Long-term Effects of Reading Problems

Ake Olofsson
Center for Reading Research
Stavanger University College, Norway

It has recently been shown that phonological problems tend to persist in adults with childhood reading problems, even when the adults reading skill is within normal range. Many adults with reading problems tend, in the long run, to develop qualitatively different word decoding ability with less specific orthographic knowledge and relying more on context and top-down processing. This presentation reports on phonological processing and word decoding abilities in samples of adults with a history of reading problems. The results also illustrate secondary effects of reading problems, like low self-esteem and low aspiration level, and how these effects may restrict the student's choice among alternative college and university programs.

Over the past two decades it has been increasingly accepted that dyslexia (or specific reading disability) is essentially a verbal processing problem and in particular a problem related to phonological aspects of language processing. A variety of phonological deficits are found to both correlate with reading development and to be a distinctive feature of dyslexia. The most salient phonological processing measures invoke phonological awareness, phonological coding in verbal short term memory and naming speed as well as measures of speech perception and speech production (see Brady & Shankweiler, 1991). There is no general agreement about the theoretical relationship between various measures of phonological processing (Elbro, 1996; Gruber, 2003; Rack, 1994; Ramus, 2001). Nevertheless the empirical results are quite impressive when it comes to the prediction of dyslexia. Most of the results are based on research on children and there are very few studies on phonological processing in adults with dyslexia. The present research investigated various aspects of phonological processing abilities in a sample of adults with a history of dyslexia. The sample was identified on the basis of their reading problems in the early school years, 20 years ago. Individuals in this sample were recently relocated and given a questionnaire and a battery of tests. This article reports on the results of this examination.

Paulesu et al. (1996) found phonological deficits in five compensated adult dyslexics in comparison to a control group. The adult dyslexics had normal reading skills (even non-word reading) and thus their identification as dyslexics was based on well documented reading problems in their earlier school years. Despite having normal reading abilities as adult, they showed weaknesses on tests of phoneme deletion and spoonerism production. Bruck (1992) correspondingly found that the phonological problems persisted in adults with childhood reading problems, even if the adults reading skill was within normal range. itemsThus, reading development for poor readers was not associated with phonological

This research was supported by a grant from the Swedish Council for Research in the Humanities and Social Sciences. This study is revisiting a subsample of Lundberg (1985). We thank Ingvar Lundberg for kindly providing archive information, Gunilla Smedberg Åman for relocating and testing, Leila Kalliokoski for valuable comments on earlier versions of the manuscript and those who kindly volunteered to participate in the study.
Correspondence concerning this article should be addressed to Åke Olofsson, Centre for Reading Research, Stavanger University College, P.O. Box 8002, N-4068 Stavanger, Norway.
E-mail: ake.olofsson@slf.his.no

awareness in the same way as it is in normal readers. Similar results were reported by Felton, Naylor and Wood (1990) in a long-term follow up study with 115 adults who had reading problems in school. They found that the adults scored lower than age matched controls on pseudo-word reading, phonological awareness and naming. Snowling, Nation, Moxham, Gallagher and Frith (1997) also found residual deficits in phoneme awareness and non-word reading in adults with dyslexia. Similar results were also reported by Elbro, Nielsen and Petersen, 1994, Lefly and Pennington (1991) and Pennington et al. (1990). Svensson (2003) in a ten year longitudinal study of poor readers found strong correlation between non-word reading tests in Grade 3 and 12, thus indicating persistence of phonological reading problems.

The overall impression from the above studies is that dyslexic children can make progress in reading acquisition but nevertheless their difficulties with pseudo-word reading, phonological awareness and rapid naming persist. This pattern of findings is stable over a variety of sampling conditions (self-referred subjects versus identified from clinical records) and for many different types of measurements. The same pattern of results also holds across different designs (reading-age control versus chronological age control) and across variations in definition criteria for dyslexia (with or without IQ-discrepancy). The present study was conducted in order to extend the previous research by using a very early (grade 2) identification of the participant with reading problems, and a 20 year follow up testing.

Method

Participants

Two groups of 27 year old Swedish adults were investigated; one group with a history of dyslexia and one without any kind of reading problems. The first group included sixteen adults (14 male and 2 female) who were diagnosed as dyslexic already when they were eight years old; the selection criteria was based on the discrepancy between Raven's matrices (non-verbal intelligence (Raven, 1960)) and poor word recognition and/or spelling on two consecutive test occasions (6 month apart). The group without reading problems, which serves as a control group, included 22 adults (20 male and 2 female) that were originally selected from the same schools and classrooms as the dyslexic group but had normal reading ability. In the original study the groups consisted of 46 dyslexic and 44 control children selected from a total of 723 pupils. Three pupils were deleted in order to assure that the children's reading difficulties were not associated with social, emotional, cultural, pedagogical or medical factors. For more details, see Lundberg, 1985. Recently about half of the subjects were relocated through and mailed a questionnaire. This questionnaire documented their school history, educational background, social status, job, reading habits and future plans. Twenty-five of the individuals (10 dyslexic and 15 controls) volunteered to participate in a testing session.

Tests

Word Decoding

Decoding of unrelated words. For this task the participant had to silently read "chains" of words that were concatenated by deletion of the inter-word blank space. Each chain consisted of two to four words, randomly ordered, and the reader had to mark each word boundary with a pencil. The chains were constructed to have no ambiguity regarding the boundary location and the chains were composed of a large proportion of high frequency words. The number of correctly marked chains in three minutes minus the number of errors were scored. Maximum score was 120.

Phonological coding in word recognition. This task was a paper and pencil Swedish adaptation of the computerized phonological coding task used by Olson, Forsberg, Wise, & Rack (1994). The task was to decide, and underline with a pencil, which one of three or four pseudo-words is a pseudo-homophone of a real word. (That is, "sounds" like a real word). There were four lists of 20 groups (rows) each of three or four word alternatives. Subjects were given two minutes to complete the task. The score was the number of words correctly chosen minus the number of wrong choices. The number of errors was very low, 68% of the participants made no errors and 12% made one error. The maximum score was 80.

Orthographic coding in word recognition. This task is a Swedish adaptation of the computerized orthographic coding task used by Olson et al. (1994). The participant had to underline the true word in true word-pseudohomophone pairs. Stimuli were presented on six lists of 20 pairs each. Note that the phonological codes for the pairs are identical so both the word and its pseudohomophone would be pronounced the same in Swedish. Thus, in order to make a correct response the reader must use word-specific orthographic knowledge. The score was the number of correctly chosen words in two minutes minus the number of wrong choices. Errors were more common than in the phonological coding task. Only one third of the participants made no errors. The maximum score was 120.

Spelling Knowledge

Spelling the complex but regular Swedish *j*-sound. Eight low-frequency one- and two-syllable words with regular spelling of the j-sound were used. Swedish spelling normally represents the *j*-sound with one of the letters *j* or *g*. (For a more detailed description of Swedish orthography and reading acquisition see Olofsson, 2003). In Swedish, a strict rule-based spelling of the *j*-sound would give approximately 20% spelling errors. The following words were used: *Sorg* [grief], *bälg* [bellows], (one syllable words, final position *j* following a consonant); *gärs* [ruff (fish)], *gös* [pike perch] *gyro* [gyro] (initial position *j* followed by a front wovel); *juvel* [jewel], *pjäs* [theater play], *miljö* [milieu] (otherwise spelled with j). The number of spelling errors was scored and the maximum score was 8.

Proof reading. A simple text with 289 words in 22 sentences had to be read and each misspelled word had to be underlined. The text contained 35 common Swedish homophones (c.f. *there, their*, in English) which in the present context were misspelled. That is, the wrong word in the homophone pair was used in the text. The score was computed as the number of detected misspellings in 2.5 minutes minus the number of incorrect choices.

Reading Comprehension

The test consisted of two texts, each written on a standard page and with a difficulty level not above every day newspaper reading. For each text there were two multiple choice questions. The first, with four alternatives, asked the participant to select an appropriate header for the text. The second consisted of six alternative sentences related to the text and the reader had to select the sentences that were true. Four of the alternatives were true; one inference, two paraphrases and one identical to the text. The erroneous alternatives included one highly plausible statement not mentioned in the text and a statement in which one word had been replaced by a word with an opposite meaning.

Phonological Processing

Digit naming speed. Two lists of 50 randomly ordered digits were read aloud. The mean reading time in seconds for each list was measured. Typically, very few errors were made on this task. The inter-list correlation was .80. The test is similar to the digit naming task used by Snowling et al. (1997).

Word span for phonologically confusable words. (This test was modeled after Schneider, Küspert, Roth and Visé (1997) who used if with children). The participants first heard a series of three words, which they were instructed to recall in the correct order. If two three-word sets were recalled correctly the number of words to reproduce was increased by one. Testing stopped if the participant made errors on two sets of the same size. The score was the maximum number of words correctly reproduced. The words consisted of two-syllable nouns and verbs with within each set phonologically confusable structures, e.g. *visa syne fina nysa*.

Phonological Awareness

Initial phoneme analysis. In this task participants said the first sound (of phoneme size) in an orally presented word. The following list of common Swedish words was used (the first sound is given in parenthesis); grönt [g] sluss [s] knä [k] gäst [j] chips [ç] kväll [k]. The number of correctly identified sounds was scored, giving a maximum score of six.

Sound deletion. In this sound elision task, the orally presented word had to be pronounced without a target sound. The instruction was similar to e.g. “Say stop, but without /p/”. The following list of Swedish common words was used (the sound to be deleted is given in parenthesis); skval (k), skrot (r), skolk (l), vits (t), snits (s), sparv (v), stoft (t), stoft (f). All of the resulting words were common Swedish words. For two of the items the to-be-deleted phoneme was present in two positions in the word. Both solutions (deletions) were scored as correct, even if the resulting word was a pseudoword. The number of successful responses was scored, giving eight as maximum score.

Syllable swapping. An orally presented bi-syllabic word had to be pronounced with the syllables in reversed order. All of the resulting words were common Swedish words. The number of correct answers was scored, giving a maximum score of six.

Questionnaire

A 60 item questionnaire was used. Twenty four items recorded various facts about educational history. Eleven items measured preferences for different school subjects and 20 measured the participant’s current habits and behaviors. The remaining items tapped current status for family and job. Both five-step rating scales and yes-no answers were used.

Procedures

The participants were tested individually in a quite room at the university, except one individual who was tested in an office room at his job. The testing was completed in a single session of approximately one hour, allowing for breaks between the blocks.

Results and Discussion

First the results from the testing session are reported and there after the questionnaire data are considered.

The comparison of group means in Table 1 shows that the adult dyslexics scored significantly lower on all measures except for reading comprehension. The difference for phonological awareness is just reaching the critical value for statistical significance. However, all variables in Table 1, except reading comprehension, are composite scores based on different tests and we will have a short "post hoc" look at the individual tests behind these scores.

For one of the word decoding tests, the "word chains" test, the difference on speed (number of correct solutions in three minutes) was not statistically significant, but the direction of the difference between the sample means was in favor of the control group. Although the dyslexic adults did not differ significantly from the controls in the number of items judged correctly, they did make significantly more errors in this task. It is likely that there is a trade off between error and speed for this test and thus a plausible interpretation is that in some sense the dyslexics "pay" for their speed with a higher error rate.

Both tests of spelling knowledge differed significantly between the groups. The significant difference on phonological processing was entirely due to the dyslexics poor results on the digit naming test. The groups did not differ on the word span test.

On phonological awareness the significant difference was caused by the dyslexics poor performance on the initial phoneme analysis task with a mean score of 1.9 (SD= 2.1) compared to 4.6 (SD= 2.2) for the normal group ($t(23) = 3.0$ $p < .01$). On the sound deletion task the dyslexics scored 4.1 (SD= 1.6) and the normal group 4.9 (SD= 1.5) ($t(23) = 1.22$, n.s.). The corresponding values for the syllable swap task was 2.25 (1.6) for the dyslexics and 3.33(2.2) for the control group ($t(23)=1.93$, $p = .066$). It could be noted that both the sound deletion and syllable swap tasks seem to be relatively difficult for even the control group and that especially on the sound deletion task the dyslexics seem to cope quite well. Observations during the testing session gave some support for the hypothesis that many dyslexics at least partly can compensate by using letter names in phonological awareness tasks. In the initial phoneme task a third of the target sounds were phonemes that do not correspond to a specific letter in the Swedish alphabet. That is, a mapping roughly similar to the relationship between the letter clusters ch- and sch- and their corresponding sounds in English.

To summarize, the tasks putting high demands on the readers' phonological processing system showed

Table 1.
Mean scores, standard deviations (SD), F-values and significance for adults with and without a history of reading problems.

Variable	Dyslexic[a] *Mean* (*SD*)	Normal[b] *Mean* (*SD*)	*F*	*Sig.*
Word decoding	-1.61 (2.39)	1.08 (2.20)	8.4	.008
Spelling	-1.29 (1.75)	.91 (1.39)	11.79	.002
Reading comprehension	7.2 (1.8)	8.1 (2.0)	1.25	-
Phonol. Processing	-.88 (1.42)	.58 (1.46)	6.14	.021
Phonol. Awareness	-.83 (1.99)	.55 (1.36)	1.86	.050

Note. For all *F*-tests the df is (1,23). [a]*N*=10. [b]*N*=15.

large group differences and the tasks involving more moderate demands on phonological skills tended to discriminate less well between groups. These results also indicate that dyslexics acquire normal skill in recognition of high frequency words and words in context, and thus perform well on one of the word decoding tests and on the reading comprehension test. Nevertheless, on the orthographic coding test they performed poorly despite the task's non-phonological nature. It should be noted that this task put extremely high demands on the recognition of a word's exact orthographic form. Such demands are very rare in normal reading, and it may well be that the development of such exact orthographic representations is dependent on well developed phonological processing abilities (see e.g. Brown, 1998; Rack, Hulme, Snowling and Wightman, 1994, Share 1995, for various related theoretical descriptions).

Similar reasoning would also predict the obtained results on the *proof reading* test. Here the misplaced or misspelled homonyms can only be detected by a reader that has well-developed representations of the word's orthographic form. Such representations may need both a large amount of print exposure and well-functioning phonological processing skills and phonological representations. Again, the test itself is more demanding than any normal reading situation, and therefore, able to discriminate between compensated dyslexics and good readers.

We now turn to the data from the questionnaire, which was answered by 15 adult dyslexics and 22 normal readers. The results showed no differences between the groups regarding family status, social relationships and a variety of general competencies (like having a driving license, or military service etc.). The occupational status differed between the groups (CHI $2_{(4)} = 12.3$, $p<.05$), a difference caused by the existence of 10 university students in the control group but none in the dyslexic group. The probability of going to the university in the future was also given a lower estimate by the dyslexics than the controls ($F(1,35) = 9.7$, $p < .01$). This fundamental difference between the groups was present already in high-school where none of the dyslexics attended an educational program preparing for university studies but 11 of the 22 in the control group did (CHI $2_{(1)} = 10.7$, $p < .01$). The groups educational history also differed significantly in secondary-school where the dyslexics completely avoided advanced theoretical programs and to a higher extent had chosen practical programs. There were large systematic effects in the choices of advanced versus standard courses in foreign language (CHI $2_{(1)} = 12.9$, $p < .001$) and mathematics (CHI $2_{(1)} = 10.9$, $p < .001$) as well as their choice of a second foreign language (CHI $2_{(1)} = 6.4$, $p < .05$). A few of the dyslexics also stated that regardless of their own interests, they chose the program expected to put the lowest demands on reading and spelling ability. However, the awareness of the real bases for their decision did not arise until several years later.

The participants self-rating of their academic skills revealed a significant difference for spelling ability ($F(1,35) = 6.2$, $p <.05$). The dyslexics also reported having more problems in foreign language (English) learning than the controls. The groups reported significantly different reading habits with respect to reading in English, both leisure time reading ($F(1,35) = 4.2$, $p <.05$) and job reading in English ($F(1,35) = 5.7$, $p <.05$). There were no differences in their self-rating of amount of reading in Swedish, neither at home or job reading (all $F(1,35) < 1.61$, n.s.). The largest difference in literacy activity was found for self-rated amount of job writing which was much more frequent for the control group ($F(1,35) = 10.3$, $p < .01$). This measure is of course also correlated to the fact that none of the dyslexics are full time students.

There were no differences in the reported frequency of e-mail usage or amount of computer usage, neither at the workplace or at home. The frequency of using a lexicon or wordbook differed greatly between the groups ($F(1,35) = 7.1$, $p < .05$). The adult dyslexics seemed to have a great dislike for the process of trying to find anything according to alphabetical order. However, when it comes to acquiring information about new and technologically advanced equipment the dyslexics gave higher ratings to the alternative "read the whole manual" ($F(1,35) = 6.0$, $p < .05$).

Conclusions

The results of this study are consistent with theories of a general phonological deficit in dyslexia. There were clear and persisting problems in tasks involving phonological processing in reading as well as in naming and phonological awareness. Even more salient deficits were found in tasks demanding advanced levels of orthographic processing. As orthographic processing is learned through reading and spelling experience these latter group differences may largely be a result of the adult dyslexic's lack of practice. On the other hand, the magnitude of the difference between the dyslexics and the controls and the absolute low levels of the dyslexics word decoding skills today, indicates that these readers have developed a reading skill that is qualitatively different from the skill of the majority of readers (cf. Brown, 1998).

The present sample was selected purely on low word decoding performance. No measures of phonological processing were involved in the selection process. However, shortly after the selection, when the children were nearly eight years old, their phonological awareness was assessed. There was a significant difference between the mean for the 16 revisited dyslexics ($M = 45.3$, $SD=8.7$) and the mean for the 21 (one missing value) revisited controls ($M = 55.0$, $SD = 7.0$, $F(1,35) = 13.9$, $p <.01$). Thus, although the dyslexia definition was based purely on reading and spelling performance and Raven, the dyslexics were found to have phonological awareness problems. Because this phonological problem existed already from the onset of reading acquisition the present findings lend support to the statement that dyslexics phonological problems persist into adulthood. This is not to deny that a reciprocal causation can exist, that is, many years of poor and infrequent reading can have a negative effect on phonological processing. Our results also showed that the dyslexics had chosen a different path through the educational system, apparently avoiding reading and language studies, and today belong to a group having no or very low access to university studies. During school the great majority of children with early reading problems seem to develop sufficient reading and compensation skills to become fairly good every-day readers, but when measured on cognitive tasks that put high demands on accuracy and speed of phonological and orthographic processing, their weakness and problems can be detected. It should also be noted that the reading comprehension test used in this research was relatively easy and did not put high demands on reading speed. It might well be that more difficult reading comprehension tests would reveal differences between dyslexics and controls (see e.g., Simmons & Singelton, 2000) and that such differences most likely are caused by a combination of underlying phonological processing problems, poor word decoding and lack of reading experience (see e.g., Lundberg, 2002).

REFRENCES

Brady, S. A., & Shankweiler, D. P. (Eds.), (1991). *Phonological processes in literacy*. Hillsdale, NJ: Lawrence

Brown, G. D. A. (1998). Connectionism, phonology, reading, and regularity in developmental dyslexia. *Brain and language, 59*, 207-235.

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

Elbro, C. (1996). Early linguistic abilities and reading development: A review and a hypothesis about distinctness of phonological representations. *Reading and Writing*. *8*, 453-485.

Elbro, C., Nielsen, I., & Petersen, D. K. (1994). Dyslexia in adults: Evidence for deficits in non-word reading and in the phonological representation of lexical items. *Annals of dyslexia, 44,* 205-226.

Felton, R. H., Naylor, C. E., & Wood, F. B. (1990). Neuropsychological profile of adult dyslexics. *Brain and Language , 39*, 485-497.

Gruber, M. (2003). Dyslexics' phonological processing in relation to speech perception. Unpublished doctoral dissertation, Umea University, Sweden.

Lefly, D., & Pennington, B. (1991). Spelling errors and reading fluency in compensated adult dyslexics. *Annals of Dyslexia, 41,* 143-162.

Lundberg, I. (2002). The child's route into reading and what can go wrong. *Dyslexia, 8*, 1-13.

Lundberg, I. (1985). Longitudinal studies of reading and reading difficulties in Sweden. In G. E. MacKinnon & T. G. Waller (Eds.), *Reading research: Advances in theory and practice* (pp.65-105). New York: Academic Press.

Olofsson, A. (2002). Twenty years of phonological deficits: Lundberg's sample revisited. In E. Hjelmquist & C. Von Euler (Eds.), Dyslexia and literacy(pp.151-62). London: Whurr.

Olofsson, A. (2003). The dyslexic reader and the Swedish language. In Nata Goulandris (Ed.), *Dyslexia: Crosslinguistic comparisons*(pp.137-156). London: Whurr.

Olson, R. K., Forsberg, H., Wise, B., & Rack, J. (1994). Measurement of word recognition, orthographic and phonological skills. In Lyon, G. R. (Ed.), *Frames of reference for the assessment of learning disabilities: New views on measurement issues* (pp. 243-277). Baltimore M.D.: Paul H. Brookes.

Paulesu, E., Frith, U., Snowling, M., Gallagher, A., Morton, J., Frackowiak, R. S. J., & Frith, C. D. (1996). Is developmental dyslexia a disconnection syndrome? Evidence from PET scanning. *Brain, 119*, 143-157.

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

Rack, J. (1994). Dyslexia: The phonological deficit hypothesis. In A. Fawcett & R. Nicolson (Eds.), *Dyslexia in children: Multidisciplinary perspectives* (pp. 5-37). London: Harvester.

Rack, J., Hulme, C., Snowling, M., & Wightman, J. (1994). The role of phonology in young children's learning of sight words: the direct mapping hypothesis. *Journal of Experimental Child Psychology, 57*, 42-71.

Ramus, F. (2001). Outstanding questions about phonological processing in Dyslexia. *Dyslexia*, *7*, 197-216.

Raven, J. C. (1960). *Guide to the standard progressive matrices. Sets A, B, C, D, and E.* London: Lewis.

Schneider, W., Küspert, P., Roth, E., & Visé (1997). Short- and long-term effects of training phonological awareness in kindergarten: evidence from two German studies. *Journal of Experimental Child Psychology, 66*, 311-340.

Share, D.L. (1995). Phonological recoding and self-teaching: Sine qua non of reading acquisition. *Cognition, 55*, 151-218.

Simmons, F., & Singleton, C. (2000). The reading comprehension abilities of dyslexic students in higher education. *Dyslexia, 6*, 178-192.

Snowling, M., Nation, K., Moxham, P., Gallager, A., & Frith, U. (1997). Phonological processing skills of dyslexic students in higher education: A preliminary report. *Journal of Research in Reading, 20*, 31-41.

Svensson, I. (2003). Phonological dyslexia: cognitive, behavioural and heredity aspects. Unpublished doctoral dissertation, Goteborg University, Sweden.