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Published in:
Psychological Research = Psychologische Forschung: An international journal of perception, learning and communication

Document version:
Author final version (often known as postprint)

Publication date:
1991

De Gelder, B., & Vroomen, J. (1991). Phonological deficits: Beneath the surface of reading-acquisition problems. Psychological Research, 53, 88-97.

Phonological deficits: Beneath the surface of reading acquisition problems

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Abstract

In experiment 1, the performance of young retarded readers on speech-segmentation tasks was compared with the performance of normal subjects matched on chronological age (CA) and with subjects matched on reading age (RA). Retarded readers were poorer than both control groups in consonant deletion, while there was no difference between the groups on a rhyme-judgement task and a syllabic-vowel reproduction task. In experiment 2, we compared another group of reading retarded children with CA and RA controls on the classification of pseudowords, either by common phoneme or by overall phonetic similarity. The retarded readers made less classifications based on common phoneme than both control groups, while there was no difference between the groups in classifications based on overall phonetic similarity. In experiment 3, adult developmental dyslexics were compared with normal adults on the tasks of experiments 1 and 2. The dyslexics made fewer classifications based on a common phoneme than the normals, while no difference was found in classifications based on overall phonetic similarity.

Introduction

Developmental dyslexia is a disorder of reading skill. More specifically, it is a disorder linked to the way that skill ought to develop. Some aspects of the disorder of reading acquisition might be linked to phonological deficits manifesting themselves on the occasion of reading acquisition. However, phonological deficits might over time be compensated for to some extent by the limited success of reading acquisition itself. The present study explores to what extent some aspects of metaphonological skills might be manifestations of a phonological deficit.

Reading, the skill, the acquisition and its pre-requisites

Most commonly, developmental dyslexia manifests itself on the occasion of reading acquisition. Moreover, developmental dyslexia is plainly a specific reading disorder in the sense that in principle no other skills are affected than the ability to read. As cases of acquired dyslexia show, our understanding of reading disorder in recent years has benefitted greatly from relying upon a structural model of skilled reading. In the same spirit efforts at understanding developmental dyslexia have been undertaken by taking as point of departure the structure of the basic reading functions (Seymour, 1986).

There are reasons to believe that structuralist models need to be complemented with proposals about the development of the disorder. Developmental dyslexia is a disorder that is less a matter of impaired exercise of a skill than of its development. Theoretical models of the development of reading skill and the acquisition of literacy can play a role analogous to that of skilled reading alluded to above. The notion is that models of development trace the route that must be travelled by the

apprentice reader if skilful reading is to be the outcome. Examples of this approach are proposed by Marsh et al., (1981), Seymour (1986), and Frith (1985).

Theoretical models of development run the risk of oversimplifying the acquisition process. The typical approach of stage theories consists of defining successive prototypical achievements. If change towards approximating the expected performance at one given moment does not occur, it becomes impossible to reach the next platform (for a recent example of that approach, see Morton, 1989). Stage theories of reading acquisition might be somewhat normative and, moreover, focus more on subsequent development than on a description of the initial state of the learner. A study by Stuart and Coltheart (1988) reveals a difficulty with current stage theories that is informative in the present context. The authors have shown that the extent to which apprentice readers start from the logographic stage of reading acquisition depends on their pre-existing phonological skills.

With the conclusion reached by Stuart and Coltheart the student of reading acquisition disorders is sent back to a tradition of reading acquisition investigating the phonological skills critical at the onset of literacy. Research on reading acquisition has been dominated for at least 15 years by the notion of phonological awareness (see Bertelson, 1986 for a critical overview). Studies of the relation between phonological awareness and reading ability use a wide range of metaphonological tasks ranging from intuitive rhyme judgement to explicit metaphonological segmentation tasks (for a review see Morais et al., 1987) which are reliable and valid indicators of the phonemic awareness needed for and developed in the course of reading acquisition (Yopp, 1988). Obviously, the fact that

segmentation tests are reliable and valid measures of phonemic awareness does not imply that phonological awareness is a cause of segmentation skills or that lack of phonological awareness is to be blamed for the absence of segmentation skills. Conclusions as these can be reached only when it is understood how the connection gets established between prerequisites for reading acquisition and reading skill.

The emergence of phonological awareness and its heterogeneity

The major trouble is that by themselves studies on segmentation skills give little indication of the modules implicated in the emergence of phonological awareness or of the development of segmentation skills. This is in part due to the historical origin of the notion of phonological awareness. When first used in the late sixties and early seventies, phonological awareness was assimilated to so called metalinguistic skills. In the Chomskyan framework of the seventies metalinguistic skills counted as the conscious manifestation of underlying knowledge of linguistic rules (Rozin and Gleitman, 1977). It was, typically, a perspective that tended to chart developmental questions along only a single continuum, going from implicit to explicit knowledge of linguistic competence and replacing the notion of acquisition with that of access (Rozin, 1976).

It is not clear whether research results obtained in the last fifteen years or so might be plotted along a single implicit vs. explicit continuum. Studies on bi-lingual speech perception (e.g., Cutler et al., 1986), on segmentation skills in non-literate adults (Bertelson et al., 1989; Morais et al., 1986a) and in non-alphabetic literates (de Gelder et al., 1990; Read et al., 1986; for a review see Bertelson and de Gelder, 1989) as well as the peculiar difficulties of dyslexics might require a proper theory of the development of

metaphonological skills. Two options are open. One can favour the view that phonemic awareness is displayed already in appreciation of nursery rhymes and develops later into more sophisticated metaphonological skills like initial consonant deletion. In that case awareness is a single, unitary or homogeneous ability explaining as well the early as the later more sophisticated achievements (Bradley and Bryant, 1983).

The other option consists in treating the set of so-called metaphonological abilities as a heterogeneous one (Bertelson and de Gelder, 1990; de Gelder, 1990). Different metaphonological abilities might rest on different representations and processes. Heterogeneity also means that the various metaphonological abilities would be different from the point of view of their developmental mechanisms. In the present experiments the latter perspective is brought to the study of reading retarded subjects.

There is growing evidence that at least some aspects of phonological awareness depend on reading acquisition while others don't (Bertelson and de Gelder, 1990; Morais et al., 1987; for a review see de Gelder, 1990). Some of these component skills are present in pre-readers, in illiterates, in non-alphabetic literates and also in dyslexics. Comparative studies of phonological awareness and segmentation skills of pre-readers (Content et al., 1986), of illiterates (Bertelson et al., 1989; Morais et al., 1986a) and of non-alphabetic readers (de Gelder et al., 1990) offer evidence for the heterogeneity of metaphonological abilities.

Some metaphonological abilities like rhyme judgement and vowel deletion develop to a large extent spontaneously, independently of school instruction. Others, like the ability needed for consonant deletion, seem to be strongly dependent on instruction. One way of making sense of the interdependency between phonological awareness and reading acquisition

is to view phonological awareness of fluent readers as a complex skill constructed from a variety of building blocks. It consists of a set of separate component skills like, for example, sensitivity to rhyme, auditory discrimination, syllabic segmentation, phonemic manipulation skill, phonological coding in short term memory. From this perspective the emergence of phonological awareness might be compared to a process whereby an interface is constructed between a set of available, possibly modular linguistic skills and graphic, external representation of spoken language acquired as a consequence of explicit instruction. If the notion of phonological awareness refers to a vast collection of skills, failure to acquire normal literacy, as exhibited by some so called phonological dyslexics, have as many causes as there are subcomponents that enter into the construction of full phonological awareness typical of skilful readers.

Comparative studies of phonological skills promise to yield a more detailed picture of the distinctions that need to be made here. Comparisons between subjects with different degrees of literacy allow us to sort out the extent to which each of the more explicit segmentation skills depend on literacy (Bertelson and de Gelder, 1990; de Gelder, 1987; Morais et al., 1987). The study of reading retarded populations is of particular importance for the insight it might give into the prerequisites of successful literacy training. The study of retarded readers is a source of critical evidence to complete the picture of phonological skills. Why then has extensive literacy training failed to bring about not only reading skill but also, the degree of phonological awareness comparisons with non-alphabetically trained populations leads us to expect? Might it be that the take-off platform for literacy training was not the same to begin with? Obviously, in the present study we only explore that question in a very limited way without claiming to

identify causes of reading retardation.

The notion of underlying phonological deficits

Studies of reading retarded populations undertaken in the phonological awareness research tradition have made use of metaphonological tasks available in the literature. As a result it is well known that retarded readers have difficulties with phonological awareness tasks (Morais, Cluytens, and Alegria, 1984; Seymour, 1986; Snowling, Stackhouse, and Rack, 1986). In general though studies of metaphonological skills of developmental dyslexics have not systematically made the distinction between different possibly heterogeneous phonological awareness skills. For example, in commenting upon a case of developmental dyslexia, Campbell and Butterworth (1985) have suggested that one and the same phonological input buffer would explain both sensitivity to phonological similarity and explicit segmentation ability. Examining this claim, Morais et al. (1986b) conclude that there is no correlation between explicit speech segmentation skills and sensitivity to interference from phonological similarity in memory.

More generally, phonological awareness itself represents only one domain of phonological skills. Clearly, there is no reason to expect that in reading impaired populations all phonological operations will be impaired to the same extent. Examining this issue, Wagner and Torgesen (1987) stress the need to distinguish between different kinds of phonological processing, eg. phonological awareness, phonological recoding and phonetic recoding in working memory.

The present study continues the exploration of the phonological awareness skills of retarded readers by looking for developmental

differences in component phonological skills. The hypothesis derived from comparative data leads us to expect that in retarded readers the skills most impaired will be the ones that are critically linked to reading skill. One would expect to find in retarded readers relatively poor explicit segmentation skills, as observed in Morais et al. (1984) contrasting with good rhyme detection ability. Obviously, to be conclusive, the observed differences should not simply reflect the difference in reading skill between the groups. Convergence of the result with data from illiterates would be helpful to rule out this possibility. An even more specific interpretation would be possible if the results from reading retarded populations could be compared with the performance of a group matched with the reading retarded subjects for reading skill and another group matched for age.

Results obtained with reading retarded populations might help to clarify some outstanding debates. As a matter of fact, a longstanding issue in discussions on the interdependency between phonological awareness and reading ability concerns the actual explanatory potential of the observed differences in segmentation skills (Cossu and Marshall, 1990; Marshall, 1985; 1989). It has been argued that the observed differences, reliable as they may well be, represent merely correlational evidence. Likewise, it has been suggested that the advantage of alphabetic literates in explicit segmentation tasks might merely be a matter of attention mechanisms and of strategies available as a consequence of their alphabetic knowledge, e.g., orthographic word images, an explicit subsyllabic representation of speech and attentional mechanisms based on orthographic knowledge. As the groups would be matched for reading skill, such strategies should equally be available to older dyslexic subjects who eventually have reached a basic level of reading competence. The

observations might not point to any deep difference between phonological skills of the groups. Ultimately, differences in metaphonological skills might be immaterial for the issue of reading ability.

As a matter of fact, we might not only be able to counter the aforementioned objections but turn them into evidence in support of the phonological deficit view. Clearly, poor segmentation skills of illiterates illustrate the limits of untutored phonemic awareness. In contrast, poor segmentation skills of retarded readers show the limits of what tutoring can achieve and give insight into the conditions that must be met for successful training. In this context we note that the performance of retarded readers after years of intensive tutoring contrasts sharply with the improvement observed in pre-readers after a short training session (Content et al., 1986a).

On the strength of the heterogeneity view one might expect that, in contrast with e.g., initial consonant deletion, phonological abilities like rhyming might merely consist of judgments of overall phonetic similarity (Bertelson et al., 1989; Bertelson and de Gelder, 1990) and not require that a segmented representation of speech be available. This view is supported by data showing that rhyme judgement ability is a relatively poor predictor of reading skill (Lundberg, 1988; Stanovich et al., 1984). In the domain of developmental reading retardation indirect support for this interpretation comes from data mentioned above showing that good readers and retarded readers are equally sensitive to interference from rhyming material in short term memory tasks (Morais et al., 1986b).

A more direct way of testing this interpretation might be available if a task could be found which required neither a rhyming judgement nor an explicit phoneme manipulation. For this purpose we designed a forced-

choice task where subjects are asked to match a given pseudo-word with either a probe sharing the initial phoneme with the target or a probe sharing overall phonetic similarity, depending on their own preferences. To the extent that there is link between explicit initial phoneme segmentation tasks, reading skill and implicit representations, subjects showing poor initial consonant segmentation skill might be expected to opt for overall similarity pairs.

One might obtain an even more conclusive evidence from the study of adult retarded readers. Unfortunately, very little research is available on these populations. Case studies have been reported in Temple and Marshall (1983), Seymour and MacGregor (1984). Campbell and Butterworth (1985) report extensively on a case of an adult phonological dyslexic who has acquired fluent reading skills but performs poorly on phonological awareness tasks. Their observations suggest the possibility that in adult retarded readers traces of a phonological dysfunction remain and that the original phonological problem is not overruled either by reading acquisition itself or by compensatory strategies generated over time. The differential performance pattern on phonological skills of adult phonological dyslexics would put one more firmly on the trace of identifying the phonological prerequisites needed for successful reading acquisition.

EXPERIMENT 1

Method

Subjects

Three groups of subjects were tested, a dyslexic group, a group of children individually matched on reading age (RA) with the dyslexics, and a

group individually matched on chronological age (CA). All subjects were given a standard reading test (Brus and Voeten, 1973) which required reading aloud Dutch real words for one minute. All were native Dutch speakers and reported normal hearing. The subjects in the control groups did not lag behind in their reading age. The dyslexic group consisted of 11 boys and 3 girls. Details are presented in table 1.

Table 1 about here

The dyslexics were children who had been referred to the university services because of their reading problems and were diagnosed as dyslexic. All the children had reading and spelling problems that could not be accounted for by factors such as intelligence, home or school background, neurological, sensory, or emotional disturbance. Nine dyslexic children attended a special school for children with learning problems, two attended a regular primary school and three others attended secondary school. They all followed remedial teaching in reading. Their mean reading age lag was 1:3 to 4:6 yr (M = 2:7 yr).

Subjects in the reading age group (RA) were selected by individually matching their performances on the reading test with those of the dyslexics. This younger group consisted of 10 boys and 4 girls. Subjects in the chronological age control group (CA) were 8 boys and 6 girls, individually matched on chronological age with the dyslexics. Subjects in both control groups were given a shortened version of the WISC. They all attended normal primary or secondary school.

Procedure

Subjects' reading level was determined by means of the Brus-1-minute test (Brus and Voeten, 1973). Subsequently, the experimental tasks were administered. At the end of the test, a shortened version of the WISC-R was administered to determine the intelligence scores of the control-group children.

1. *Rhyme judgement task*: The experimenter explained that she would enunciate two words which sometimes would rhyme and sometimes not. She gave two examples for each category. The test consisted of 20 experimental pairs, all monosyllabic words, 10 rhymed. Subjects were instructed to repeat the word pairs and to judge whether or not the two words rhymed. No corrective feedback was given.
2. *Initial consonant-reproduction and initial vowel-reproduction task*: The task was to isolate the initial consonant or the initial syllabic vowel from a pseudoword. Instructions were presented by means of two examples illustrating consonant reproduction and two illustrating vowel reproduction (For example: "when I say "OLAN", you say 'O'"). The task consisted of 10 experimental trials, half of them requiring consonant reproduction and half vowel reproduction. No corrective feedback was given.
3. *Initial consonant-deletion task*: The tasks involved deleting the initial consonant from a pseudoword. 10 monosyllabic and 10 bisyllabic pseudowords were used. Before each set, the experimenter presented two examples (For example: "when I say KUR you say UR"). Correct deletion never resulted in a word. Again, no corrective feedback was given.

Results

Table 2 presents the results of the three groups on rhyme judgement,

initial vowel reproduction, initial consonant reproduction, and initial consonant deletion. On the rhyme task, all three groups performed (nearly) perfectly. According to a analysis of variance (ANOVA) for related designs, there was no significant difference in the percentage of correct responses on this task [$F(2,26) = 1.00$, NS]. Only one dyslexic subject made a single mistake. On the vowel-reproduction task, there was again no significant difference between the groups [$F(2,26) = 1.68$, NS]. Subjects of the two control groups were at ceiling on this task, in the dyslexic group two subjects made one mistake. On the initial-consonant reproduction task, dyslexics performed worse, although the difference between the groups did not reach significance [$F(2,26) = 1.70$, $p = 0.20$]. Compared with the RA group, four dyslexics performed worse on consonant reproduction than their controls. All other dyslexics were at ceiling. The difference was marginally significant according to a non-parametric Wilcoxon matched-pairs signed-ranks test ($Z = 1.82$, $p = 0.07$). Compared with the CA group, four dyslexics performed worse than their controls, one performed better and all other pairs performed equally well ($Z = .9$, $p = .34$). There were significant differences between the groups on initial consonant deletion [$F(2,26) = 7.53$, $p < 0.005$]. Post hoc tests (Fisher's LSD) showed that dyslexics performed worse than the RA group ($\alpha = .05$), and the CA group ($\alpha = .01$). Individual comparisons showed that, compared with the RA group, six dyslexics performed worse than their controls, 5 dyslexics performed better, and three pairs performed equally well ($Z = 1.24$, $p = .21$). Compared with the CA group, 11 dyslexics performed worse than their controls, and three pairs performed equally well ($Z = 2.93$, $p < .01$).

Discussion

The major conclusion from the experiment is that the differences between the groups appear in the initial consonant deletion tasks. In this task dyslexics perform more poorly than the chronological age and reading age controls. The result confirms the importance of a critical distinction among metaphonological skills. The design of the experiments allows more specific conclusions than have been reached in the past concerning that distinction. Moreover, there are some suggestive contrasts with previous comparative studies where the same distinction was shown to be critical. One might be tempted to perceive the contrast between rhyme ability and first consonant segmentation as reflecting the distinction between untutored and tutored phonological awareness. To the extent that the performance of retarded readers reflects the limits of what explicit alphabetic tutoring can achieve, our results might challenge that distinction. We discuss each of these aspects in turn.

Our study strengthens previous conclusions by showing that the observed differences are not due to a difference in degree of literacy. In general, the results confirm earlier findings on the positive relation between basic reading skill and initial phoneme segmentation and on the absence of a relation between reading skill and rhyming ability (for a review see Morais, in press). For instance, a study by Stanovich et al. (1984) shows that a clear correlation exists between reading ability and good performance on tasks requiring a decision on initial consonants. The authors also shows that no such relation obtains between reading and rhyming skill. Similar results have been obtained in a study by Yopp (1988) and by Lundberg (1988).

The fact that dyslexic subjects perform at ceiling on the rhyme judgement task is compatible with findings showing that there is no

difference in the susceptibility to interference from rhyming in memory for verbal information between dyslexics and good readers (Morais et al., 1986b).

So far our discussion of the results has pointed out the similarities between the performance of populations with basic alphabetic reading skills and on the other hand, pre-readers, illiterates, non-alphabetic literates and retarded readers. It might be misleading to put retarded readers in the latter category even if they belong to it as far as their segmentation performance is concerned. Indeed, the most critical aspect of the data is that given the same level of reading skill, dyslexics still perform worse than their reading match. In contrast with pre-readers and illiterates not showing segmental skills and not being exposed to alphabetic training, the dyslexic subjects have had much more training than the average beginning reader. If so, one critical question prompted by the results is how literacy training has failed to result in segmental analysis skills.

It is tempting to look for a cause of the absence of success of tutoring in an underlying phonological deficit. Propositions along that line have been formulated on the basis of poor performance of retarded readers on phonological processing (see reviews by Jorm and Share, 1983; Snowling, 1987). One reason why straightforward conclusions about a phonological deficit will be hard relates to multiple facets of phonological skills. On the strength of the heterogeneity thesis we must expect differences in representations underlying the various components of phonological skills as well as differences in the developmental course of the components. Conclusions concerning links between what might be separate components must remain hazardous. For example, the fact that poor readers are just as susceptible as good readers to interference from rhyme in short term

memory might be taken as evidence against the existence of a phonological deficit in speech representation. From that perspective one might argue that phonological skills depend on metalinguistic knowledge only. Poor metalinguistic skills would then not allow conclusions about an underlying phonological deficit. This conclusion would constitute a rejoinder to the claim that conscious segmentation skills and tasks requiring awareness do not give a good measure of phonological competence per se (Marshall and Cossu, 1987).

Fortunately, we are not limited to analytical arguments. The notion that the relevance of the observations of poor segmentation skills would be restricted to explicit segmentation tasks can be tested by using a task not requiring conscious manipulation of consonants. Evidence of contrasts in performance between the dyslexic subjects and controls would constitute a small step further towards unpacking the above issues. Experiment 2 was designed with that purpose.

EXPERIMENT 2

Method

Subjects

21 new dyslexic children (18 male, 3 female) were tested. They were of average intelligence (at least an IQ of 90 on the Peabody Picture Vocabulary Test or on the Raven Coloured Progressive Matrices), and there were no apparent emotional problems or other complicating factors. The dyslexics attended a school for learning disabled children. They were reading at least 2 years behind their norms as measured by the Brus 1-minute test (Brus and Voeten, 1973). Two control groups of normal readers

were chosen from a middle-class elementary school. One group consisted of 18 children (8 male, 10 female) matched on chronological age (CA) with the dyslexics, the other group consisted of 19 children (15 male, 4 female) matched on reading age (RA). Details of the groups are presented in table 3. No gross speech or hearing disorder was reported for any child at the time of testing, and all subjects were native speakers of Dutch.

Table 3 about here

Stimuli and Design

24 triads of monosyllabic nonsense words were used. One pair of the triad always shared the initial phoneme, while another pair was phonetically more similar. For example, in the triad /pIm/, /bin/, /pas/, the common-phoneme pair is /pIm/ and /pas/, the phonetic-similar pair is /pIm/ and /bin/, and the anomalous pair is /bin/ and /pas/. The phonetic similarity of a pair was calculated as in Treiman and Bréaux (1982) on the basis of similarity ratings of phonemes (Singh and Woods, 1971; Singh, Woods, and Becker, 1972). The sum of the similarity ratings of each pair of corresponding phonemes was taken as the phonetic similarity of a syllable pair. The stimuli were produced by a female speaker who assigned approximately equal stress to the syllables of a triad. The stimuli were recorded on a cassette recorder (Audio-Visual, model D6920) using a high-quality microphone.

Procedure

Each subject was tested individually in a single session. The session included the classification task, an assessment of reading ability (Brus 1-

minute test) and IQ (Peabody Picture Vocabulary Test and Raven Progressive Matrices for Children). Only subjects that passed the criteria for reading and IQ were administered the classification task. In the classification task, subjects were told that they would hear three pseudo-words. One of the three was an odd one because it sounded different from the rest. Subjects had to indicate which was the odd one. As an example, a rhyming pseudo-word pair and a pseudo-word that did not share any phoneme with the rhyming pair was given by the experimenter (/bam/, /zam/, and /gIk/). When subjects classified the right item, /gIk/ as the odd one, testing began. The items were presented by a cassette recorder at a comfortable listening level.

Results

Table 4 presents the mean proportion of common phoneme classifications (CP), overall (phonetic) similarity classifications (OS), and anomalous classifications (AC). Three separate ANOVAs were performed on these proportions. An ANOVA on the proportion of CP responses indicated that there was a main effect of subject group [$F(2,55) = 3.63$, $p < .05$]. Post hoc analysis (Fisher's LSD, $\alpha = 0.05$) showed that the chronological age group made more classifications based on a common phoneme than dyslexics and reading age controls. There was also a significant difference in the proportion of AC classifications [$F(2,55) = 5.57$, $p < .01$]. Again, post hoc analysis indicated that the chronological age group made less anomalous classifications than dyslexics and reading age controls ($\alpha = .01$). The proportion of OS classifications did not differ between the groups [$F(2,55) = 1.09$, NS].

Table 4 about here

Comparisons between groups are, however, complicated because the chronological age group made less AC-classifications. To correct for random guesses it is assumed that a subject can be in one of three states (see also Treiman and Bréaux, 1982). In the "common phoneme state", the subject makes CP-classifications, in the "overall similarity state" , the subject makes OS-classifications, and in the "guessing state", the subject makes CP-, OS-, and AC-classifications with equal probabilities. If cp is the probability of the common phoneme state and os is the probability of the similarity state, it follows that cp = p(CP)-1/3 p(AC) and os = p(OS) - 1/3 p(AC). The individual proportion of cp, os, and guess states were submitted to 3 separate ANOVAs with group as between-subjects factor. An ANOVA on the proportion of cp states indicated that there was a main effect of group [$F(2,55) = 6.28$, $p < .005$]. Post hoc analysis (Fisher's LSD, $\alpha = .01$) showed that the chronological age group was more often in a cp state than the dyslexics and the reading age group. The chronological age group was also less often in a guess state than the other groups [$F(2,55) = 7.14$, $p < .005$; Fisher's LSD, $\alpha = .01$]. No difference between the groups was found in the proportion of os states [$F(2,55) = 1.69$, NS].

Table 5 about here

Thus, correcting for guessing does not lead to different conclusions:

the better readers are more sensitive to common phoneme relations and make less guesses.

Discussion

Experiment 2 was conducted in order to find out whether the initial consonant segmentation problems observed in the first study would also be found in a task not requiring conscious identification and manipulation of phonemic segments. The data show that both retarded readers and reading age controls show less preference for matching pseudo-words by common first consonant and make more guesses in answering than the chronological age group. This finding contrast with the results of experiment 1 where a difference between retarded readers and reading age controls was observed for the explicit segmentation task.

It has been suggested that metaphonological tasks like the initial consonant deletion task might not allow inferences about underlying representation of spoken language (e.g., Marcel, 1983). It has also been argued that conscious segmentation skills or phonological awareness do not play an essential role in reading acquisition (Cossu and Marshall, 1990). If so, poor performance at metaphonological tasks could hardly offer evidence about a deficit at an implicit processing level. The present task relies much less on awareness and explicit segmentation. The results of this experiment show that in a task not requiring conscious manipulation of phonemes the reading retarded subjects are not at a disadvantage.

Taken together, the results of experiment 1 and 2 suggest that the effect of the first months of reading instruction on other components of phonological awareness than phoneme segmentation is not so instantaneous as is sometimes assumed. The comparison between the two

control groups highlights the limited effects of alphabetic instruction. In normal subjects alphabetic instruction leads within a couple of months to a sudden dramatic increase in phonemic segmentation skills (see Morais et al., 1987, for a review). The present result suggests that development of underlying, less explicit speech representations might follow a slower time course. The few available studies on phonological development (for a review see Morais, in press) and on speech sound categorization (de Gelder and Vroomen, 1988; Massaro, 1987) also suggest that phonological development continues some time beyond the standard age of reading acquisition.

Having found that there is a discrepancy between phonological skills of retarded readers and controls in tasks of explicit segmentation (experiment 1) vs. more implicit tasks (experiment 2) the question arises on the development of these abilities over time and the selective influence of reading acquisition on phonological skills. The study of a population of adult developmental dyslexics makes it possible to investigate modifications in segmentation skills over a longer time. In adult dyslexics reading tuition has continued and some basic reading skills have been achieved. Experiment 3 was designed to gain insight into the long term evolution of the explicit and implicit segmental abilities.

EXPERIMENT 3

Method

Subjects

10 adult developmental dyslexic subjects (6 male, 4 female) were tested. During childhood, all had experienced major reading problems that could not be accounted for by general intelligence, emotional problems, or

lack of tuition. At the time of testing, subjects could read, although most complained about not being able to read fast. Reading scores were measured by the Brus 1-minute test (Brus and Voeten, 1973). Because of possible ceiling effects with normal controls, subjects also had to read as fast as possible a list of pseudo-words in one minute. Pseudo-words were created by changing one or two phonemes of Dutch words. A control group of 17 normal adult readers (9 male, 8 female) was chosen. Details of the groups are presented in table 6. No gross speech or hearing disorder was reported for any subject at the time of testing, and all subjects were native speakers of Dutch.

Table 6 about here

Stimuli and Design

The same stimuli as described in experiment 1 and 2 were used. In addition, an initial vowel deletion task was used in which the subjects had to delete the initial syllabic vowel of a bisyllabic word (For example: "when I say "APA" you say 'PA'").

Results

Table 7 presents the mean proportion of correct responses on these tasks. As can be seen, all subjects were (almost) at ceiling; there were no significant group differences according to analysis of variance on the proportion of correct responses (all $p > .10$). All subjects performed perfectly at rhyme judgement, vowel production, and consonant production. One

dyslexic subject made mistakes at consonant deletion, and two dyslexics made a single mistake with vowel deletion.

Table 7 about here

For the classification task, the mean proportion of common phoneme classifications (CP), overall similarity classifications (OS), and anomalous classifications (AC) of each group are presented in table 8. Three separate ANOVAs for each classification were

Table 8 about here

performed. Normal adults made more CP classifications [$F(1,25) = 8.61$, $p < .01$] and less AC classifications [$F(1,25) = 10.65$, $p < .005$] than dyslexics. There was no significant difference in OS classifications [$F(1,25) = 3.27$, $p = .08$]. Correcting for guessing (as in experiment 2) did not change the pattern of results. Table 9 shows the mean percentage of common phoneme states (cp), overall (phonetic) similarity states (os), and guess states. Normal subjects were more often in a cp state [$F(1,25) = 13.14$, $p < .005$] and less often in a guess state [$F(1,25) = 12.17$, $p < .005$] than dyslexics. No difference was found for the os state [$F(1,25) < 1$].

Table 9 about here

Discussion

The two groups perform at ceiling on the rhyme judgement task and on each of the metaphonological tasks. In contrast, on the matching task we observe pretty much the same picture of a marked preference for overall similarity judgements that was found in the previous experiment with young retarded readers. The major finding of this experiment concerns the difference in performance between the explicit segmentation task and the implicit matching task. The data show that the former but not the latter improves together with improvement in reading skill. This result, important in itself, also allows us to elaborate and strengthen the points made in the discussion of the results of Experiment 2.

The observed contrast in developmental course between two phonological awareness tasks suggests that the two types of tasks are indeed different in the sense that each requires another component of phonological skills, different from the other in developmental course and possibly also in underlying representations and processes. Moreover, the two tasks are not equally sensitive to influences from reading acquisition itself. This suggests that in adult retarded readers good performance at phonemic segmentation, classification and reading skill are three different matters. Performance on the classification task -which presumably offers evidence about a more implicit level of representations- seems much less related to reading skill than phoneme segmentation. However, explicit segmentation skill shown by our subjects contrasts with relatively poor

performance on the pseudo-word reading task. This finding can be compared with poor phonemic awareness skills and poor pseudo-word reading reported in Campbell and Butterworth (1985). One must note though the absence of data on the standard segmentation tasks we use here. Like them we find that given basic reading skills, reading of pseudo-words in phonological dyslexics remains poor.

The findings of experiment 3 illuminate the remarks made in the discussion above. It would seem that there is indeed reason to worry about the criticism addressed at explicit segmentation tasks. As our data show, good performance on such tasks may result from extensive reading training and remedial tutoring more than from reading skill. The risk one runs is that good performance on phonological awareness tasks could become a goal in itself, disconnected in terms of causal efficacy from any real improvement in reading skill or from any real modification of the underlying phonological representations that need to be present for normal reading acquisition.

General discussion

The present experiments were conducted in order to find out (1) whether the distinction between rhyming ability and segmental awareness is critical for our understanding the problems of retarded readers; (2) whether the impaired segmentation skills might also be manifest at an implicit level of processing more suggestive of a possible phonological deficit and (3) whether such a phonological deficit might be manifest itself in adult developmental dyslexics having acquired some basic reading skill and performing normally on metaphonological tasks.

Suggestions of phonological deficits underlying reading problems in some populations have been formulated for some time now. Frith (1985)

rightly remarks that no coherent picture of a phonological dysfunction has emerged from available studies. Her alternative, developmentalist explanation proposes to account for the observations of performance of retarded readers by focusing on compensatory strategies cropping up as deviational routes along the normative developmental path. It remains to be seen whether a unified picture is what one should hope for. We believe as do Liberman and Liberman (1990) that the notion of a phonological deficit represents our best chance for understanding developmental manifestations of phonological dyslexia. The present data suggest the need for descriptions of underlying phonological representations that are more fine-grained than the ones needed for rhyme judgment and less detailed than or different from phonemic representations. Our results give a more detailed picture of the precise nature of poor performance on phonological awareness tasks and of the implicit sound classification skills of poor readers. Further research might tell whether the absence of effect of alphabetical training in dyslexics is indeed due to a specific impairment in phonological representations. Our data suggest that sufficiently sensitive tasks do bring out persisting differences in phonological representations. Existence of underlying phonological deficits might represent an obstacle to successful reading instruction. It is worth noting that reading instruction by itself does not guarantee a normal development of reading skill even if to some extent the explicit segmentation skills associated with it in normal readers do get acquired. Specific conditions that are independent of alphabetic instruction must be present in the organism. These are probably hidden from sight in normal readers where an interactive improvement between reading skill and explicit segmentation ability is commonly observed. To what extent this line of thought might constitute a challenge to

the view that phonological awareness and reading skill develop interactively is a matter of future concern. We noted, following Wagner and Torgesen (1987) that phonological awareness represents but one aspect of phonological skills. We have observed poor serial recall for digit lists in the dyslexic subjects of experiments 2 and 3 (de Gelder and Vroomen, in press). Yet the relation between phonological awareness, as investigated in the experiments reported here, and phonetic recoding in short term memory remains to be investigated.

Moreover, at a more basic level there is a great deal of uncertainty as to a possible link between either of these two and robustness of phonological categories in young and adult dyslexics. We have observed evidence for less robust speech categories both in the auditory and in the visual speech modality in young dyslexics compared to control groups studied in Experiment 1 (de Gelder and Vroomen, 1988). Comparable results have been reported in Werker and Tees (1989). However, we do not find a difference in speech sound categorization between adult developmental dyslexics and normal readers.

A very critical question concerns the impaired development of the reading disorder. At least two options are open. On one account, developmental reading disorders occur in the course of the development of reading skill itself. On another account, abnormal development has its origin in deficits related to the initial situation of the reader. The accounts are not incompatible and data are currently lacking to understand the implications of each perspective.

Observations of impaired phonological segmentation have been made in cases of acquired phonological dyslexia (for an overview, see Shallice, 1988). We have discussed the possibility of a comparison between the

acquired and the developmental disorders elsewhere (de Gelder and Vroomen, 1990). On the face of it, it seems unlikely that impaired segmentation skills observed in acquired dyslexics could be traced back to a phonological deficit present at the beginning of reading acquisition.

If the most obvious thing about development is that there is change (Frith, 1985), then the most obvious fact about disorders of development is that there is no change where there should be. Exactly where there should be change is the question.

Acknowledgements

The present research was partly supported by a research grant from Tilburg University to the first author. We thank H. van der Vlugt for giving us access to the dyslexic subjects and R. Yap for assistance in gathering the data of the first experiment. We are grateful to P. Bertelson and D. Holender for comments on an earlier draft and to M. van Zon for assistance with the manuscript.

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TABLE 1

Experiment 1

Details of the Three Groups

Group	N	Age		WISC IQ (yr:mnth)		Reading age (yr:mnth)	
		Mean	Range	Mean	Range	Mean	Range
Dyslexics	14	11:5	9:4-14:2	104	85-123	8:7	7:3-10:8
Reading age controls	14	8:11	7:7-11:5	116	90-121	8:7	7:2-11:3
Chronological age controls	14	11:5	9:4-14:2			112	92-143
	11:1	8:0-12:6					

TABLE 2

Experiment 1

Percentage of Correct Responses on the Experimental Tasks

Group	Rhyme judgement	Initial vowel reproduction	Initial consonant reproduction	Initial consonant deletion
Dyslexics	98	94.3	80.0	61.0
Reading age controls	100	100	92.8	82.8
Chronological age controls	100	100	98.5	98.9

TABLE 3

Experiment 2

Details of the Three Groups

Group	N	Age (yr:mnth)		IQ Raven		Reading age Peabody	
		Mean	Range	Mean	Mean	Mean	Range
Dyslexics	21	11:1	9:7-12:9	98	111	7:11	7:2-9:6
Reading age controls	19	7:9	6:9-9:11	118	116	8:0	7:3-9:3
Chronological age controls	10:9	18	10:5 8:9-12:6	8:1-12:8		116	124

TABLE 4

Experiment 2

Mean Proportion of Common Phoneme, Overall Similarity and Anomalous Classifications

Group	Common phoneme	Overall similarity	Anomalous
Dyslexics	.37	.36	.27
Reading age	.36	.38	.26
Chronological age	.48	.36	.16

TABLE 5

Experiment 2

Mean Proportion of common phoneme, overall similarity, and guess states

Group	Common phoneme	Overall similarity	Guess
Dyslexics	.13	.11	.76
Reading age	.14	.16	.70
Chronological age	.32	.21	.47

TABLE 6

Experiment 3

Details of the Two Adult Groups

Group	N	Age (yr:mnth)	Reading words		Reading nonsense words	
		Mean	Mean	Range	Mean	Range
Dyslexics	10	27:3	75.7	50-107	38.3	17-54
Normals	17	33:6	100.1	68-116	74.3	52-99

TABLE 7

Experiment 3

Percentage of Correct Responses on the Experimental Tasks (Rhyme Judgements, Vowel Reproduction, Consonant Reproduction, Consonant Deletion, Vowel Deletion)

Group	Rhyme repr.	Vowel repr.	Cons. del.	Cons. del.	Vowel del.
Dyslexics adults	100	100	100	92	97
Normal adults	100	100	100	100	100

TABLE 8

Experiment 3

Mean Proportion of Common Phoneme, Overall Similarity and Anomalous Classifications

Group	Common phoneme	Overall similarity	Anomalous
Dyslexic adults	.41	.39	.20
Normal adults	.65	.26	.08

TABLE 9

Experiment 3

Mean Proportion of Common Phoneme, Overall Similarity and Guess States

Group	Common phoneme	Overall similarity	Guess
Dyslexic adults	.23	.20	.57
Normal adults	.57	.19	.24