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IMPORTANCE OF PHONOLOGICAL SKILLS AND UNDERLYING PROCESSES TO READING ACHIEVEMENT

A study on dyslexic and specific language impaired children[1]

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Abstract

In this study we compared dyslexic children and specific language impaired (SLI) children on phonological skills and underlying processes, i.e. working memory and auditory perception. Problems with phonological skills and underlying processes occur in both dyslexic and SLI children. However, dyslexic children experience particularly problems in word recognition, while a considerable number of SLI children develop relatively good reading skills. What is the importance of phonological skills and underlying processes to reading achievement? Results show differences in degree of problems between dyslexic and SLI children. Patterns of results of performance between groups differ. This could imply that both groups differ in (other) underlying skills which explain poor performance on tasks of this study but are not necessarily related to reading achievement.

1 Introduction

Studies on dyslexia and specific language impairments often report similar problems for both disorders. However both groups of disorders differ in their development of word recognition. Dyslexia is characterized by severe reading problems while a considerable number of specific language impaired (SLI) children develops accurate decoding skills at the beginning of their reading development (Snowling, Bishop and Stothard, 2000) despite their overall language problems.

Problems in the processing of phonological aspects of language are characteristic for the poor reading skills associated with dyslexia (Stanovich, 1988; Stanovich & Siegel, 1994; Vellutino et al., 1991; Wagner & Torgesen, 1987). However, phonological abilities are only one aspect of different language skills which contribute to the complex learning process of reading (Bradley & Bryant, 1985). Also language problems, i.e. (morpho-) syntactic, semantic and pragmatic problems, are found to be related to reading disorders (Catts & Kamhi, 1999). Although SLI children experience

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problems with overall aspects of language to a different degree, not all SLI children experience problems in learning to read (Catts, 1993).

Yet the phonological abilities are found to be related to both reading and language development (Snowling, 2000; Tallal et al., 1997). Therefore it has been suggested that problems with phonological abilities could underly reading as well as language problems. Dyslexic and language disordered children could suffer from qualitatively poor phonological representations (Snowling & Hulme, 1994; Gathercole & Baddeley, 1990).

Tallal et al. (1997) have suggested that dyslexia and specific language impairments are manifestations of the same underlying disorder. According to this view, dyslexia is considered to be a mild form of the same underlying disorder in specific language impairments, differing in degree of language disorder. However, other authors suggest that differences in the reading development arise from qualitative differences in underlying processes which are not task specific or task related to reading development (Snowling et al., 2000) and by interaction between different processes and skills (Plaut et al., 1996; Snowling, 1998).

Underlying processes which are often mentioned to be related to reading and language development are processes of working memory and auditory perception. Both dyslexic and SLI children show problems on tasks tapping different aspect of working memory and auditory perception.

In this study we addressed the question whether there exist qualitative differences in reading related skills and processes resulting in a differentiation of reading skills. We wanted to find out whether dyslexic and (better-reading) SLI children differ in phonological skills, working memory and auditory perception.

The following questions were addressed in this study:

1) Do dyslexic and (better-reading) SLI children differ in phonological skills that have been shown to be related to reading achievement?
2) Do dyslexic and (better-reading) SLI children differ in underlying processes, i.e. working memory and auditory perception?

2 Method

2.1 Design

Dyslexic children, SLI children and a control group participated. The dyslexic children were selected on low reading accuracy in contrast with the SLI and control group.

The SLI children were selected at schools for special education. The dyslexic children were selected at schools for special education and at regular primary schools. All children were selected by specialists at school on the base of available data. The control group followed regular education.

We matched groups on chronological age, educational age, nonverbal IQ and sexe. Measures of reading accuracy and verbal IQ were used as selection variables. We used the speeded Three Minutes Reading Test (TMRT; Verhoeven, 1993) to measure reading accuracy. We excluded children with problems other than reading or language problems.

2.2 Participants

All three groups consisted of 15 children. Mean age was 10 years. The children from the experimental groups had been diagnosed to be dyslexic or specific language impaired. Specifications are summarized in Table 1. Groups did not differ on chronological and educational age and nonverbal IQ ($p>0.5$). Reading grade was significantly different between all groups. The controlgroup outperformed both the dyslexic and SLI children ($p<0.001$ and $p<0.001$), respectively). However the SLI children obtained significantly better reading scores than the dyslexic children ($p<0.005$). The dyslexic and SLI children show a delay in reading development of 23 and 14 months, respectively.

Table 1. Overview of subjects: gender (b = boys, g = girls). Mean and standard deviation (between parentheses) are given for chronological age (C.A.) and educational age (E.A.) in months, for non verbal IQ (NV IQ) and for reading grade (R.G) based on scores on TMRT.

group	N	gender	C.A	E.A.	NV IQ	R.G.
DYS	15	11b	127.7	40	39.3	16.33
		4g	(11.75)	(10)	(4.8)	(8.76)
SLI	15	11b	127.6	39.4	38.1	25.07
		4g	(10.31)	(11)	(2.7)	(7.77)
CONTR	15	10b	127	41.12	41.4	40.53
		5g	(9.27)	(5.2)	(4.8)	(5.07)

2.3 Procedure

Administration of the tests took place at seven different schools during the months December 2000 until June 2001. Each child has been tested within a period of about one and a half month. Tests were administered during four separate sessions of half an hour each.

2.4 Material

The investigated *phonological skills* included phonological decoding, phonological awareness, rapid retrieval of phonological information. Phonological decoding was measured by a *non-word reading task* (Klepel; Van den Bos et al., 1994) which is a standardized test requiring the speeded reading of nonwords. Score is the total number of words read correctly in two minutes. Phoneme awareness was measured by a *phoneme deletion task*. The child is instructed to delete a phoneme from a non-word presented by audiotape. Score is the total number of correct responses. Rapid retrieval of phonological information was measured by different *rapid automatized naming tasks* (RAN), i.e. rapid naming of objects, letters and numbers. The children have to name as quickly as possible objects, numbers or letters, which are presented on separate cards. The time needed to name all objects, numbers or letters on a card is noted.

Investigated processes of *working memory* were the phonological loop, storage and processing. The phonological loop was measured by the *non-word repetition task* (De Jong, 1998). This task measures the quality of the phonological store of verbal working memory without reliance on phonological representations from long term memory. The child has to repeat nonwords varying in length from one to four syllables which are presented by audiotape. The tests consists of 48 nonwords. The score is the total number of correct responses. Storage capacity in working memory is further investigated by a *word span test* which requires the retention and reproduction of sequences of one-syllable words. The number of words in a sequence increases from three to eight words. A sequence of equal length was presented twice. The child had to repeat a sequence of words in the same order. Administration of the test was stopped when a child failed on two lists of equal length. The score was the total number of sequences repeated in the correct order. Working memory capacity is investigated by the *Star Counting Test* (De Jong & Das-Smaal, 1990, 1995). The test measures the ability to activate, modulate and inhibit processes in working memory which are assumed to require working memory capacity. The test consists of items of nine rows of three to five stars. The child is instructed to count the stars from left to right and from top to bottom starting from an initial number. Plus and minus signs between stars indicate the direction (forward or backward) in which subsequent stars have to be counted. The number of the last star is the answer to the item. The score on the test is the total number of items correct within 10 minutes.

For the possible influence of rate of articulation on memory processes we administered also an *articulation test* (Thoonen et al., 1996). The articulation rate is measured by instructing children to repeat as quickly as possible the sequences /papapa/, /tatata/, /kakaka/ and /pataka/. From each sequence, twelve successive most quickly produced syllables are selected and the number of seconds per syllable has been computed.

Auditory perception has been investigated by a *classification* and *discrimination paradigm* using a ba-da continuum, changing stepwise from /*ba*/ into /*da*/ resulting in 10 stimuli (Schwippert, 2000). The paradigm used for classification was a two alternative forced choice classification task in which each stimulus occurred twice. For the discrimination task, a same-different discrimination paradigm was used. Stimulus pairs were formed that were differentiated by varying stepsize from zero to four steps. Responses and reaction times were registered using the software of E-Prime (Psychology Software Tools, Inc., Pennsylvania USA).

3 Results

We analysed differences in mean performance on all tasks between the three groups. Groups are referred to in this section as DYS (dyslexic group), SLI (specific language impaired group) and CONTR (control group). We used univariate and multivariate *post hoc* analyses and contrast analyses to look for significant differences between groups.

3.1 Phonological skills

We compared groups on mean performance on the speeded non-word reading task, phoneme deletion task and rapid naming, see Table 2.

Groups performed significantly different on the non-word reading task ($F(2.42)=1.1618$, $p<0.001$). *Post hoc* analysis (Bonferroni) showed better performance of CONTR compared to both SLI ($p<0.03$) and DYS ($p<0.001$). SLI obtained significantly better scores than DYS ($p<0.001$).

The phoneme deletion task consists of three parts. Part I and II consist each of 9 one-syllable pseudowords (part I) and two-syllable pseudowords from which one phoneme has to be deleted (part II). Part III consists of two-syllable pseudo-words in which one phoneme occurs twice which has to be deleted twice. Mean performance on three categories was significantly different between groups ($F(2.42)=21.03$, $p<0.001$). Mean performance on three categories differed significantly within groups ($F(2.84)=85.398$, $p<0.001$). In addition, we found a significant interaction effect ($F(4.84)=4.82$, $p<0.005$; see Figure 1). The dyslexic children performed significantly poorer than the control group on all categories, i.e. part I ($p<0.03$), part II ($p<0.001$) and part III ($p<0.001$). Although there are no significant differences between DYS and SLI, SLI and CONTR did not differ significantly in performance on the category of one-syllabic words (part I, $p>0.05$) but SLI performed worse on part II and part III ($p<0.001$).

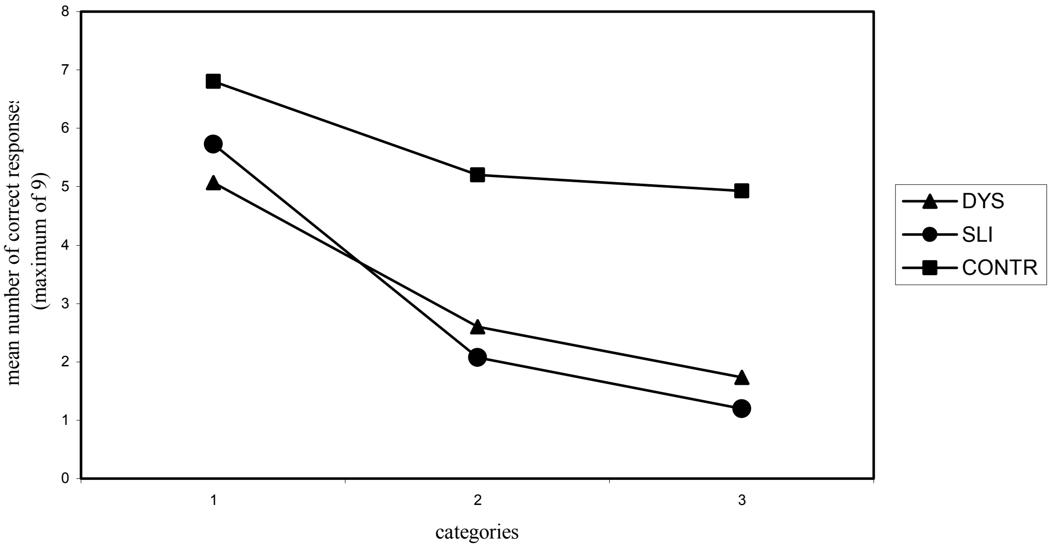

Figure 1. Performance on the phoneme deletion task

We used four versions of the Rapid Naming (RAN) task. Separate cards present objects (objects 1), objects with phonologically confusable names (objects 2), i.e. *broek, broer, bloem, bloed*, letters and digits. Mean performance on four categories was significantly different between groups ($F(2.42)=7.894$, $p<0.002$). Mean performance on four categories differed significantly within groups ($F(3.40)=96.822$, $p<0.001$). Both SLI and DYS performed worse than CONTR on RAN objects 2 ($p<0.003$ and $p<0.007$, resp.), and on RAN Letters ($p<0.02$ and $p<0.003$, resp.). DYS showed significantly slower naming on RAN digits than CONTR ($p<0.02$). Differences in performance on the different categories between SLI and DYS were not significant.

Table 2 gives an overview of results of *post hoc* analyses (Bonferroni).

Table 2. Overview of differences between groups on measures of phonological skills. Not significant (n.s.), * p<0.05, ** p<0.01, *** p< 0.001

tasks	DYS-SLI	DYS-CONTR	SLI-CONTR
Non-word Reading	***	***	*
Phoneme deletion I	n.s.	*	n.s.
Phoneme deletion II	n.s.	***	***
Phoneme deletion III	n.s.	***	***
RAN objects 1	n.s.	n.s.	n.s.
RAN objects 2	n.s.	**	***
RAN letters	n.s	*	n.s.
RAN digits	n.s.	**	*

3.2 Working memory

We compared groups on mean performance on the Non-word Repetition Task (NRT), Wordspan Task and Star Counting Test, see Table 3.

We divided the 48 nonwords of the Non-word Repetition Task over four categories according to word length, i.e. one to four syllables. Mean performance on four categories was significantly different between groups (F(2.42)=34.185, *p*<0.001). Mean performance on four categories differed significantly within groups (F(3.126)=106.045, *p*<0.001). Moreover, we found a significant interaction effect between group and categories (F(6)=16.851, *p*<0.001; see Figure 2). The score of SLI on NRT 3 is significantly poorer than performance of DYS (p<0.003) and CONTR (*p*<0.001). All groups performed significantly different on NRT 4 with SLI showing poorest performance (*p*<0.001).

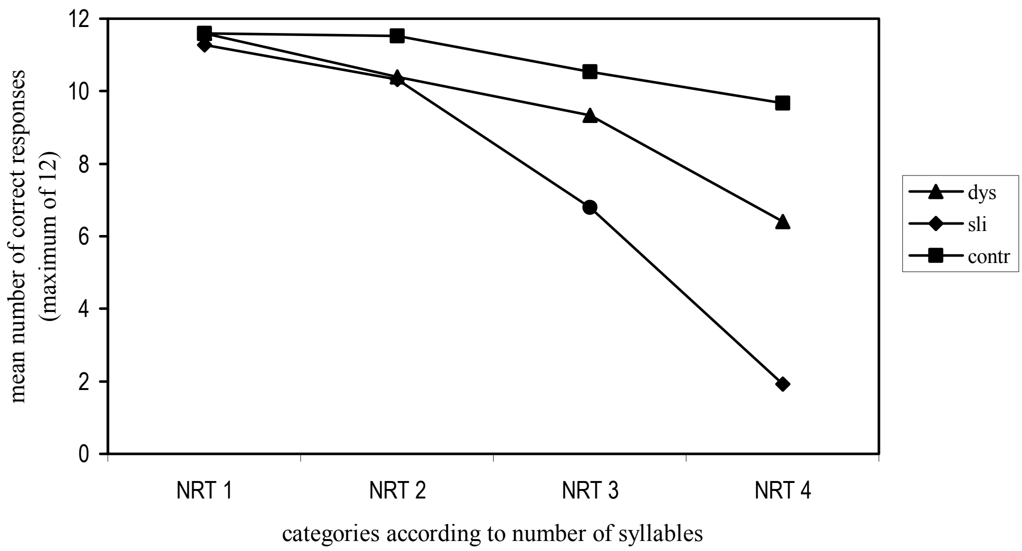

Figure 2. Performance on the Non-word Repetition Task

Mean performance on the wordspan task was significantly different between groups (F(2.42)=26.07, p<0.001). *Post hoc* analysis showed that CONTR obtained better scores than both SLI (p<0.001) and DYS (p<0.05). DYS performed better than SLI (p<0.001).

Groups did not perform significantly different on the star counting test (F(2.42)=3.127, p>0.05). However the p-value approached significance (p=0.054) and *post hoc* analysis showed significant difference between DYS and the CONTR (p<0.05), DYS performing worse than CONTR.

Rate of articulation is assumed to influence processes in (phonological) working memory. Therefore we controlled for articulation rate. Groups differed in articulation rate (F(2.42)=11.443, p<0.001). *Post hoc* analysis showed significantly slower articulation rate for SLI compared to CONTR (p<0.001) and DYS (p<0.05). DYS showed also slower articulation rate than CONTR but this difference was not significant (p>0.1).

Table 3 gives an overview of results of *post hoc* analyses (Bonferroni).

Table 3. Overview of differences between groups on measures of working memory. Not significant (n.s.), * p<0.05, ** p<0.01, *** p< 0.001

tasks	DYS-SLI	DYS-CONTR	SLI-CONTR
Star Counting Test	n.s.	*	n.s.
NRT 1 syllable	n.s.	n.s.	n.s.
NRT 2 syllables	n.s.	n.s.	n.s.
NRT 3 syllables	**	n.s.	***
NRT 4 syllables	***	***	***
Wordspan	***	*	***
Articulation rate	*	n.s.	***

3.3. Auditory perception

We have compared groups on mean performance on the classification task and discrimination task, see Table 4.

For the classification task we computed the mean number of responses of /*ba*/ for each of the 10 stimuli with a maximum of 10. Mean classification scores did not differ significantly between groups (F(68)<1, p>0.5). We also recorded reaction times. There was a significant difference in reaction time between groups (F(2)=3.68, p<0.04) with DYS performing slower than CONTR.

The discrimination task includes four categories of pairs of stimuli, in which the difference between stimuli was 0, 2, 3 or 4 steps on the continuum. For analysis we used the categories of 2, 3 and 4 steps of difference. We compared groups on their judgements of perceived difference between stimuli. The mean discrimination of stimuli with 2 steps of difference (Discrimination 2) was not significantly different between groups (F(74)=1.7, p>0.05). The mean discrimination of stimuli with 3 steps of difference was significantly different between groups (F(2)=5.06, p<0.02). DYS differed significantly from CONTR (p<0.02) and SLI (p<0.02) in mean number of perceived differences. The mean discrimination of stimuli with 4 steps of difference was significantly different between groups (F(2)=3.43, p<0.05). DYS differed significantly from CONTR (*p*<0.04) in mean number of perceived differences. The groups did not differ in mean reaction time on the discrimination task ($F(68)=1.63$, $p>0.05$).

An overview of *post hoc* analyses (Bonferroni) is given in Table 4.

Table 4. Overview of differences between groups on measures of auditory perception. Not significant (n.s.), * p<0.05, ** p<0.01

tasks	DYS-SLI	DYS-CONTR	SLI-CONTR
Classification	n.s.	n.s.	n.s.
Reaction Times	n.s.	*	n.s.
Discrimination 2	n.s.	n.s.	n.s.
Discrimination 3	*	*	n.s.
Discrimination 4	n.s.	*	n.s.
Reaction Time	n.s.	n.s.	n.s.

4. Discussion and conclusion

In this study we compared dyslexic and (well-reading) specific language impaired (SLI) children on a number of skills which are suggested to be related to reading development and language development.

The first question we addressed was whether dyslexic and well-reading SLI children perform differently on tasks tapping phonological abilities which are specifically related to reading development. As expected the SLI children did not perform as worse as the dyslexics on the phonological decoding task (Table 2). They showed some delay as compared to the control group but this was in accordance to the other reading measurement (TMRT, Three Minutes Reading Test, Verhoeven, 1993). Some delay in reading development is not unexpected, considering their (educational) history of language problems.

We found poor performance of both groups on measures of phoneme awareness and rapid automatic retrieval (Table 2). However performance of both groups differed in severity. SLI children performed worse than the DYS on the phonemic deletion task when words of two syllables were involved. However they did not show poor performance on the category of one-syllable words compared to the controls, suggesting that they have some phonemic awareness. De Jong and Van der Leij (2003) point out that phonemic awareness tasks are complex tasks in which several processes of memory, articulation and so on are involved. Differences in pattern of perfomance on the phoneme deletion task are possibly related to differences in these underlying processes.

Indeed, SLI children performed poorly on articulation rate and several memory tasks (Table 3). Their problems were more severe than those of the dyslexics. Their problems could be explained by a limited storage capacity of verbal material in the short term memory. The dyslexics seem to experience problems with the working memory capacity which involves serial processing of information. They also show problems in storage of information although to a lesser extent than the SLI children.

Perhaps some of the difficulties of SLI children are related to their slow articulation rate as suggested by some authors (McDougall et al., 1994; Dollaghan &

Campbell, 1998). Hulme and Roodenrys (1995) suggest that memory skills can not completely explain reading and language problems. They suggest that possibly auditory perception determines both memory and language skills.

However, we did not find poor performance of SLI on auditory perception tasks (Table 4). The dyslexics did not show poor classification scores which is in accordance to Landerl & Wimmer (2000) who also did not find any problems for dyslexics on a classification task. We found slow reaction times on the classification task for dyslexics. This could imply that the process of identification of phonetic features is not or less automatized. Discrimination task are suggested to be more related to phonological skills and reading problems (Cornelissen et al., 1996). We also found dyslexics to have more problems although the differences were small. They did not differ on discrimination of stimulus pairs of small difference. This is contrary to other studies (Schwippert, 2000) which implied that stimuli which have a small difference are particularly difficult to discriminate. Possibly the results depend on age. In the study of Schwippert (2000) adult dyslexics participated.

In summary, dyslexic as well as better-reading specific language impaired children experience problems on tasks tapping phonological skills which are considered to be strongly related to reading ability. Apparently, the used tasks appeal to skills and processes which are not necessary to develop technical reading skills. Poor performance on these tasks is not always related to poor reading skills. Although the relationship between these tasks and reading problems has been found in dyslexics, the specific language impaired children also show problems in executing these tasks despite their relatively good reading skills. SLI children suffer from poor articulation rate and problems in working memory which probably influence performance on phonological tasks.

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