The Nonword Reading Deficit in Developmental Dyslexia: Evidence from Children Learning to Read German

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This study examined whether dyslexic children learning to read German show the same nonword reading deficit, which is characteristic of dyslexic children learning to read English (Rack, Olson, & Snowling, 1992), a deficit which is taken as evidence for a phonological impairment underlying dyslexia. Because the German writing system, in contrast to English, exhibits comparatively simple and straightforward grapheme-phoneme correspondences, the generality of the nonword reading deficit across different alphabetic systems seemed questionable. Actually, it was found that 10-year-old dyslexic children learning to read German exhibited rather high reading accuracy for nonwords when compared to that typically found among dyslexic children learning to read English. Nevertheless, the children learning German did exhibit a nonword reading deficit. Specifically, their speed for nonwords was impaired in relation to younger control (nondyslexic) children matched on reading speed for frequent words. This nonword reading deficit was observed for nonwords with little similarity to existing German words as well as for nonwords which were analogous to short, frequent content words. It is hypothesized that dyslexic children learning German do not differ from dyslexic children learning English in their underlying phonological impairment, but that they do differ with respect to the expression of this impairment.

Dyslexics’ poor ability to pronounce nonwords provides evidence for the hypothesis that developmental dyslexia is caused by an underlying phonological deficit. This follows from the obvious fact that reading of nonwords depends on phonological processes to a greater extent than reading of words. Furthermore, the ability to produce new pronunciations for visually unfamiliar letter sequences, or nonwords, is a stringent test of the state of the sublexical (indirect, alphabetic) reading procedure. This procedure is considered critical for reading development as it allows the child to read words which are visually unfamiliar in

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the early phases of reading development (e.g., Jorm & Share, 1983; Stanovich, 1986).

To date, most studies have examined dyslexic children’s difficulty with nonword reading in the English language. In a recent review, Rack, Olson, and Snowling (1992) found that of 16 such studies, 10 reported impaired nonword reading accuracy of the dyslexic children (typically over age 10) in comparison to younger reading-level-matched control children. Error rates for the dyslexic groups tended to be between 40 and 60%. In contrast, a study with dyslexic children learning to read German (Wimmer, 1993) found an error rate of only 17% at the end of Grade 2, and this rate dropped further to 8% by the end of Grade 4. The dyslexic Grade 4 children learning German did not differ from a reading-level-matched control group of Grade 2 children. In contrast to reading accuracy, there were large differences between dyslexic children and age-matched control groups in the speed of nonword reading. These data suggest that dyslexic children learning to read German, just as their English counterparts, may suffer from impaired nonword reading, but that the form of the difficulty may differ. However, because the dyslexic and younger control children were not matched on reading speed for frequent words or text, it could not be determined whether dyslexic children’s slow nonword reading rate was even more impaired than their slow reading speed for frequent words and for text.

Given the importance of a specific nonword reading deficit for the theoretical characterization of developmental dyslexia, the present study extended the examination of nonword reading to another sample of severely dyslexic children learning to read German. Stringent methodological precautions were used to determine the specificity of any nonword reading deficit. The critical contrast was between reading speed for frequent words and for analogous nonwords. The nonwords were derived from the words by exchanging the initial letters of the words within the list. In the large majority of items, these initial letters stood for consonantal onsets. Therefore, the items of the nonword list were of the same length as the items of the word list, consisted of the very same letters, and were made up of the same letter clusters (mostly in the rimes) as the words. The second critical aspect of the present study was that the reading-level-control children were matched with the dyslexic children on reading speed (and accuracy) on the word list. Thus, the nonwords were similar in all superficial features with the words and the dyslexic children did not differ from younger normal readers with respect to reading performance on the words from which the nonwords were derived. The critical question was whether—given this double-match of nonwords with words and of dyslexic with control children on word reading—dyslexic children would still show a nonword reading deficit. Such a finding would constitute unequivocal evidence for a genuine difficulty with the processes involved in nonword reading.

To allow a comparison with Wimmer’s (1993) sample of dyslexic German readers, we additionally used his nonwords with the present sample. Wimmer had used nonwords with little orthographic and phonological similarity to Ger-
man words. Examples are toki, holotu, and fekota. These “Japanese”-sounding nonwords consisted of two or three most simple syllables without any consonant clusters. For these nonwords it should be rather easy to assemble pronunciations starting with grapheme–phoneme conversion, while knowledge of typical German word spellings should be of little use. In this respect, the Japanese nonwords differ from the analogous nonwords.

METHOD

Subjects and Design

Twenty-one dyslexic children (13 boys, 8 girls) and 21 reading-level-matched control children constituted the main comparison groups. In addition, 21 age-matched control children were tested. The dyslexic children were all tested at the end of their fourth year in school (mean age: 10.4; range: 9.10–11.4). They were selected from a pool of subjects who participated in a longitudinal study on reading difficulties of Austrian children. These subjects were nominated by their teachers at the end of Grade 1 or at the end of Grade 2 as showing unexpected difficulties in learning to read and/or to spell. Children were included in the longitudinal sample when the teacher judgment was confirmed by a score on an individual word reading test corresponding to a percentile below 20 and by a nonverbal IQ score (Raven’s Coloured Progressive Matrices) in the normal range (mean = 103, lowest score = 87). This word reading test and the Raven’s were administered when the child was nominated by his or her teacher. For the present study, children were selected from this longitudinal sample when in addition to these early difficulties, their reading performance on a text reading test (described below) was below a percentile rank of 17 (corresponding roughly to one standard deviation below the mean of the Grade 4 norm sample of about 300 children). For this assessment, reading speed had to be used, since the dyslexic children made few or, in 8 cases, no errors. The median of the text reading time scores of the dyslexic sample corresponded to a percentile of about 6 for Grade 4 children. Both the reading time scores for the text and the frequent word task (see below) were in the normal range for the second grade control subjects. Therefore, the present dyslexic children were about two years behind in their reading development. Because the reading impairment of the present dyslexic children was based on both teacher judgment and two individually administered reading tests, it is unlikely that essentially normal readers were misdiagnosed as dyslexic. Rack et al. (1992) have warned that some studies may have failed to find a nonword reading deficit because of subject selection based on a single reading assessment with the danger of regression to the mean.

The majority of the dyslexic children suffered not only from slow reading speed, but also from spelling problems. Fourteen of them scored below a percentile rank of 10 on a standardized spelling test for Grade 4 children. Seven of the dyslexic children had experienced atypical school careers. Two attended special schools for children with general learning difficulties as there are no
special schools for dyslexic children in Austria. Five other children had repeated a grade and were in Grade 3 when they were tested. However, to refer to number of years in school, the phrase “dyslexic Grade 4 children” will be used. All the dyslexic children had received extra reading instruction in school for some time (small groups with about one extra reading lesson per week). Six of them had also participated in a short (30 h) individual remediation program offered by our research group at the University of Salzburg, when they were in Grade 2. As evident from the fact that these children were about 2 years behind in their reading development, these remediation attempts were not particularly effective. Moreover, the remediation attempts apparently did not specifically improve dyslexic children’s nonword reading performance. Their median reading times for both the analogous nonword task and the Japanese nonword task corresponded to the 5th percentile for Grade 4 students. For the Japanese nonword task a comparison with the dyslexic Grade 4 sample used by Wimmer (1993) was possible. The present dyslexic sample scored slightly lower on both reading time and errors than the previous one.

The reading-level-matched control group (mean age: 8.2, range: 7.7 to 8.8) was chosen by selecting for each dyslexic subject a Grade 2 child of the same sex and with similar reading time and similar error score on the frequent word task from a larger sample of Grade 2 children. The reading performance of the reading-level-matched controls tended to be in the normal range for their age and grade. The median percentile rank (based on a Grade 2 norm sample) for reading time on the frequent word task (see below) was 51 (range: 10 to 65). The age-matched control group consisted like the dyslexic group of 13 boys and 8 girls. The mean age of the Grade 4 control children was 10.3 (9.5–11.0). The median text reading time of the children in this group corresponded to a percentile of 56 (range: 30–71).

Materials and Procedures

For both word and nonword reading, children had to read a list of items aloud. This continuous reading format was chosen because it mimics the normal reading process, where the skilled reader might achieve high speed by previewing the words that come next. For each task, the child was presented a single page containing several lines of items and asked to read the words as quickly and accurately as possible. A practice page with two lines of single words introduced the task format, and another practice page introduced children to nonword reading. The child’s reading of each test page was recorded for later error analysis. The time to read each test page was taken and later converted into reading time per item, although this measure is not a precise estimate of reading time per item as it includes eye movements from word to word and movements from the end of a line to the beginning of the next.

Frequent content words. Thirty short words such as Ball (ball), Schnee (snow), Mutter (mother), and Esel (donkey) were presented. With the exception of four adjectives, these words were nouns. All of the items were among the most
frequent words used in essays written by German children in Grades 3 and 4 (Pregel & Rickheit, 1987). Of the 30 words, 18 consisted of one syllable and 12 consisted of two syllables. The words ranged in length from 3 to 6 letters.

**Analogous nonwords.** These nonwords were derived from the words by exchanging the initial letters of the frequent content words. With the exception of three words, these initial letter(s) were always the consonantal onsets of the words. For 16 of the 17 one-syllable words, this method of generating nonwords left onset and rime units intact. The only exception was that in the case of alt (old) the a was replaced by O. However, the resulting nonword Olt constitutes a rime in German words (e.g., in holt). For 11 of the 13 two-syllable words, the whole rhyme of the word (i.e., the rime of the first syllable plus the whole second syllable) was left intact by exchanging the initial letter(s). Two words began with a vowel grapheme: Esel (donkey) and Oma (grandma). Here the first grapheme is a whole syllable. Therefore, exchanging the first grapheme in these cases means that all the syllables were left intact. The Appendix contains the 30 words and the 30 analogous nonwords resulting from this procedure.

**Japanese nonwords.** These 24 nonwords were constructed in such a way that similarity to German word spellings would be minimal, but pronunciation would be quite easy. Words were used which most often consisted of two or three consonant–vowel (CV) syllables (see Appendix). Such simple open CV syllables may not be as typical for German as closed ones (e.g., CVCs), but they nevertheless do occur in frequent words. Examples of German CVCV words are Puppe (doll), Nase (nose), Hose (trousers), Hase (hare), Liebe (love). In contrast to English, the final -e is pronounced in these words.

**Text.** This text reading task, which was used here only for selection of subjects, was a short, simple story consisting of 7 sentences with 57 words. The percentile ranks used for the selection of the dyslexic children are based on 300 Grade 4 children.

The order of the tasks was: frequent words, text, Japanese nonwords, and analogous nonwords. Since two tasks separated frequent word reading from analogous nonword reading, it is unlikely that reading of the latter was primed by reading of the corresponding words. A practice task, which introduced children to the task format (i.e., reading as quickly and accurately as possible several lines of unrelated words), was administered at the beginning of the test session. The Japanese nonword reading task was also preceded by a practice task; the child was told that the next list of words had no meaning.

**RESULTS**

The reading performance of the dyslexic children and the reading-level-matched control children is shown in Table 1. Reading time per item is the main measure, because—as can be seen from Table 1—error rates were low for both groups of children.

**Frequent words vs analogous nonwords.** The differential effect of distorting frequent words into nonwords on reading speed of children and reading-level-
matched control children was apparent from a reliable interaction between word category (words vs analogous nonwords) and group (dyslexic vs reading-level-matched control), $F(1,40) = 5.1$, $p < .03$. Because reading time scores for frequent words were nearly identical for dyslexic and control children, the interaction could only be due to dyslexic children’s slower reading time for nonwords. The means of nonword reading time differed reliably between the two groups, Newman–Keuls procedure: $p < .05$. The main effect of word category was significant, $F(1,40) = 229.1$, $p < .001$, while the group effect was not, $F(1,40) = 1.71$, $p > .10$. The differential effect of the word–nonword variation was also found, when dyslexic children were compared to the age-matched control children. Again the interaction between word category and group for reading time was reliable, $F(1,40) = 23.4$, $p < .001$. The mean reading time per item of age-matched control children was .64 s for frequent words and 1.16 s for analogous nonwords. The resulting reading time difference between words and nonwords of about .5 s per item is only about half the reading time difference between words and nonwords shown for the dyslexic children from Table 1.

The differential effect of the word–nonword variation on the reading speed of the dyslexic and reading-level-matched control children was accompanied by a corresponding differential effect on error rates. However, because of the frequent absence of errors, no analysis of variance was possible. From the mean error percentages it is evident that the frequent words were read nearly errorlessly by both groups of children, while analogous nonwords led to somewhat more errors among the dyslexic children than among the control children, $U$ test: $Z(\text{correct}$
for ties) = 1.93, \( p = .027 \) (one-tailed). Of the 58 erroneous readings of the analogous nonwords committed by the dyslexic children, 43 (about 60%) were nonwords themselves, and not a single instance of reading refusal occurred. Examples of errors being nonwords were Teft \( \rightarrow \) “Taft,” Put \( \rightarrow \) “Rup” and “Kut,” Asel \( \rightarrow \) “Alsel,” Stutter \( \rightarrow \) “Sutter,” Schett \( \rightarrow \) “Schnett,” Stronne \( \rightarrow \) “Storne.” Examples of erroneous word responses were Muppe \( \rightarrow \) “Puppe,” Bür \( \rightarrow \) “Büro,” Kaus \( \rightarrow \) “Haus.” From these examples it is obvious that errors tended to be minor deviations from the target, in the sense that one phoneme was wrong, missing or added.

**Japanese nonwords.** As in the case of the analogous nonwords, dyslexic children needed more time to read the Japanese nonwords than the reading-level-matched control children, \( t(40) = 2.1, p = .02 \) (one-tailed). The dyslexic children also committed more errors, \( U \) test: \( Z(\text{correct for ties}) = 2.24, p < .02 \) (one-tailed). The Japanese nonwords, in contrast to the analogous ones, did not mislead dyslexic children into erroneous word responses. With two exceptions, all of the 82 errors were nonwords. As in the case of the analogous nonwords, no reading refusals were observed. Examples of errors are ketal \( \rightarrow \) “kutal,” fekota \( \rightarrow \) “lekata,” “fektota,” sitime \( \rightarrow \) “stime,” kamof \( \rightarrow \) “komof.” Among the errors of the dyslexic children one type was rather frequent. It is termed recency error in Table 1 to indicate that a syllable appearing later in the nonword affected the reading of a prior syllable. For example, when toki was read as “koki,” the onset of the second syllable replaced the onset of the first syllable. Other examples were molas \( \rightarrow \) “malas,” where the vowel of the second syllable replaced the vowel of the first, or alomu \( \rightarrow \) “almomu,” where the onset of the third syllable replaced the onset of the second one. The percentages of recency errors were higher for the dyslexic than the control children, \( U \) test: \( Z(\text{correct for ties}) = 2.0, p < .023 \) (one-tailed). Interestingly, the opposite case of a syllable prior in the nonword affecting a later syllable (e.g., alomu \( \rightarrow \) “alamu,” kutefa \( \rightarrow \) “kuteta”)—termed primacy error in Table 1—was of somewhat higher frequency among the errors of the control than of the dyslexic children, although in absolute numbers these errors were infrequent in both groups. There was also a tendency to replace a CV syllable by a more typical German CVC syllable (18% of dyslexic children’s errors, 6% of control children’s errors). Examples are kerata \( \rightarrow \) “kertalta,” fekota \( \rightarrow \) “fektota,” and holotu \( \rightarrow \) “holtu.”

**DISCUSSION**

The findings of present study provide evidence for a specific difficulty of nonword reading for dyslexic children learning to read German. The nonwords used in the critical comparison were derived from frequent short words by exchanging the consonantal onset graphemes between the words, and the reading-level-matched control children were matched with the dyslexic children on reading speed (and accuracy) for the frequent short words. Despite this double-match of nonwords with words and of dyslexic children with control children on word reading, the dyslexic children were found to read the nonwords at slower
speed and with slightly lower accuracy than the reading-level-matched control children. Similar deficits were also found for the Japanese nonwords with little similarity to German word spellings.

Compared to the high error rates reported in studies with dyslexic children learning to read English (see Introduction), the present dyslexic children learning to read German exhibited rather accurate nonword reading. This finding suggests that, overall, these children have less difficulty than English children with the acquisition of the sublexical (alphabetic) reading procedure, which in some influential models of reading development is postulated as the main early stumbling block for dyslexic children (Frith, 1985; Jorm & Share, 1983; Marsh, Friedman, Welch, & Desberg, 1981; Seymour, 1986). Of course, it does not follow that dyslexic children learning to read German have no difficulties at all with the sublexical procedure. There are, in fact, findings that point to early difficulties. Wimmer and Hummer (1990) compared normally progressing children with children who experienced specific difficulties in learning to read at the end of Grade 1 (after about 7 months of reading instruction). For the latter group, error rates for words and corresponding simple nonwords were 30 and 44%. However, as shown in the present study, at least after 3 more years the early difficulties with reading accuracy were largely overcome. The most plausible reason why dyslexic children learning to read German have less difficulty with sublexical, alphabetic word recognition lies in the fact that they are introduced to reading via a phonics approach and that the German writing system, in contrast to English, exhibits rather simple and straightforward grapheme–phoneme correspondences. For vowel graphemes, the difference between German and English is particularly striking. To illustrate, the a in the German words Katze (cat), Ball (ball), and Garten (garden) gets an identical pronunciation, while in the corresponding English words it is pronounced differently.

Given the lesser difficulty of acquiring the sublexical reading procedure for dyslexic children learning to read German, nevertheless even after 4 years of schooling, the dyslexic children read both types of nonwords slower than the younger reading-level-matched control children. Furthermore, it seems plausible that quite a few errors resulted from impaired efficiency in generating pronunciations. Particularly indicative were the recency errors committed by the dyslexic children in reading the Japanese nonwords, where apparently the most recently assembled syllable affected an earlier assembled syllable of the same word. If syllables are assembled at comparatively slow speed, as presumably is the case for dyslexic children, then there is obviously a higher chance that earlier assembled syllables fade from short-time memory and that interference from the most recent syllable occurs.

It is important to note that the dyslexic children were carefully matched with younger normal readers on reading speed for the frequent words from which the analogous nonwords were derived. This is methodologically important for several reasons. Because of this match, it is implausible that dyslexic children’s inefficient nonword reading is due to weaker memory representations for the
This match also rules out the hypothesis that visual deficits (e.g., Lovegrove, Garcia, & Nicholson, 1990) may have selectively affected dyslexic children’s nonword reading. Words and nonwords consisted of the same letters and the arrangement of the words and nonwords on the corresponding pages was exactly the same. The matching procedure also rules out impaired articulation speed (e.g., Baddeley, 1986) as possible cause of dyslexics nonword inefficiency, because the frequent words were read at the same speed by dyslexic and control children. Furthermore, the selectively impaired efficiency of nonword reading speaks against Nicholson and Fawcett’s (1990) proposal that dyslexic children suffer from a general impairment of skill automatization. This explanation would predict that reading of often processed frequent words should be more affected than reading of never processed nonwords, but just the opposite was found.

In contrast, the low efficiency with which the present dyslexic children learning to read German read nonwords is consistent with the phonological deficit explanation of dyslexia (e.g., Catts, 1989; Liberman & Shankweiler, 1985; Snowling, 1987; Stanovich, 1988). Moreover, it extends this account in an interesting way. The dominant version of this account is that the phonological deficit affects learning to read via impaired acquisition of grapheme–phoneme correspondences. According to this view, children with phonological impairments at the beginning of reading instruction have little awareness of the phonological form of spoken words and, in particular, no awareness of phonemic constituents. This leads to difficulties when the graphemes of a word have to be related to phonemes of the pronunciation. However, without grapheme–phoneme correspondences there can be no productive sublexical reading procedure, which allows the reliable recognition of new words.

This version of how a phonological deficit may affect reading acquisition is certainly more valid for English orthography, with its complex and inconsistent grapheme–phoneme correspondences, than for German, with its rather straightforward and consistent correspondences. For our dyslexic children, after 4 years of schooling, it can be ruled out that the nonword reading deficit is due to insufficient knowledge of grapheme–phoneme correspondences. However, there are other plausible accounts for how a phonological impairment may affect nonword reading. One is that dyslexic children may suffer from slow access to phonological memory representations as evident from dyslexic children’s poor performance on rapid naming tasks (see Wolf, 1991, for review). This generally slow access to phonology affects the speed of grapheme–phoneme conversion. Nonword reading, quite plausibly, is more affected by impaired speed of grapheme–phoneme conversions than word reading, because for nonwords no shortcuts to pronunciations are possible. Wimmer (1993) had found that speed of digit naming in a rapid naming task was the best predictor of nonword reading speed among dyslexic children learning to read German.

Another possibility is that dyslexic children’s particular difficulty with nonword reading results from inefficient access to syllables or syllable constituents.
(onsets and rimes). For this proposal, one has to note, that nonword reading requires the generation of new pronunciations starting with the phonemes delivered by grapheme–phoneme conversion. In the resulting pronunciations the phonemes have to be coarticulated. The most efficient way to achieve coarticulation is to access existing syllables. There are two problems with such access. First, such syllables may not be free-accessible, because for the purpose of speaking they are embedded in phonological word representations. (For a specification of the role of syllables in phonological word representation see Levelt, 1989). Second, the bottom-up activation (via grapheme–phoneme conversion) of syllables which in turn provide coarticulation patterns for the phonemes has to be a high speed process, otherwise no fluent pronunciation in reading is possible. That phonologically impaired children may have difficulties with these demands, may not be astonishing.

APPENDIX

Frequent Content Words

Katze, alt, Hut, Ball, Esel, Heft, Papa, Buch, jetzt, Schnee, Nase, viel, Oma, Schule, Tür, Maus, Bett, Mutter, Straß(e), Brief, Tag, Stein, Tante, Zeit, Mann, Sonne, Puppe, klein, Leute, Küche.

Analogous Nonwords

Natze, Olt, Put, Kall, asel, Teft, Hapa, Luch, Tetzt, Mee, Sase, Hiel, Ema, Mule, Bürger, Kaiser, Schett, Stutter, jaβbe, kliβ, Pag, Zein, Bante, Beut, vann, Stronne, Muppe, Brein, Schneute, Tüche.

Japanese Nonwords

Talire, holotu, ketal, filuno, toki, fekota, faluko, komof, sitime, kerata, torukim, futero, tulif, mukatal, natak, ituma, rosoti, matoru, towami, emak, molas, kutefa, rone, alomu.

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