities are of critical importance can be illustrated by the findings of Bruck and Treiman (1990). Among the various tasks used in that study, there was a phoneme identification task in which children were asked whether a CCV nonword began with a prespecified phoneme. In a corresponding phoneme deletion task, children had to delete the first sound from CCV nonwords. The 10-year-old dyslexic children performed at ceiling on the identification task but close to zero on the deletion task. Obviously, the phonemic awareness deficit of the dyslexic children was more apparent in the deletion task than in the phoneme identification task. The interpretive problem is that the identification task is a much more straightforward assessment of phonemic awareness. For correct identification, the child has to isolate and determine the identity of the initial phoneme of the cluster of a CCV nonword. Additional demands are involved in the deletion task. The main problem seems to be that the child has to program a response that begins with the second phoneme of the initial cluster. Therefore, the implication is that dyslexic children have little difficulty with phoneme awareness per se but suffer more from the additional demands of the deletion task.

Another limitation of the evidence for a phonemic awareness deficit in dyslexia is the fact that most of the studies have been done with English-speaking children or adults (e.g., Bowey, Cain, & Ryan, 1992; Bradley & Bryant, 1978; Bruck, 1992; Bruck & Treiman, 1990; Manis, Seidenberg, Doi, McBride-Chang, & Petersen, 1996; Pennington, van Orden, Smith, Green, & Haith, 1990; Perin, 1983). One may reason that the many inconsistent grapheme–phoneme relations of English, together with a meaning-based teaching approach, make the acquisition of phoneme awareness skills especially hard. Less difficulty is expected when an orthography exhibits consistent grapheme–phoneme relations and when the teaching approach explicitly introduces such relations (not letter names) and word recognition via phoneme blending. These advantageous circumstances were available to a group of German dyslexic children studied by Wimmer (1993). These children exhibited a very serious reading fluency impairment but showed high reading accuracy, even for nonwords. Most important, in the present context, they showed high performance on a vowel substitution task and on a nonword spelling task. In the vowel substitution task, children had to replace the vowels of a word with an /i/ (e.g., MAMA → MIMI); the nonword spelling task required full phonemic segmentation of a new phonological form. The dyslexic fourth graders with more than two years' delay in reading fluency scored close to ceiling on both the vowel substitution and nonword spelling tasks. This finding speaks against the possibility of a phonemic awareness deficit in dyslexic children. Wimmer (1993) interpreted the high phonemic awareness of his German dyslexic children as resulting from the combination of a transparent orthography and a synthetic phonics teaching approach.

However, when Landerl, Wimmer, and Frith (1997), in a direct comparison of English and German dyslexic children, used a spoonerism task (FISH–BOAT → BISH–FOAT) to assess phonological awareness, the German dyslexic children showed low performance levels similar to those of the English dyslexic children, with only about 40% correct – a performance level below that of a younger, reading-level control group. This finding appears to be inconsistent with Wimmer's (1993) argument that learning to read a regular orthography by a phonics teaching approach leads to phonemic awareness even among dyslexic children.

The equally poor performance by the German and English dyslexic children studied by Landerl et al. (1997) on the spoonerism task was all the more surprising as the German dyslexic children exhibited much better phonological recoding abilities than their English counterparts. Given that the German dyslexic samples tested by Wimmer (1993) and by Landerl et al. were quite comparable, there is reason to believe that the vastly different phonemic awareness performance levels found in the two studies reflect different task demands. One argument would be that the more demanding spoonerism task revealed phonemic awareness deficits that were masked by the easier vowel substitution and nonword spelling tasks. In fact, this was the reasoning behind the choice of the spoonerism task by Landerl et al. However, the interpretive problem is similar to the one posed by the discrepant findings of Bruck and Treiman (1990): the nonword spelling task used by Wimmer (1993) is a more direct assessment of phonemic awareness than the spoonerism task used by Landerl et al.

In fact, an analysis of the spoonerism task in terms of the segmental levels involved leads to an expectation contrary to the findings; this task only requires segmentation at the level of onset and rime and not at the level of individual phonemes, as is the case in the nonword spelling task. However, with respect to extra task demands, the spoonerism task appears much more complex than either the vowel substitution or the nonword spelling task. Let us take as an example the item FISH and BOAT. In performing the task, the child first has to segment the two stimulus words into onsets and rimes: that is, /f/–/iʃ/ and /b/–/out/. The child may then proceed by computing one response word by blending /b/ with /iʃ/, resulting in /biʃ/. This intermediate result has to be stored while the remaining segments /f/ and /out/ are blended. If the first response word is still accessible, then the child is able to produce the correct output BISH and FOAT. The task requires blending skills as well as segmentation skills. The main problem appears to be that a maximum of four segments must be kept in working memory, and that close monitoring of the required phonological manipulation is necessary to determine which segments have been blended and which still have to be assembled. Quite likely, it may be these complex demands on phonological working memory and monitoring skills rather than the onset–rime segmentation requirements that cause the poor performance of the dyslexic children.

In an attempt to reconcile the inconsistent findings of Wimmer (1993) and Landerl et al. (1997) on the phonemic awareness deficit of German dyslexic children, we carried out a reanalysis of the spoonerism responses observed by Landerl et al. Based on the task analysis presented here, we tried to distinguish between segmentation difficulties and the additional difficulties resulting from memory and control problems. Our strategy was to credit the child with segmental ability even if the response was not fully correct. Note that a correct response to a spoonerism item always has to consist of two response words: for example, the fully correct response for FISH and BOAT is BISH and FOAT. Landerl et al.'s original scoring was based on such fully correct responses. This strict scoring scheme was adopted from Perin (1983), who was the first to show a dyslexic deficit on a spoonerism task. However, a typical error expected from the multistage nature of the task is that a child will produce one correct response word but will fail on the second one. For example, instead of responding to FISH and BOAT with BISH and FOAT, a child may respond with BISH and FISH, BISH and BOAT, or simply BISH (or FOAT). The point is that the single correct response word BISH indicates that both of the stimulus words have been segmented at the onset–rime level: the child has isolated the /b/ in B-OAT and the /iʃ/ in F-ISH to come up with BISH. Therefore, in the present reanalysis we counted an item as correct if a single response word was correct.

Another response type allowing a similar interpretation occurred for items such as BALL and GREEN, where one stimulus word contained a consonant cluster onset (this was the case in half of the items). For such cluster onsets, the children were carefully prepared; nevertheless, responses such as GALL and BREEN instead of GRALL and BEEN did occur. This response resulted from exchanging the first phoneme of the cluster instead of exchanging the whole cluster. Such responses were counted as incorrect by Landerl et al. (1997) because the child failed to distinguish between onset and rime, which was required by the instruction and which is the segmental basis for the naturally occurring spooner-type speech errors. However, another perspective on these errors is that the child performed a phonological process that was more demanding than the one required by breaking up the consonant clusters into single consonants. It is possible that this type of response is triggered by a spelling-based strategy: that is, the child exchanged the first letters of the two-word spellings. Nevertheless, this graphemic exchange has to be duplicated on the phonemic level as well. Based on this reasoning, we decided here to count such initial phoneme exchanges as correct. Furthermore, we applied the same criterion and counted a cluster item as correct if only one response exhibited the initial phoneme exchange (e.g., for BALL and GREEN, a child responded only with GALL).

The rescored performance of the spoonerism task was contrasted with performance on a nonword spelling task. Performance on the spelling task is of particular interest in the present context as the demands on working memory and monitoring skills are greatly reduced in this task: the child has on paper what is already transcribed and so can easily check what still has to be done. Because of space limitations, the results of the spelling task had to be deleted from Landerl et al. (1997), which focused on comparing the reading difficulties of German and English dyslexic children. The nonwords used by Landerl et al. were derived from one-, two-, and three-syllable words that were similar in English and German, such as *ball–Ball* or *summer–Sommer*. By this method it was ensured that the nonwords presented to the English and German dyslexic children would also be very similar: for example, *grall–grall* or *dummer–dommer*. Apart from increasing length, the nonwords posed no particular segmentation difficulties as only a few nonwords included consonant clusters. To evaluate the performance of the English and German dyslexic children on the spoonerism and the nonword spelling tasks, we used the reading-level and age-level control groups for each language used in Landerl et al.

STUDY 1

Participants

The participants in the present study were the same children who participated in Landerl et al.'s (1997) study. Details of subject selection may be found in that article. Sample characteristics, together with reading and spelling levels and nonverbal intelligence, are displayed in Table 1.

Table 1. *Mean age, reading level, spelling level, and nonverbal intelligence of English and German dyslexics, reading age (RA) controls, and chronological age (CA) controls (ranges in parentheses)*

	N (% boys)	Age	Reading level (Percentile)[a]	Spelling level (Percentile)[b]	Nonverbal IQ
English					
Dyslexics	17 (83)	12;3 (10;9–13;11)	8 (2–19)	8 (2–22)	103 (91–121)
RA controls	21 (57)	8;3 (7;4–9;1)	8 (2–19) (50 [33–64])[d]	—	106 (97–130)
CA controls	19 (58)	12;7 (11;6–14;0)	66 (33–97)	48 (16–96)	106 (91–124)
German					
Dyslexics	18 (78)	11;7 (10;7–12;7)	12 (1–41)	3 (0–13)	103 (85–145)
RA controls	18 (56)	8;8 (7;4–9;5)	17 (1–75) (56 [23–90])[d]	—	107 (99–132)
CA controls	18 (56)	11;7 (10;4–13;2)	87 (50–99)[c]	46 (2–99)	100 (91–145)

[a]English: BAS Word Reading Test; German: Salzburger Lese- und Rechtschreibtest.
[b]English: BAS Spelling Scale; German: DRT 4-5.
[c]The reading level of the German CA control group seems to be quite high. However, this is an artifact because the test we had to use is only standardized up to grade 4, whereas the subjects of the present study attended grades 5 or 6. The average spelling level of this group in fact suggests that their literacy development was normal.
[d]For the RA controls, two mean percentile scores are presented. The first score is based on the grade 4 norm sample with which the dyslexic sample was compared. This score shows that the RA controls' reading level is similar to that of the corresponding dyslexic sample. The second score presents the mean percentile in comparison to the norm group of the same age. This score shows that the RA controls were normally developing readers.

English dyslexic children's reading abilities were assessed using the British Ability Scales Word Reading Test (Elliot, Murray, & Pearson, 1983), a graded word reading test. As can be seen in Table 1, the word recognition abilities of all the English dyslexic children were below the 19th percentile, compared with normal readers of the same age. Their mean reading age was 8;3 years (range = 7;3–10;9). On average their reading abilities were about four years below their chronological age. Table 1 shows that the dyslexic children's spelling abilities, as assessed by British Ability Scales Spelling Scale (Elliot, 1992), were even poorer than their reading skills, corresponding to a mean percentile rank of 8.

The German[1] dyslexic children's current reading abilities at 11 to 12 years were assessed using the Salzburger Lese- und Rechtschreibtest (Landerl, Wimmer, & Moser, 1997), a standardized word reading test. Although this test is only standardized up to grade 4 (the children of the present study were in grades 5 and 6), it was more appropriate for the present purpose; all available German reading tests for children older than 10 years are tests of reading comprehension. As older German dyslexic children did not produce many reading errors, the main diagnostic criterion was reading speed. As Table 1 shows, the mean reading speed of the present group of dyslexics corresponded to a mean percentile of 12, compared with a slightly younger grade 4 norm sample. Reading speed was measured both for a short text and a list of complex compound words (e.g., *Obststand, Krankenschwester*). As a group, the German dyslexic children's reading speed was low-average, compared with 8- to 9-year-old children. Thus, their reading development was delayed by about three to four years. Table 1 shows that the German dyslexic children generally had very poor spelling abilities, corresponding to a mean percentile rank of 3 on the standardized spelling test (DRT 4-5; Seyfried, Klauser, & Weyermüller, 1987).

Children's nonverbal intelligence, as assessed by Raven's Standard Progressive Matrices (Raven, 1987), was average for both the English and German children. Their socioeconomic background was predominantly middle class.

Two control groups were assigned to each of the two dyslexia groups. The CA controls were matched for chronological age. Table 1 shows that their reading and spelling development was age equivalent. The RA controls were matched for reading level as well as spelling level. Both the English and the German RA control groups were three or four years younger than the corresponding dyslexic children. For the RA controls, Table 1 presents two mean percentile scores for spelling and reading. The first score compares the control children's scores with the same norm sample with which the dyslexic children were compared (i.e., 10- to 12-year-old children). This score shows that the English RA controls had a spelling level age equivalent and similar to that of the English dyslexic children. This analysis was facilitated by the British Ability Scales Spelling Scale (Elliot, 1992) – a graded word spelling test conducted with children between the ages of 5 and 15 years. The German spelling test, on the other hand, was specifically designed for children in grades 4 and 5. It was not possible to conduct the complete test with the 8-year-olds since it would require them to spell 65 rather difficult words. To determine RA controls' spelling level, they were asked to spell every third word of the spelling test. On average, they spelled 6.4 of the 22 words correctly ($SD = 3.4$). Their performance was not significantly different from that of the German dyslexic children, who spelled 8.5 words ($SD = 3.4$) of this subset correctly, $t(34) = 1.58$, $p > .05$.

Tasks

Spoonerisms. Presented with 10 word pairs, the children were asked to exchange the consonantal onsets of these word pairs (e.g., BOAT–FISH → FOAT–BISH). In five word pairs, both words had only one consonant in the onset (e.g., SHIP–CAT → KIP–SHAT); in the other five word pairs, one of the two words started with a consonant cluster (e.g., BLUE–RED → RUE–BLED). Only words that were similar in English and German languages were used: that is, the words were similar in pronunciation and spelling and identical in meaning (e.g., English, GOLD–SILVER; German, GOLD–SILBER). All items are listed in Appendix 1. To reduce the memory load, the participants were shown a booklet with two pictures on each page depicting the word pairs. The experimenter named the two pictures and asked the child to "exchange the word beginnings of these two words." Children were told that it was not the first letter that had to be exchanged. Five practice examples were administered to clarify the meaning of "word beginning." The first practice example (MAN–HAT → HAN–MAT) was demonstrated by the experimenter, and the child was asked to repeat it. The second practice item also consisted of two words with single consonant onset (HEN–BUS → BEN–HUS). The child was asked to try to exchange the onsets and was given help if necessary. Next, two practice items with a consonant cluster in one of the two onsets followed (BROWN–FOX and HAIR–GLASS). The child was told that now the word beginning was not equivalent to the first letter in a word. The first cluster trial was modeled by the experimenter. The child was asked to repeat it and was given corrective feedback if necessary. For the second cluster example, the child was asked to give it a try and was given help if necessary. If the child attempted to exchange the first sound or letter, he or she was once again reminded to exchange the word beginnings and not the first letters.

Nonword spelling. The children were asked to spell 24 nonwords of one-, two-, and three-syllables in length. The nonwords used for this task comprise a subset of the 192 items of the single word/nonword reading task described in Landerl et al. (1997). All nonwords were derived from existing words. The words from which the nonwords were derived were very similar in English and German in terms of spelling and pronunciation, and they were identical in meaning (e.g., *boat–Boot, motor–Motor, quality–Qualität*). The one- and two-syllable nonwords were derived from the words by exchanging the consonantal onsets. For example, the English nonword *hoat* was derived from *hand* and *boat*, and the German nonword *Hoot* was derived from *Hand* and *Boot*. For the three-syllable nonwords, the syllables of the words were rearranged. For example, the English nonword *ralective* was constructed by combining the first syllable of *radio,* the second syllable of *electric,* and the third syllable of *positive*. The German equivalent of this nonword was *Ralektiv*. By this means of item construction it was ensured that the nonwords would be similar in the two orthographies and that they would conform to the phono- and graphotactic rules of each language. To reduce the risk that any effects were based on a specific set of items, two item sets were compiled. Each of the two sets was conducted with half of the children in each group.[2] The nonword items are given in Appendix 2. An inspection of the mean scores showed that there were no remarkable differences between the two item sets. This factor was ignored in further statistical analysis.

Any graphemic transcription of a phoneme that exists in a real word, irrespective of position and graphemic context, was accepted. For example, the English nonword pronunciation /ri:m/ could be spelled as *reem, ream, reme,* or *rem*. Although German is highly consistent in the direction from grapheme to phoneme, there is a certain amount of inconsistency in the direction from phoneme to grapheme: that is, there is usually more than one possible graphemic translation for a certain phoneme. For example, for the nonword /brukə/, three different spellings (*Brucker, Brucka, Bruker*) were counted as correct. For the phonemic correctness of the spelling, it was irrelevant whether the first letter was capitalized. The variability of correct spellings was still higher for the English children

Table 2. *Percentage of errors on the spoonerism task and phoneme distance scores for nonword spelling for English and German dyslexic children and RA and CA control groups*

	English			German		
	M	*Mdn*	*SD*	*M*	*Mdn*	*SD*
Spoonerisms (% errors)						
Dyslexic children	26	10	27	15	10	19
RA control group	21	10	27	7	0	15
CA control group	4	0	5	4	0	6
Nonword spelling: Phoneme distance score						
Dyslexic children						
One and two syllables	3.2	2.0	3.6	0.9	0.0	1.2
Three syllables	10.3	10.0	5.7	2.2	2.0	2.0
RA control group						
One and two syllables	2.9	2.0	2.0	0.6	0.0	0.8
Three syllables	6.6	5.5	4.5	2.3	2.0	2.4
CA control group						
One and two syllables	0.7	0.0	1.0	0.1	0.0	3.2
Three syllables	1.1	1.0	1.5	1.1	0.0	1.5

than for the German children. On average, German dyslexic children provided 2.6 different correct spellings for a particular nonword, whereas English children produced 3.3 different correct spellings.

Results

Spoonerism task. Table 2 shows central tendency measures resulting from the modified scoring of the spoonerism performance of the English and German dyslexic children and their corresponding control groups.

The first observation concerns the low error levels given by the modified scoring described earlier. In contrast to the original scoring reported by Landerl et al. (1997), which produced error means of 73% and 63% for the English and German dyslexic children, the new error means were reduced to 26% and 15%. As evident from the low error medians and the high standard deviations, the means in Table 2 are distorted by a few dyslexic children with high error scores. Because of these distributions we used nonparametric Mann–Whitney U-tests for comparing groups. The slightly worse performance of the English dyslexic children was not reliably different from that of the German dyslexic children ($U = 120$, $z = -1.1$, $p > .20$). The English dyslexic children scored very similar to the RA controls ($U = 143$, $z = -.8$, $p > .30$) but differed from the CA controls ($U = 64.5$, $z = -3.3$, $p = .001$), whose performance was close to errorless. The German dyslexic children committed slightly more errors than the RA controls, but not reliably so ($U = 107$, $z = -1.6$, $p > .10$). As with the English dyslexic children, they differed from the CA controls ($U = 111.0$, $z = -1.96$, $p = .05$).

For about 40% of the items, both dyslexic groups produced only one response word correctly but not the other. These items were counted incorrect in the original scoring but correct in the present modified system. The other change in scoring was that we counted an answer correct when, instead of the cluster onset, only the first phoneme of the cluster was exchanged. Overall, this had comparatively little effect, as it could only affect the scoring of half of the items. Nevertheless, for the German dyslexic children, about 20% of the cluster items were affected by this rescoring, compared with about 10% for the English dyslexic children.

Nonword spelling. For a fine-grained evaluation of children's phonemic spelling accuracy we used the phoneme distance score of Bishop (1985). Instead of simply counting the number of phonemically acceptable spellings, the distance score evaluates how much a spelling deviates by counting the number of inadequate graphemic translations, deletions, or incorrect additions for each spelling. For example, the spelling of /idasment/ as "eduent" resulted in a distance score of 2, because the phonemes /s/ and /m/ were not transcribed. All graphemes that represent a certain phoneme in English spellings were accepted, irrespective of position and graphemic context. For example, *bruger* or *brugar* were acceptable spellings for the English nonword /brugə/). The distance scores were added for the eight nonwords of each item length. Preliminary analyses showed very few deviations from the phonemically acceptable spellings for either the one- or two-syllable nonwords. Therefore, the distance scores for the two sets of nonwords were added and contrasted with the distance scores for the three-syllable nonwords, which led to higher error rates (see the lower section of Table 2). For the interpretation of the central tendency measures, one has to consider that, for the short nonwords (16 items with between 3 and 6 phonemes), a total of 70 phonemes would have to be correctly transcribed; for the long nonwords, 60 phonemes would have to be transcribed adequately (8 nonwords with between 5 and 10 phonemes). These are the maximum distance scores (70 and 60 for the short and the long nonwords, respectively) that would result if a child's spelling of all the short or long nonwords were completely different from the phonemically acceptable transcriptions or if a child refused to spell the nonwords.

Table 2 shows very low phoneme distance scores for both the English and the German dyslexic children for the short nonwords. In fact, 10 of the 18 German dyslexic children had an errorless spelling performance, and the highest error score was 4. Only 2 of the 17 English dyslexic children made an errorless performance, and only 3 had a phoneme distance score higher than 4. The small difference was nevertheless reliable ($U = 71$, $z = -2.8$, $p = .005$). It should be remembered that a distance score of 4 could result, for example, if a child deleted a single phoneme in 4 of the 16 nonwords. Therefore, in absolute terms, even the highest distance scores indicate good phonemic spelling performance. An interesting observation is that only a minority (i.e., 28%) of the acceptable spellings of the short nonwords were analogous to the words (e.g., *fand* and *hand*) from which the nonwords were derived by exchanging the onsets. Examples for the more frequent nonanalogous spellings are "dren" for *dreen,* derived from *green;* "boffe" for *boffee,* derived from *coffee;* and "Billck" for *bilk,* derived from *milk*.

Table 2 also shows that for the long nonwords the phonemic spelling performance of the English dyslexic children deteriorated, whereas the spelling performance of the German dyslexic children remained high, $t(33) = 5.6$, $p = .03$. However, even the mean distance score of about 10 for the English dyslexic children implies that on average only slightly more than one phoneme per item was incorrectly transcribed or deleted. Interestingly, the spelling errors of the English children for the long nonwords came mainly from the concatenation of two consonants at syllable boundaries: for example, /idasment/ spelled as "eduent."

As evident from Table 2, the English dyslexic children were very similar to the RA controls in their combined phoneme distance score (short plus long nonwords) ($U = 117$, $z = -1.6$, $p > .1$), but they differed from the CA controls, who were close to errorless ($U = 8.5$, $z = -4.9$, $p < .001$).

In summary, the overall quite high phonemic spelling performance of both the English and German dyslexic children corresponds to the high performance levels implied by the rescoring of the spoonerism responses. However, the good spoonerism performance does not contradict the postulated difficulties of dyslexic children with the phoneme level of speech, as the spoonerism task requires only segmentation at the onset–rime level and not at the phoneme level. A similar argument applies, in principle, to the good phonemic spelling performance of the dyslexic children on the short word-analogous nonwords where, for example, the spelling "bilk" may have resulted from noticing the analogy to *milk*. However, as noted, the majority of the nonword spellings gave little indication for analogies (e.g., "Billck" instead of *bilk*). Nevertheless, it seemed important to examine the phoneme awareness deficit hypothesis more directly. This was the goal of Study 2, which used another sample of German dyslexic children. In this study, we focused on the segmentation of consonant clusters into phonemes and used nonwords with little similarity to existing words. All nonwords consisted of two syllables with a cluster at the beginning of the first syllable and a cluster at the end of the second syllable: that is, the structure was always CC(C)VCVCC(C), such as /ˈgluwisp/ and /ˈflamont/. In the oral version of the task, children had to name the phonemes of the words, and in the spelling version, they had to write down the nonwords. The spelling version was intended to minimize memory and control problems. Another difference from Study 1 was that we decided to test younger (i.e., 9-year-old) dyslexic children on the grounds that, to some extent, difficulties with access to the phoneme level of speech may be diminished in older dyslexic children.

STUDY 2

Participants

A total of 13 poor readers (11 boys, 2 girls) and 23 normal readers (13 boys, 10 girls) participated in Study 2. All of the children were native speakers of German and were in grade 3. The groups were selected on basis of a class reading test developed in our lab to assess children's reading fluency. For this task, children silently read short sentences as quickly as possible and judged their semantic correctness. Besides each sentence a checkmark and a cross were printed. Semantically correct sentences were marked by circling the checkmark; for incorrect sentences, the cross was circled. Care was taken that the presented sentences posed low comprehension demands. The raw score was the number of correct responses that could be given within the working time of 10 minutes. The task was standardized on a sample of 364 third graders. The 13 poor readers selected for the present study all performed below the 10th percentile, with a mean percentile rank of 5.1 ($SD = 3.0$); the 23 normal readers performed on average at the 50th percentile ($SD = 9.7$). The performance of the poor readers of the classroom reading test mainly reflected a reading speed problem, as few incorrect semantic judgments were observed: that is, 8% for the poor readers and 3% for the normal readers. Nonverbal IQ, as assessed by Raven's Coloured Progressive Matrices (German norms: Schmidtke, Schaller, & Becker, 1978), was 113 ($SD = 9$) for the poor readers and 118 ($SD = 9$) for the normal readers. The mean age was 9;2 years ($SD = 0;4$) for the poor readers and 9;4 years ($SD = 0;4$) for the normal readers.

Tasks

Phoneme segmentation. In the oral version of the task, the children were presented with 9 nonwords of the structure already mentioned and were asked to segment these nonwords into their constituent sounds. First, the experimenter demonstrated the required segmentation process for the practice item /pfank/; the child was then asked to segment three practice items: /′ʃpekonst/, /′tramunχ/, /′ʃofrit/. The experimenter instructed the child to name the sounds but not the letter names and gave a reminder whenever the child responded with letter names. However, responding with letter names was not counted as a segmentation error. To make sure that the child perceived the items correctly, he or she was asked to repeat each nonword before segmenting it into phonemes.

Nonword spelling. The spelling version of the task was analogous to the oral version in all respects. The 9 items of the nonword spelling task were almost identical to the items in the oral version; only the vowels and the order of the items were different. The child was asked to repeat the nonword presented by the experimenter before writing it down.

The order of the tasks (oral segmentation before spelling, and vice versa) was counterbalanced. The two tasks were part of a larger assessment battery on cognitive deficits that lasted about 1½ hours. The tasks never followed in immediate succession.

Results

Only errors in segmenting or spelling the onset and end clusters were evaluated. Errors concerning the vowels or the middle consonant were infrequent and were not considered for the present purpose. Table 3 presents the mean percentages

Table 3. *Mean percentages of correct responses for phoneme segmentation and nonword spelling*

	Phoneme segmentation		Nonword spelling	
	Onset clusters	End clusters	Onset clusters	End clusters
Dyslexic children	86.3 (24.9)	74.4 (24.6)	92.3 (13.9)	90.6 (16.3)
Control children	88.9 (15.7)	83.1 (15.3)	98.6 (3.8)	96.1 (7.2)

of correct responses for phoneme segmentation and nonword spelling separately for onset and for end clusters.

In a Task (phoneme segmentation vs. nonword spelling) × Condition (onset vs. end cluster) × Group (dyslexic vs. control) ANOVA, the main effect of group was not reliable, $F(1, 34) = 2.2$, $p > .1$. Table 3 shows that the performance of the control children was very high, and that the dyslexic children's performance was only slightly lower. Only in the end cluster condition of the phoneme segmentation task was the difference between the control and dyslexic children somewhat more marked; however, none of the interactions involving group reached significance. The only reliable effects were the main effects of task and condition and the interaction between these two factors, $F(1, 34) = 20.5$, $p < .001$, and $F(1, 34) = 6.5$ and 4.4, $p < .05$. From Table 3 it is evident that the phoneme segmentation task was more difficult than the nonword spelling task, that end clusters were more difficult than onset clusters, and that the difference between onset and end clusters was more marked in the phoneme segmentation task than in the nonword spelling task.

In summary, Study 2 extends the findings of Study 1 in several ways. First, the phoneme segmentation task used in Study 2 is a better test for children's access to the phoneme level than the spoonerism task of Study 1, which only requires access to the onset–rime level. Segmenting consonant clusters into their constituent phonemes, as required in Study 2, is generally assumed to be a highly demanding task. Second, in contrast to Study 1, the items were specifically selected not to be similar to existing words so that spelling by analogy was impossible. The results show convincingly that the German dyslexic children had close to perfect access to the phonemic level of speech. This finding is even more impressive, given that the participants of Study 2 were only 9 years old and therefore considerably younger than the participants of Study 1. Obviously, three years of experience with a consistent orthography is sufficient to induce access to the phoneme level even in dyslexic children.

Another interesting finding of Study 2 is that the experimental comparison of phoneme segmentation and nonword spelling of highly similar items (and, in fact, identical onset and end clusters) shows that the "pure" phoneme awareness task is generally more taxing than the nonword spelling task. Both tasks require precise segmentation at the phoneme level; however, the phoneme segmentation task appears to pose additional demands on memory. Interestingly, the dyslexic children tended to suffer more from these demands than the control children.

While their performance in nonword spelling was very good, their scores, especially in the end cluster condition of the segmentation task, were somewhat lower, with only about 75% correct responses. This observation strengthens our argument that in the spoonerism task in Study 1 the dyslexic children were able to fulfill the segmentation requirement but were handicapped by the additional demands on working memory.

GENERAL DISCUSSION

The main finding of Study 1 was that the change in scoring on the spoonerism task revealed good segmental performance by both the English and German dyslexic children, with only 26% and 15% errors compared to 73% and 63% errors in the original scoring reported by Landerl et al. (1997). The low error levels that resulted from the rescoring still indicated lower performance than that of CA controls, but the difference compared to the RA controls was not reliable. The main difference from the original scoring was that we counted a response as correct if one of the two required response words for an item was correct. This change in scoring was justified by the fact that the production of one correct response word was taken to indicate that both stimulus words had been segmented at the onset–rime level. The present result of a large change in performance with the lenient scoring supports the findings of Perin (1983), who tested 14-year-old English dyslexic children with a spoonerism task. Perin found a very high percentage of errors (about 70%) when the scoring required both response words to be correct, but she noted that, in a large percentage of responses, at least one of the two response words was correct. The conclusion from both studies is that the standard scoring of the spoonerism task significantly underestimates dyslexic children's competence with onset–rime segmentation. A large proportion of the erroneous responses is apparently due to the high memory and monitoring demands of the spoonerism task. One may reason that even the rescored spoonerism responses may underestimate dyslexic children's segmental abilities: producing even one response word correct involves more than simply segmenting the two stimulus words. A difficulty with blending or a memory failure may prevent a child from getting even one response word correct.

These doubts on the validity of the rescored spoonerism results for the assessment of segmental deficits are strengthened by the finding of close to perfect performance when the same children had to spell the shorter (one- and two-syllable) nonwords. For this set of nonwords almost 70 phonemes had to be transcribed, with the nonwords varying in length from 3 to 6 phonemes. The median number of deleted or erroneously transcribed phonemes was 2 for the English dyslexic children and 0 for the German dyslexic children.

The nonword spelling performance of the English dyslexic children in Study 1 deteriorated slighted for the long (three-syllable) nonwords but was still quite good in absolute terms. On average, only one or two phonemes of these complex phoneme sequences were transcribed inadequately. The German dyslexic children's nonword spelling skills were less affected by syllable length. The advantage of the German children for these long items may stem from the higher frequency of long complex words in German than in English (e.g., *gesprungen* 'jumped', *Haustürschlüssel* 'house key').

It should be noted that the one- and two-syllable nonwords included only few consonant clusters, which may have posed greater difficulties (Bruck & Treiman, 1990). Furthermore, the short nonwords in Study 1 allowed spelling by analogy, as these were derived from existing words. Both limitations were eliminated in Study 2, where we used nonword items that bore little similarity to existing words and included highly complex consonant clusters. Quite impressively, the comparably young German dyslexic participants of Study 2 had little difficulty in fulfilling the task demands. The present findings of good segmental performance by the German dyslexic children on phonological segmentation (spoonerisms and phoneme segmentation) and on nonword spelling in both studies correspond with the earlier finding of German dyslexic children's high segmental abilities in vowel substitution and nonword spelling tasks (Wimmer, 1993). It also corresponds with observations that the many orthographic misspellings produced by German dyslexic children are, with very few exceptions, phonetically acceptable (Wimmer, Mayringer, & Landerl, 1998). However, this good segmental performance has to be put into a developmental perspective. In a retrospective study of a small sample of children who, at the end of grade 4, were diagnosed as dyslexic, Wimmer (1996) looked at their difficulties with phonemic segmentation at an early phase of reading and writing acquisition in grade 1. On a nonword spelling task, enormous differences emerged. About a quarter of the older dyslexic children exhibited hardly any difficulties at all, whereas half of them were more or less unable to perform the task. Therefore, for a substantial number of German dyslexic children, phoneme segmentation and phoneme identification do pose a problem in the early phases of learning to read and to write. These early difficulties may be more transient than they are for English dyslexic children due to the benefits of a more transparent orthography and the synthetic phonics-based teaching and remediation approaches. At the end of grade 2, most German children who were diagnosed as reading or spelling impaired at that time were found to show little difficulty with nonword spelling, even when the nonwords contained consonant clusters (Wimmer, 1993; Wimmer & Landerl, 1997, Study 2). Thus, at least for German speakers, we find little evidence for Shankweiler's (1999) recent statement that "phonological awareness is largely absent in dyslexic children and adults, and nonword decoding skills are correspondingly weak" (p. 119).

What do the present findings imply for the phonological deficit explanation of dyslexia? It may be useful here to distinguish between different versions of the explanation. Clearly the present findings are critical for a version that sees the current reading and spelling difficulties of dyslexic children (who typically are beyond the first years in school) as being caused by a current deficit in accessing the phonemic level of speech. The German dyslexic children of Study 1 suffered from a delay in reading fluency of about four years and from an orthographic spelling problem; but, as was evident from their nonword spelling performance, they had hardly any difficulty in segmenting a new phonological form into phoneme size units and in identifying those as phonemes corresponding to graphemes. More or less the same is true for the English dyslexic children, as was evident from their very high performance in spelling the shorter nonwords. For the English children, this high phonemic spelling performance was even more surprising as their ability to read words and nonwords correctly was very poor, as shown in Landerl et al. (1997). Therefore, for both dyslexic groups it can be stated that their serious reading and spelling difficulties were accompanied by a basic competence in the ability to segment new words into phonemes. A version of the phonological deficit account that postulates a current phonemic awareness deficit seems inconsistent with these observations.

The present findings cannot speak against a version of the phonological deficit explanation that locates the deficit in the access to the phoneme level of speech at the early phase of learning to read. An early phoneme awareness deficit may cause – as a consequence of the early phoneme awareness difficulty – an early problem with the acquisition of phonological recoding in word reading. The direct consequence is a reduced self-teaching of orthographic patterns, which enables correct and automatic reading of an increasing number of words as well as orthographically correct spelling (Share & Stanovich, 1995). At the age of the dyslexic children in the present studies, early difficulties with phonemic awareness and phonological recoding may have disappeared, while the deficit in the orthographic lexicon and its consequences for reading and spelling still persisted. This version would explain the present findings. It would also account for the minor difficulties the English dyslexic children had with nonword spelling. These would be seen as late indications of an earlier, more massive phoneme awareness deficit. Direct evidence for the early phoneme awareness deficit of German dyslexic children comes from Wimmer (1996), who found that a substantial number of the later diagnosed dyslexic children had great difficulties with nonword spelling in grade 1. What does not fit with the sketched version of the early phoneme awareness deficit account is the persistence of the reading and spelling problems in the case of the German dyslexic children. As noted, most of the German dyslexic children had already overcome the initial difficulties with phoneme awareness and particularly with phonological recoding in word recognition by the end of their second year in school. One would expect that from then on self-teaching would build up the orthographic lexicon so that children could gradually recover from their initial reading and spelling difficulties. However, no such improvement was found in a large longitudinal study (from the end of grade 2 to the end of grade 8) with about 350 German-speaking Austrian children conducted by Klicpera, Schabmann, and Gasteiger-Klicpera (1993). A majority of those children, who at the end of grade 2 exhibited a massive oral reading fluency impairment by scoring below the 5th percentile, were still scoring below the 5th percentile at the end of grade 8, and none of them had improved over the 15th percentile in oral reading fluency.

The present findings and the longitudinal findings on German-speaking dyslexic children seem to favor a version of the phonological deficit explanation that would posit a dysfunction of the phonological module that has little to do with segmental awareness difficulties. Wimmer (1993) found that a deficit in continuous, rapid naming tasks, in accord with Denckla and Rudel (1976), was the dominant cognitive deficit of his German dyslexic children. This was replicated in a different sample by Wimmer et al. (1998). In this study, we were able to show that the impaired naming speed was not associated with speeded visual tasks. Furthermore, we found that dyslexic children had difficulties with phonological short-term memory (nonword repetition) but no deficit in speech perception under noise and no deficit in alliteration and rhyme recognition. Mayringer and Wimmer (2000) established a deficit of German dyslexic children in phonological long-term memory when nonwords had to be learned for visually presented referents. Phonological dysfunctions of this kind probably have negative effects on the build-up of orthographic word representations on which automatic word recognition and orthographic spelling depend. The effects of these phonological dysfunctions are therefore more detrimental and persistent than difficulties in phoneme awareness and segmentation skills, which can be overcome by adequate instructional and remediation techniques.

APPENDIX 1

ITEMS OF THE SPOONERISM TASK

	English	German
Practice	MAN–HAT	MANN–HUT
	HEN–BUS	HENNE–BUS
	BOOK–MOUSE	BUCH–MAUS
	BROWN–FOX	BRAUN–FUCHS
	HAIR–GLASS	HAAR–GLAS
Phonemic Onset	BOAT–FISH	BOOT–FISCH
	SUN–MOON	SONNE–MOND
	SHIP–CAT	SCHIFF–KATZE
	GOLD–SILVER	GOLD–SILBER
	HEART–NOSE	HERZ–NASE
Cluster Onset	BALL–GREEN	BALL–GRÜN
	BLUE–RED	BLAU–ROT
	NET–STONE	NETZ–STEIN
	GREY–DOOR	GRAU–TÜR
	RAIN–SNOW	REGEN–SCHNEE

APPENDIX 2

ITEMS OF THE NONWORD SPELLING TASK

	Set A		Set B	
	English	German	English	German
One syllable	ream	raun	grall	grall
	bood	But	brind	Brind
	dreen	Trün	fand	Fand
	frook	Fruch	blost	Blost
	mound	munt	hoat	Hoot
	biend	Beund	blear	blär
	bilk	Bilch	bish	Bisch
	yead	jot	poung	Pung
Two syllables	dummer	Dommer	sutter	Sutter
	brugar	Brucker	odern	odern
	milver	Milver	potor	Potor
	wother	Wutter	meather	metter
	boffee	Baffee	soctor	soktor
	nalad	nalat	sother	Schuder
	cusic	Kusik	maper	Mapier
	moven	Mofen	servous	servös
Three syllables	atledent	atledent	ralective	Ralektiv
	renito	renite	semater	semater
	quaductric	quaduktrisch	edusment	edusment
	poracous	Porakös	therigious	therigiös
	predition	Prädition	inlio	Inlio
	usision	usision	chacustre	Chakuster
	prositry	Prositrie	etracty	Etraktät
	disaform	Disaform	tolition	Tolition

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NOTES
1. As the Austrian children spoke German and had acquired German orthography, we will refer to them as German throughout this article.
2. Due to an error in procedure, 8 of the German control children worked on form A and 10 on form B.

REFERENCES

Bishop, D. V. M. (1985). Spelling ability in congenital dysarthria: Evidence against articulatory coding in translating between phonemes and graphemes. *Cognitive Neuropsychology, 2,* 229–251.

Bowey, J. A., Cain, M. T., & Ryan, S. M. (1992). A reading-level design study of phonological skills underlying fourth-grade children's word reading difficulties. *Child Development, 63,* 999–1011.

Bradley, L., & Bryant, P. E. (1978). Difficulties in auditory organisation as a possible cause of reading backwardness. *Nature, 271,* 746–747.

Bruck, M. (1992). Persistence of dyslexics' phonological awareness deficits. *Developmental Psychology, 28,* 874–886.

Bruck, M., & Treiman, R. (1990). Phonological awareness and spelling in normal children and dyslexics: The case of initial consonant clusters. *Journal of Experimental Child Psychology, 50,* 156–178.

Byrne, B. (1998). *The foundation of literacy: The child's acquisition of the alphabetic principle*. Hove: Psychology Press.

Denckla, M. B., & Rudel, R. (1976). Rapid Automatized Naming (RAN): Dyslexia differentiated from other learning disabilities. *Neuropsychologia, 14,* 471–479.

Elliot, C. D. (1992). *British Ability Scales: Spelling Scale*. Windsor: NFER–Nelson.

Elliot, C. D., Murray, D. J., & Pearson, L. S. (1983). *British Ability Scales: Word Reading*. Windsor: NFER–Nelson.

Frith, U. (1985). Beneath the surface of developmental dyslexia. In K. E. Patterson, J. C. Marshall, & M. Coltheart (Eds.), *Surface dyslexia* (pp. 301–330). Hillsdale, NJ: Erlbaum.

Klicpera, C., Schabmann, A., & Gasteiger-Klicpera, B. (1993). Lesen- und Schreibenlernen waehrend der Pflichtschulzeit: Eine Laengsschnittuntersuchung ueber die Haeufigkeit und Stabilitaet von Leseund Rechtschreibschwierigkeiten in einem Wiener Schulberzirk [The development of reading and spelling skills from second to eighth grade: A longitudinal study on the frequency and stability of reading and spelling retardation in a Viennese school district]. *Zeitschrift fuer Kinder- und Jugendpsychiatrie, 21,* 214–225.

Landerl, K., Wimmer, H., & Frith, U. (1997). The impact of orthographic consistency on dyslexia: A German–English comparison. *Cognition, 63,* 315–334.

Landerl, K., Wimmer, H., & Moser, E. (1997). *Salzburger Lese- und Rechtschreibtest* [Salzburg reading and spelling test]. Bern: Huber.

Liberman, A. M. (1989). Reading is hard just because listening is easy. In C. von Euler, I. Lundberg, & G. Lennerstrand (Eds.), *Wenner–Gren International Symposium Series: Brain and reading* (pp. 197–205). Basingstoke: Macmillan.

Liberman, I. Y., & Liberman, A. M. (1992). Whole language versus code emphasis: Underlying assumptions and their implications for reading instruction. In P. B. Gough, L. C. Ehri, & R. Treiman (Eds.), *Reading acquisition* (pp. 343–366). Hillsdale, NJ: Erlbaum.

Manis, F. R., Seidenberg, M. S., Doi, L. M., McBride-Chang, C., & Petersen, A. (1996). On the bases of two subtypes of dyslexia. *Cognition, 58,* 157–195.

Mayringer, H., & Wimmer, H. (2000). Pseudoname learning by German-speaking children with dyslexia: Evidence for a phonological learning deficit. *Journal of Experimental Child Psychology, 75,* 116–133.

Pennington, B. F., van Orden, G., Smith, S. D., Green, P. A., & Haith, M. M. (1990). Phonological processing skills and deficits in adult dyslexics. *Child Development, 61,* 1753–1778.

Perin, D. (1983). Phonemic segmentation and spelling. *British Journal of Psychology, 74,* 129–144.

Raven, J. C. (1987). *Manual for Raven's Progressive Matrices and Vocabulary Scales, Section 3. Standard Progressive Matrices*. London: Lewis & Co.

Schmidtke, A., Schaller, S., & Becker, P. (1978). *Raven-Matrizen-Test: Coloured Progressive Matrices*. Weinheim: Beltz.

Seyfried, H., Klauser, H., & Weyermüller, F. (1987). *Diagnostischer Rechtschreibtest DRT 4–5* [Diagnostic spelling test for grades 4 and 5]. Vienna: Ketterl.

Seymour, P. (1986). *Cognitive analysis of dyslexia*. London: Routledge.

Shankweiler, D. (1999). Words to meanings. *Scientific Studies of Reading, 3,* 113–127.

Shankweiler, D., & Liberman, I. Y. (1976). Exploring the relations between reading and speech. In

R. M. Knights & D. J. Bakker (Eds.), *Neuropsychology of learning disorders: Theoretical approaches* (pp. 297–313). Baltimore: University Park Press.

Share, D. L., & Stanovich, K. E. (1995). Cognitive processes in early reading development: Accommodating individual differences into a model of acquisition. *Issues in Education, 1,* 1–57.

Stanovich, K. E. (1994). Annotation: Does dyslexia exist? *Journal of Child Psychology and Psychiatry, 55,* 579–595.

Wimmer, H. (1993). Characteristics of developmental dyslexia in a regular writing system. *Applied Psycholinguistics, 14,* 1–33.

(1996). The early manifestation of developmental dyslexia: Evidence from German children. *Reading and Writing: An Interdisciplinary Journal, 8,* 1–18.

Wimmer, H., & Landerl, K. (1997). Spelling German differs from spelling English. In C. A. Perfetti, L. Rieben, & M. Fayol (Eds.), *Learning to spell: Research, theory, and practice across languages* (pp. 81–96). Mahwah, NJ: Erlbaum.

Wimmer, H., Mayringer, H., & Landerl, K. (1998). Poor reading: A deficit in skill-automatization or a phonological deficit? *Scientific Studies of Reading, 2,* 321–340.