Effects of word length and wordlikeness on pseudoword repetition by poor and normal readers

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ABSTRACT
This study investigated whether the pseudoword repetition difference between poor and normal readers could be explained by differences in memory for verbal materials or in familiarity with the composition of verbal materials. Dutch second graders and poor readers scoring in the same range on a word-reading test repeated pseudowords that varied in length and wordlikeness. The pseudoword repetition deficit of poor readers reported in the literature was replicated. Although the repetition scores were influenced by pseudoword length and wordlikeness, no interaction with reader group was found, thus indicating that neither variable represented a causal factor in the poor readers' repetition deficit. Statistical correction for reader group differences on a phoneme detection task and an auditory discrimination task made the pseudoword repetition difference disappear. We conclude that the basic problem is unlikely to be with subvocal rehearsal, and that the cause of the repetition deficit is already operative in early, perceptual stages of processing.

Reading and writing are complex skills that require a multitude of more basic competencies, each of which could be an impediment to the acquisition of literacy. Evidence has been accumulating, however, that a central problem for children with developmental reading and writing disorders or dyslexia lies in the phonological basis of reading and writing, and that problems in reading and writing often are related to limited phonological competence. This relationship has been studied most intensively in the area of phonological awareness and segmentation – that is, the awareness that words can be analyzed into component speech sounds and the ability to manipulate these segments (e.g., Goswami & Bryant, 1990; Stanovich, 1986; van Bon, Schreuder, Duighuisen, & Kerstholt, 1994; Wagner & Torgesen, 1987). There are still many uncertainties in this field, not only with respect to the causal nature of the relationship between phonological aware-
ness and the development of literacy, but also with respect to the character and delineation of the phonological deficit.

In recent years, several studies have used word repetition tests to investigate the phonological competence of children with reading problems. Deviant speech development and problems with articulating complex words in particular have often been reported for poor readers (e.g., Blalock, 1982; Cicci, 1983; Denckla, 1977; Ingram, Mason, & Blackburn, 1970; Johnson, 1980; Johnson & Myklebust, 1967; Lyle, 1970; Miles, 1974; Taylor, Fletcher, & Satz, 1982). Most studies that we are aware of (Brady, Poggie, & Rapala, 1989; Brady, Shankweiler, & Mann, 1983; Catts, 1986; Kamhi, Catts, Mauer, Apel, & Gentry, 1988; Schwartz, 1993; Snowling, 1981; Snowling, Goulandris, Bowby, & Howell, 1986; Taylor, Lean, & Schwartz, 1989) have demonstrated that reading skill and word repetition ability indeed are related. It should be noted, however, that not all studies found such a relationship. Wimmer (1993) failed to find relatively poor (pseudo)-word repetition performance in dyslexic children and referred to the comparable results of a study by Bowers (1989). No agreement exists as to whether the word repetition problem is general or if it is restricted to verbal items that are unfamiliar and thus may not have been lexicalized (i.e., pseudowords and low-frequency words).

Various authors have proposed that a word repetition deficit in poor readers has its origin at some point in the process of response preparation rather than in actual response execution (articulation). Snowling (1981), however, found a repetition deficit for pseudowords, but not for closely similar real words - a finding that was replicated in a study restricted to monosyllabic words (Snowling et al., 1986). Brady et al. (1983) found no repetition deficit unless the items were presented in noise points in the same direction, since it was unlikely that the addition of noise to stimulus presentation would elicit problems of an articulatory nature. Catts (1986) interpreted his finding of repetition problems with specific words rather than with specific speech sounds in his dyslexic subjects as indicative of difficulties with input processing and response planning rather than with response execution. A comparable point was raised by Kamhi et al. (1988), who suggested that the dyslexic subjects in their study made neither consistent nor distinguishing articulation errors on the repetition task. Brady et al. (1989) showed that below-average and average readers did not differ in response latency, even for conditions in which accuracy differences were found. That there nevertheless may be problems in response execution is suggested by the observation by Catts (1986); his dyslexic subjects occasionally attempted to correct their faulty repetition or gave another indication that their speech output did not reflect how they remembered the stimulus.

The earliest stage at which the deficit could arise is in the perception of the verbal items to be repeated. Such a problem in early perceptual processing was suggested by the finding of a repetition difference between good and poor readers for (monosyllabic) real words, but only if these were presented in noise (Brady et al., 1983). They concluded that poor readers require a high-quality signal for adequate speech processing. Brady et al.
(1989), however, argued that the interaction between reader type and stimulus condition (noise vs. no-noise) could have been due to ceiling effects for the monosyllabic words in the no-noise condition and suggested that, with more difficult words, differences would be found even under clear listening conditions. Their argument was supported by the results of Snowling et al. (1986), who found a difference between their reader groups (dyslexics vs. age and reading level controls) in overall repetition performance, an interaction between presentation condition (with or without noise) and word type (monosyllabic high-frequency, low-frequency, and pseudowords), but no differential effect of noise on reader groups. The results of Kamhi et al. (1988) also suggested that a repetition deficit is not determined by perceptual processing factors; they found that the repetition of monosyllabic pseudowords by reading-disabled children is even less affected by the addition of noise to the stimulus presentation than the performance of their age-matched normal reading counterparts.

The next hypothetical stage in word repetition is the creation and maintenance of a phonological representation (e.g., Brady et al., 1989). Snowling (1981) suggested that the poor readers' problem in reading and word repetition is limited to the phonological processing involved in setting up speech-motor programs for novel verbal items (as opposed to addressing and executing lexicalized articulatory programs). She deduced this from the lower performance of dyslexic children than that of normal readers (matched with the dyslexic readers on a real word reading test) in reading and repeating pseudowords, but not in real word repetition. This explanation was elaborated by Snowling et al. (1986). The dyslexics in their study did not differ from the age and reading level controls when repeating high-frequency words; however, they scored lower than the age controls when repeating low-frequency words and lower than the age and reading level controls with pseudowords. Snowling et al. argued that the deficit must lie in the phonemic analysis that the repetition of nonlexical items requires—a deficit that most likely is related to the phonemic segmentation problems that have been documented for dyslexics. The differential effect of word frequency is explained by assuming that phonemic analysis is also required for establishing lexical phonological representations of spoken words.

That the repetition problem is not confined to pseudowords has been demonstrated in a number of studies. Brady et al. (1989) found repetition differences for polysyllabic words and monosyllabic pseudowords (but not for monosyllabic real words). They therefore suggested that poor readers' encoding processes are less efficient for all speech stimuli. A study by Catts (1986) also suggested that the repetition problem is not confined to pseudowords. He found adolescent poor readers to score lower than CA matched normal readers in their reproduction of polysyllabic real words and phonologically complex phrases. Catts claimed that the polysyllabic words, as well as the simple words used in the phrases, could be assumed to be familiar to persons in the age range concerned. Kamhi et al. (1988) found lower repetition scores for reading-disabled children than for age-matched normal readers with polysyllabic real words as well as with mono-
syllabic pseudowords. The evidence clearly does not support Snowling's claim that the poor readers' repetition problem is restricted to novel verbal items. Rather, it appears that it is under demanding task conditions in general (e.g., unfamiliar words, phonologically complex phrases, consonant clusters [Snowling, 1981]) that group differences may be expected. Since such conditions may also affect early (perceptual) and later (articulatory) stages of repetition performance, they do not necessarily imply problems in an intermediate stage of encoding and code maintenance.

From this short discussion it can be concluded that, apart from the study by Wimmer (1993), the evidence indicates that a word repetition deficit can be reliably demonstrated in poor readers by using pseudowords (but is not restricted to such words), and that the nature of the basic problem is still unclear.

The current study investigates the operation of two possible causal factors in bringing about a possible repetition difference in favor of the normal readers: memory for verbal materials and familiarity with the composition of verbal materials. Gathercole, Willis, Emslie, and Baddeley (1991) put forward these hypothetical determinants of pseudoword repetition performance in order to explain the strong positive relation they found between pseudoword repetition and vocabulary knowledge. One explanation for that relation - the phonological memory hypothesis - assumes that temporary representations of unfamiliar words are the basis for constructing more permanent lexical specifications of word phonology. As a consequence, children with deficient phonological memory skills, as indicated by their poor pseudoword repetition performance, will have more problems learning the sound pattern of new words. Another explanation - the linguistic hypothesis - assumes that the short-term retention of a phonological representation needed for pseudoword repetition is supported by the use of stored sublexical linguistic units, with vocabulary knowledge partly determining the familiarity of linguistic units. Evaluating the role of phonological memory (by manipulating pseudoword length) and the availability of sublexical linguistic units (by varying wordlikeness of the pseudowords), Gathercole et al. (1991) found repetition accuracy in children to be independently influenced by both factors; they suggested that "repeating nonwords involves temporary phonological memory storage which may be supported by either a specific lexical analogy or by an appropriate phonological frame generated from structurally similar vocabulary items" (p. 349). The study by Gathercole et al. raises the question of whether the lower repetition scores of poor readers can be explained by one or both of these factors.

The studies discussed here suggest that both factors may be operative in causing the repetition deficit. Our study investigates this systematically by varying word length and wordlikeness and by testing whether the poor readers, compared with (younger) normal readers performing at the same reading level, are differentially affected by these factors. A larger negative effect of increased word length on the performance of poor readers would point to problems involving working memory (cf. Baddeley, Thomson, & Buchanan, 1975; Hitch, Halliday, & Littler, 1993). If poor readers are more
hindered by low wordlikeness than normal readers, this would suggest that their repertory of units for phonological and/or articulatory encoding is relatively restricted. If both factors appear to negatively influence the poor readers more than their normal counterparts, then Gathercole et al.’s explanation could be adopted.

Commenting on Gathercole et al. (1991), Snowling, Chiat, and Hulme (1991) stated that pseudoword repetition is a complex task in which factors other than phonological memory are crucial. In particular, defective phonological segmentation in particular was proposed by Snowling et al. (1986) as the probable causal factor, while ruling out perceptual problems. Snowling et al.’s (1986, 1991) speculations will be tested in this study using an auditory discrimination task like the one sketched by Snowling et al. (1991) to determine auditory perceptual ability and a phoneme detection task to measure phonological segmentation skill. The phoneme detection task is an adaptation of the sound-to-word matching task that has been used for the assessment and training of phonological awareness (cf. Byrne & Fielding-Barnsley, 1993; Yopp, 1988).

METHOD

Subjects

Subjects were selected from three schools for children with learning difficulties in the Netherlands. Children are usually admitted to these special schools because of large discrepancies between their scholastic achievement and their intelligence. Teachers chose children with specific reading difficulties who were reading at the second-grade level. A further selection was made using the One-Minute Test (OMT) (Brus & Voeten, 1972), a much used and well-documented (e.g., Mommers, van Leeuwe, Oud, & Janssens, 1986) reading test which involves reading aloud a graded list of 116 regular words, ranging from waar ‘where’ to rubberaanplanting ‘rubber planting’. The number of words read correctly in 1 minute constitutes the test score. Only children scoring about the mean of grade 2 (45 words correct) participated in the experiment. Children with scores lower than 32 or higher than 57 were excluded because of practical limits on the testing time available. The age of the remaining 21 poor readers (9 boys, 12 girls) ranged from 9;10 to 11;10, with a mean of 10;3 (SD = 0;7). The mean percentile on the Coloured Progressive Matrices (CPM) (Raven, 1965; van Bon, 1986), 45 (SD = 22.1), was slightly below the population mean. No severe conduct disorders or physical defects were reported or observed that could be held responsible for the learning difficulties of these children.

All 25 second graders (13 boys, 12 girls) from three regular elementary schools constituted the group of younger normal readers; these children scored in the same range on the OMT and were judged by their teachers to read according to didactic age. Their average reading score (47, SD = 5.3) was slightly, but significantly, $F(1, 44) = 7.35, p < .01$, above that of the poor readers (42, SD = 7.7). Their ages varied from 7;8 to 9;5, with a
mean of 8.4 (SD = 0.5). One of the oldest subjects (aged 9.5) was reported to have been kept an extra year in kindergarten because of pedagogical considerations that were not reading-related. The mean CPM percentile (57, SD = 26.9) of the normal readers was somewhat above the population mean, but did not differ significantly from that of the poor readers, $F(1, 44) = 2.81, p = .10$.

Calculating differences between the actual and age-expected OMT scores for the two groups resulted in nonoverlapping distributions. The mean discrepancy for the poor readers (30.50 words below expected) appeared to be significantly different from zero, $t(20) = -18.90, p < .01$, whereas the mean discrepancy for the normal readers (1.70) was not, $t(24) = -1.03, n.s$. The children in both groups came mostly from low and middle socio-economic backgrounds. No subject in either reading group had any noticeable articulation problem, as determined with an informal articulation test (repetition of existing CVCs) by the second author, a trained speech therapist. According to their teachers, no permanent hearing loss had been observed for any of the participating students during the periodic school medical examinations.

**Materials**

Pseudowords of different length (one, two, three, or four syllables) were constructed by specifying 20 arrays of vowels, with 5 arrays per word length. Each array was the basis for the construction of a word of a given length, and each vowel was the nucleus for a syllable. The vowels were randomly selected from among the Dutch long and short vowels, the diphthongs, and the schwa. No vowel was used more than once for each word.

Two pseudowords were constructed from each vowel array, one of low wordlikeness and one of high wordlikeness. Using a frequency count of single consonants and biconsonantal clusters in initial (onset) and final (coda) positions in Dutch syllables (Willemse, n.d.), the pseudoword of low wordlikeness was formed for each vowel array by choosing low-frequency onsets and codas for each syllable. The corresponding pseudoword of higher wordlikeness was formed with high-frequency onsets and codas having the same number of consonants (one or two) as their counterparts in the less wordlike pseudoword. Because consonants are not obligatory at the prevocalic and postvocalic places in Dutch syllables, in some arrays a slot was not filled with consonants, for both items formed from that array. Table 1 gives the resultant pseudoword list. Stress patterns were assigned to each pair of pseudowords according to rules for Dutch.

**Tests**

For the pseudoword repetition test, the 40 items were placed in a random order and read by a trained speech therapist, with an interval of 5 seconds between words. Each word was preceded by an alerting sound. This high-quality tape-recording was copied to a cassette tape, which was presented
Table 1. *The pseudowords used in the repetition task*

<table>
<thead>
<tr>
<th>Number of syllables</th>
<th>Wordlike</th>
<th>Less wordlike</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>ant</em> (<em>nant</em>)</td>
<td><em>amf</em> (bamf)</td>
</tr>
<tr>
<td></td>
<td><em>dels</em> (tels)</td>
<td><em>gefs</em> (kefs)</td>
</tr>
<tr>
<td></td>
<td><em>veet</em> (veef)</td>
<td><em>feew</em> (veew)</td>
</tr>
<tr>
<td></td>
<td><em>ston</em> (stan)</td>
<td><em>skof</em> (skaf)</td>
</tr>
<tr>
<td></td>
<td><em>graar</em> (grar)</td>
<td><em>fraal</em> (fral)</td>
</tr>
<tr>
<td>2</td>
<td><em>in-tent</em> (<em>in-tant</em>)</td>
<td><em>ik-tesp</em> (ik-tep)</td>
</tr>
<tr>
<td></td>
<td><em>wul-staas</em> (<em>wuk-staas</em>)</td>
<td><em>suk-glaak</em> (<em>sut-glaak</em>)</td>
</tr>
<tr>
<td></td>
<td><em>zun-te</em> (<em>zun-ter</em>)</td>
<td><em>puk-ë</em> (puk-te)</td>
</tr>
<tr>
<td></td>
<td><em>vraa-schoor</em> (<em>kraa-schoor</em>)</td>
<td><em>smaa-skoom</em> (<em>snaa-skoom</em>)</td>
</tr>
<tr>
<td></td>
<td><em>schier-den</em> (<em>skier-den</em>)</td>
<td><em>smief-gep</em> (<em>smij-gep</em>)</td>
</tr>
<tr>
<td>3</td>
<td><em>ocht-ver-schie</em></td>
<td><em>olg-hep-zwie</em></td>
</tr>
<tr>
<td></td>
<td><em>hiek-en-taar</em></td>
<td><em>jieg-ep-jaaaf</em></td>
</tr>
<tr>
<td></td>
<td><em>mee-slooo-dek</em></td>
<td><em>bee-ploo-pem</em></td>
</tr>
<tr>
<td></td>
<td><em>blet-slos-lent</em></td>
<td><em>flef-twop-sept</em></td>
</tr>
<tr>
<td></td>
<td><em>praat-trent-elt</em></td>
<td><em>knaa-knerf-eë</em></td>
</tr>
<tr>
<td>4</td>
<td><em>ost-miel-noo-ste</em></td>
<td><em>opt-jiep-zoo-pje</em></td>
</tr>
<tr>
<td></td>
<td><em>nark-ik-stoo-riek</em></td>
<td><em>kasp-ip-knoo-pief</em></td>
</tr>
<tr>
<td></td>
<td><em>bup-noo-kon-daal</em></td>
<td><em>lug-poo-hop-baan</em></td>
</tr>
<tr>
<td></td>
<td><em>goom-dram-ruk-tant</em></td>
<td><em>toof-knit-buf-wapt</em></td>
</tr>
<tr>
<td></td>
<td><em>drui-blor-an-se</em></td>
<td><em>frui-smol-ak-je</em></td>
</tr>
</tbody>
</table>

*Note:* Stressed syllables are italicized. A schwa is indicated by e. The wordlike pseudowords were also employed in the phoneme detection test. Discrimination test items were developed from pseudowords, which are followed by a similar item in parenthesis (combination with the pseudoword in parenthesis produced a “different item”).

to the subjects by means of a simple cassette player. The subjects were instructed that they would hear strange words, and that they should repeat each word as accurately as possible. The tape was stopped in cases where a subject needed more than 5 seconds. Incorrect responses were immediately transcribed. A tape-recording was made of each session for checking the transcriptions. There were three practice items.

The phoneme detection test used only the 20 most wordlike pseudowords. A cassette tape had been prepared with these items in a random order and a between-item interval of 5 seconds. The subjects’ task was to verify whether the pseudoword contained an /s/: “You know the sound of a snake? It is the sss. Listen carefully and raise your hand if somewhere in the word you hear the sound of a snake.” An item was scored correct if the subject correctly indicated whether the pseudoword did or did not contain an /s/. There were three practice items.

A one or two syllable pseudoword was used to make two items for the discrimination test: one consisting of a repetition of the word (same item), and one consisting of the pseudoword and a slightly different version of the
Table 2. Mean number correct (SD within parentheses) for pseudoword repetition, phoneme detection, and word discrimination conditions, split by reader group

<table>
<thead>
<tr>
<th>Pseudoword repetition (max. = 5)</th>
<th>Poor readers</th>
<th>Normal readers</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 syllable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wordlike</td>
<td>3.95 (.87)</td>
<td>4.36 (.81)</td>
<td>4.17 (.85)</td>
</tr>
<tr>
<td>less wordlike</td>
<td>3.76 (1.18)</td>
<td>4.72 (.54)</td>
<td>4.28 (1.00)</td>
</tr>
<tr>
<td>2 syllable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wordlike</td>
<td>3.38 (1.24)</td>
<td>3.64 (.91)</td>
<td>3.52 (1.07)</td>
</tr>
<tr>
<td>less wordlike</td>
<td>2.38 (1.40)</td>
<td>3.28 (.79)</td>
<td>2.87 (1.19)</td>
</tr>
<tr>
<td>3 syllable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wordlike</td>
<td>2.87 (1.15)</td>
<td>3.60 (.96)</td>
<td>3.00 (1.23)</td>
</tr>
<tr>
<td>less wordlike</td>
<td>1.67 (1.23)</td>
<td>2.48 (.96)</td>
<td>2.11 (1.16)</td>
</tr>
<tr>
<td>4 syllable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wordlike</td>
<td>.95 (1.24)</td>
<td>1.48 (1.05)</td>
<td>1.24 (1.16)</td>
</tr>
<tr>
<td>less wordlike</td>
<td>1.05 (.81)</td>
<td>1.64 (.86)</td>
<td>1.17 (.88)</td>
</tr>
</tbody>
</table>

Phoneme detection
{/s/} items (max. = 11)          
10.57 (.68)                      
8.10 (.83)                       

No /s/ items (max. = 9)          
10.76 (.44)                      
8.68 (.48)                       

Discrimination (max. = 20)       
“Same” items                     
17.86 (1.91)                     
17.71 (1.31)                     

“Different” items                
18.72 (1.24)                     
18.28 (1.02)                     

pseudoword (different items). Alterations were produced by replacing a consonant or a vowel by another one or by deleting or adding a consonant. The resulting 40 items were tape-recorded in a random order, with word order in the different items randomized. The interval between items was 5 seconds; the interval between words in an item was 1 second. Subjects were required to raise their hands if the words of a pair were different. The response to an item was scored correct if the subject correctly indicated whether the two pseudowords in an item were identical or not. The task was practiced with three items.

Procedure

The CPM, the pseudoword repetition test, the phoneme detection test, and the discrimination test were administered, in that order, in individual sessions. No subject showed evidence of not understanding the experimental task, neither with the practice items nor with the proper test items.

RESULTS

Effects in the pseudoword repetition test data were tested by means of an analysis of variance, with reading group as a between-subjects factor, pseudoword length (one, two, three, or four syllables) and wordlikeness (low or high) as within-subjects factors, and number correct as the dependent variable (see Table 2 for the pertinent mean scores). The difference between the reader groups was significant, F(1, 44) = 21.92, p < .001,
with the poor readers having lower scores, $M = 19.42$, $SD = 5.15$ than the normal readers, $M = 25.20$, $SD = 3.10$, as expected. Main effects were also found for wordlikeness, $F(1, 44) = 10.05, p < .01$, and pseudoword length, $F(3, 42) = 185.17, p < .01$. All comparisons between adjacent levels of pseudoword length were significant (all $p < .01$), with longer words being more difficult. The interaction of wordlikeness and word length (see Figure 1) was also significant, $F(3, 42) = 5.21, p < .01$. Effects of wordlikeness were only significant for the two and three syllable pseudowords, $F(1, 44) = 7.69, p < .01$, $F(1, 44) = 16.70, p < .01$, respectively.

The interactions of reader group with wordlikeness and pseudoword length were not significant, $F < 1$, $F(3, 42) = 1.82$, respectively. The second order interaction of reader group, wordlikeness, and pseudoword length was also not significant, $F(3, 42) = 1.68$. Thus pseudoword repetition by poor readers appears not to be differentially influenced by the frequency of occurrence of the consonant patterns or by the memory load involved.

Because the reader groups differed significantly in their reading test scores, the analysis was repeated with the OMT scores as a covariate. Neither the main effect of reader group nor any interaction in which reader group was involved changed from significant to insignificant, or vice versa. Correction for the effect of the covariate made the mean repetition scores of the poor and the normal readers changed only slightly, from 19.42 to 19.75 and from 25.20 to 24.88, respectively.

An analysis of variance of the phoneme detection test data used reader group as a between-subjects factor, presence or absence of the target phoneme /s/ as a within-subjects factor, and the proportion of correct responses as the dependent variable. The difference between the reader groups was significant, $F(1, 44) = 9.68, p < .01$, with the poor readers scoring lower (93% correct) than the normal readers (97% correct). The
difference between pseudowords with and without /s/ was also significant, $F(1, 44) = 8.08, p < .01$. Correct responses were more frequent for words containing /s/. There was a near-significant interaction between reader group and presence or absence of the target sound, $F(1, 44) = 3.26, p = .08$. This interaction is probably due to the normal readers' ceiling scores (98%) for the words with /s/.

Next, we sought to verify whether the pseudoword repetition difference between the reader groups could be explained by their phoneme detection score as an index of their insight into the phonological make-up of spoken words. An analysis of variance was done with the pseudoword repetition scores as the dependent variable, reader group as a between-subjects factor, and the phoneme detection scores as a covariate. Indeed, there was no longer a significant difference between the reader groups, $F(1, 42) = 1.36, n.s.$

An analysis of variance of the discrimination test data, with reader group as a between-subjects factor, item type (different or equal pairs) as a within-subjects factor, and number correct as the dependent variable, showed a significant effect of reader group, $F(1, 44) = 7.58, p < .01$, an insignificant difference between item types, $F(1, 44) = .84, n.s.$, and an insignificant interaction of reader group and item type, $F(1, 44) = .22, n.s.$ Averaged over item types, poor readers scored 89% correct, and normal readers, 96%. With the discrimination test scores as a covariate, the difference between the reader groups in their pseudoword repetition scores again was no longer significant, $F(1, 42) = 2.23, p = .14$. In a statistical sense, then, the pseudoword repetition difference between the two groups could be explained by their difference in phoneme detection and in word discrimination.

DISCUSSION

Pseudoword repetition performance indeed was influenced by the factors suggested by Gathercole et al. (1991). Syllabic length, as well as degree of wordlikeness, were determinants of repetition scores. Unlike in the study by Gathercole et al., however, these factors were not independent, but interactive. Figure 1 suggests that there may have been a facilitating effect of wordlikeness for items with two or three syllables, but that the addition of a fourth syllable to wordlike nonwords definitively overloaded most subjects' capacity for repetition. Syllabic length, wordlikeness, and their interaction, however, appeared not to be relevant for the difference in repetition performance between both reader groups, because these factors did not differ in their effects on the two reader groups. As a consequence, the cause of the poor readers' inferior repetition performance should not be sought in restricted phonological memory, nor in the limited availability of the phototactic units from which words are composed.

The repetition difference might be explained, however, by differences in phonological segmentation ability, as suggested by Snowling et al. (1991). The reader groups appeared to differ in their segmentation ability, as deter-
mined by the /s/-detection task, and statistical correction for this difference eliminated the difference in pseudoword repetition scores. The pseudoword repetition difference then could follow from the inability to analyze the target words into building blocks for the assembly of the corresponding articulation programs. That poor readers have lower phonological segmentation scores is a fact that has been established rather firmly in the literature. But, just as for the question of whether poor reading is the consequence or the cause of poor segmentation ability (e.g., Wimmer, Landerl, Linortner, & Hummer, 1991), poor segmentation ability could be the consequence or a corollary rather than the cause of the central problem in pseudoword repetition. After all, the segmentation of a word—even with such an undemanding task as phoneme detection—requires that it be retained in working memory for some time, perhaps by subvocal rehearsal and, if so, involves some kind of word repetition. Phonological segmentation, however, is much easier than pseudoword repetition (see Table 2). Good pseudoword repetition ability, therefore, is unlikely to be a necessary requirement for phonological segmentation, unless overt repetition is more difficult than subvocal rehearsal only because of additional task demands that are not correlated with the between-group difference. And, as our discussion of the literature shows, there indeed is some evidence that the between-reader group difference does not arise in the final, articulatory stage of overt response production. Catt's (1986) observation that his dyslexic subjects were apparently aware of differences between their responses and the items to be repeated constitutes counterevidence only if it can be shown that they do so proportionately more often than normal readers.

We also found a between-group difference in auditory discrimination, which statistically explains the difference in pseudoword repetition scores. It is reasonable to assume that the auditory discrimination task used in this experiment was of a global nature, did not involve an element-by-element comparison of the two words, and therefore did not require word analytic operations. Since the between-group difference was found on tasks that most likely did not require word segmentation, it can be argued that the central problem of these children did not lie in phonological segmentation, but already existed in early stages of input registration and was, perhaps, of a "perceptual" nature. However, the same doubts concerning the relation between phoneme detection and pseudoword repetition can be raised regarding the relation between auditory discrimination and pseudoword repetition. Since the auditory discrimination task in our study required the short-term retention of at least one word, which perhaps was done by subvocal rehearsal, the same reasoning can be applied to the relation between auditory discrimination and pseudoword repetition. It is unlikely, however, that the differences between reader groups on the phoneme detection task and the auditory discrimination tasks should be explained from a difference in subvocal rehearsal ability, because such a difference would predict an interaction of reader group and number of syllables in the word to be rehearsed. But, as we have seen, even in overt repetition no such interaction is found.
Differences between reader groups in auditory discrimination performance have been found in other studies as well (De Weirdt, 1988; Godfrey, Syrdal-Lasky, Millay, & Knox, 1981; Reed, 1989; Werker & Tees, 1987), even with nonspeech stimuli (De Weirdt, 1988; Reed, 1989; Tallal, 1980). A difference in the discrimination of nonspeech stimuli would preclude a rehearsal deficit as an explanation of the relation between the repetition and the discrimination deficit that we found in the poor readers. Care should be taken, however, in relating our results to these findings because pseudoword repetition performance was not measured in the latter studies, and it is not certain, except in De Weirdt's study, that the poor readers' discrimination deficit with nonspeech stimuli was accompanied by a pseudoword repetition deficit. It should be remarked that the poorer repetition, segmentation, and discrimination results in the poor readers might have originated from differences in hearing acuity, except that no participating child had a permanent hearing loss at the periodic medical examinations.

The present study replicates the pseudoword repetition deficit found in English-speaking poor readers among Dutch children with a reading disability, even though Dutch is a language with a relatively shallow orthography. In this respect, our findings contrast with those of Wimmer (1993), who found no such repetition difference in German-speaking reader groups. According to Wimmer, the results of his study show that German dyslexics do not suffer from impairments in basic perceptual and memory processes associated to spoken language input; he related this to differences between the respective orthographies. German has a more regular and shallow phonetic writing system than English, which makes the German writing system easier to learn and causes reading education in German-speaking countries to be more phonics-oriented. Wimmer inferred that the basic reading difficulties of a German sample of dyslexics may be of another kind than those of an English sample.

If Wimmer is correct, then there also should be no pseudoword repetition deficit in Dutch dyslexics, as the Dutch situation is comparable to that of German on the main points mentioned by Wimmer. (See Reitsma & Verhoeven, 1990, for a concise description of Dutch orthography and of early reading instruction in the Netherlands.) Our data, however, suggest that Wimmer's negative findings most likely do not originate from a shallow orthography causing another "type" of children to be poor readers. They also cannot be explained by a difference in age between the subjects of Wimmer's study and ours. Our normal readers were second graders, and according to their ages, our poor readers should have been in fourth, fifth, and sixth grades. Wimmer's subjects (poor and normal) stemmed from second, third, and fourth grades and scored far below ceiling level. For the time being, we prefer to consider Wimmer's results as spurious, perhaps originating from subject sampling variation or limited test reliability.

The conclusion from our results is that, in Dutch, a language with a relatively shallow orthography, there is a difference in pseudoword repetition ability between normal readers and children with reading disabilities. This difference is caused neither by a difference in memory for linguistic
materials, nor by a differential acquaintance with phoneme sequences that are phonotactically legal. The poor readers' deficit is not restricted to pseudoword repetition, but is also found in perceptual tasks that do not require overt speech production and involve only a minimum of processing for response determination.

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