Children at family risk of dyslexia: a follow-up in early adolescence

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Background: This study is the follow-up in early adolescence of children born to families with a history of dyslexia (Gallagher, Frith, & Snowling, 2000). Methods: Fifty young people with a family history of dyslexia and 20 young people from control families were assessed at 12–13 years on a battery of tests of literacy and language skills, and they completed questionnaires tapping self-perception and print exposure. One parent from each family participated in an interview documenting family circumstances (including family literacy) and a range of environmental variables considered likely correlates of reading disability. They also rated their child’s behavioural and emotional adjustment and their own health and well-being. Parental literacy levels were also measured. Results: Forty-two per cent of the ‘at-risk’ sample had reading and spelling impairments. A significant proportion of the literacy-impaired group were affected by behavioural and emotional difficulties, although they were not low in terms of global self-esteem. The children in the at-risk subgroup who did not fulfil criteria for literacy impairment showed weak orthographic skills in adolescence and their reading was not fluent. There were no differences in the literacy levels or activities of the parents of impaired and unimpaired at-risk children, and no significant correlation between parent and child reading levels in the at-risk group. The impaired group read less than the other groups, their reading difficulties impacted learning at school and there was evidence that they also had an impact on family life and maternal well-being. Conclusions: The literacy difficulties of children at family-risk of dyslexia were longstanding and there was no evidence of catch-up in these skills between 8 and 13 years. The findings point to the role of gene–environment correlation in the determination of dyslexia. Keywords: Dyslexia, reading difficulties, risk factors, environment, adolescence.

It is widely recognised that dyslexia is a language-based disorder that runs in families and is heritable (Pennington & Olson, 2005). Accordingly, a number of studies have followed the progress of children at genetic risk of dyslexia from the pre-school years, before ‘dyslexia’ can be diagnosed (e.g., Elbro, Borstrom, & Petersen, 1998; Hindson et al., 2005; Lyytinen et al., 2006; Pennington & Lefly, 2001; Scarborough, 1990). Such studies avoid the bias that arises when children who have failed to learn to read are recruited to clinical samples; they also provide evidence regarding risk and protective factors in reading development.

Initial findings from family studies of children at ‘high risk’ of dyslexia suggested that the behavioural profile of dyslexia changes with age, from a pattern of delayed language development in the pre-school years to the more specific profile of phonological difficulties in the school years (Scarborough, 1990). As further evidence has accumulated, it has become clear that a more common scenario is for poor readers in at-risk samples to be characterised by broader language difficulties (Hindson et al., 2005; Lyytinen et al., 2006; Snowling, Gallagher, & Frith, 2003). Moreover, a number of pertinent findings suggest that the risk of reading disorders is multi-factorial, with ‘impaired’ individuals sharing certain risk factors with unimpaired individuals from similar family backgrounds.

Elbro et al. (1998) were the first to report continuity of risk for dyslexia in a study following Danish children from dyslexic families; while literacy-impaired at-risk children showed deficits on tests of letter knowledge, phoneme awareness, verbal short-term memory (STM) and the distinctness of phonological representations, they shared deficits on tests of morphological awareness and articulatory accuracy with unimpaired children from similar family backgrounds. Pennington and Lefly (2001), following the progress of English-speaking children, reported that children who became reading-disabled shared deficits in verbal STM and rapid serial naming (RAN) with high-risk unimpaired children, but only the impaired group had problems on phonological awareness tasks. Converging findings from Snowling, Gallagher, and Frith (2003) suggested that, whereas high-risk literacy-impaired children had poor phonological awareness, both high-risk impaired and unimpaired 6-year-olds showed slow acquisition of grapheme–phoneme skills. Together, these findings are consistent with the action of multiple-gene systems contributing through interactions with environmental factors to continuous variations in a phenotype. How this risk unfolds over time is under-researched – and the focus has been...
on cognitive risk factors; it is important also to consider the role of environmental factors in determining the developmental outcome of children from high-risk families.

The present study investigated the cognitive, educational and psycho-social outcomes of children at family risk of dyslexia at the age of 12–13 years. The study sample consisted of the cohort of children at family risk of dyslexia followed by Snowling and colleagues from the age of 3 years, 9 months (Gallagher, Frith, & Snowling, 2000; Snowling et al., 2003). Its focus was on the characteristics of dyslexia in early adolescence, and on how these are related to individual, home and school variables.

Although dyslexia is a well-researched learning disorder, surprisingly few studies have documented the progress of children with dyslexia. Those that have done so have reported a slow rate of reading and spelling development, with poor levels of literacy into adulthood (Maughan, 1995; Maughan & Hagell, 1996). Follow-up studies of clinical samples have sometimes portrayed a different picture in which reading difficulties resolve while problems of spelling and phoneme awareness persist (Bruck, 1990, 1992).

In the present sample, 66% of 8-year-old children from high-risk families had reading and spelling attainment one standard deviation below the mean of the control group and were defined as ‘literacy-impaired’. We predicted that at follow-up, these children would show persisting literacy problems (Shaywitz et al., 1995). The remaining 34% of the high-risk group were defined as ‘unimpaired’ at 8 years, although they had been slow to learn letter names and displayed deficits in nonword reading and phonetic spelling skills at 6 years. Based on the assumption that deficiencies in phonological decoding can constrain the development of orthographic learning over time (Share, 1999), we predicted that these ‘unimpaired’ high-risk children would do less well in word-level reading and spelling than controls in adolescence. In contrast, given the good language levels this group showed at previous test points, we predicted they would show average reading comprehension (Gough & Tumner, 1986; Muter, Hulme, Snowling, & Stevenson, 2004).

**Psycho-social development in children at risk of dyslexia**

To assess the possible impact of literacy difficulties on psychosocial adjustment, self-perception, behavioural and emotional difficulties were investigated. There is strong evidence of a link between reading difficulties and both externalising and internalising disorders (Maughan & Carroll, 2006). However, the two types of disorder show different links with literacy difficulties. Carroll, Maughan, Goodman, and Meltzer (2005) reported that children with literacy difficulties are at increased risk of anxiety, attention problems and conduct disorder. Although the associations with conduct and attention disorder can be explained in terms of the increased levels of inattention present in each condition, anxiety appeared to be directly caused by literacy difficulties. One possible explanation is that behaviour problems associated with reading difficulties may be mediated by progressive school failure and lowered self-esteem (Chapman & Tunmer, 1997). An alternative is that they are caused by shared genetic or environmental risk factors. If the latter is true, one might expect that at-risk unimpaired children would also show elevated levels of inattention and behavioural problems. If the problems are, in contrast, caused by the literacy difficulties themselves, one might expect to see elevated levels of difficulties only in the at-risk impaired group.

**Environmental correlates of literacy outcome**

The role of the home environment has not generally been shown to play a large role in the development of literacy in typically developing families. Wadsworth, Corley, Hewitt, Plomin, and DeFries (2002) examined the association between parent and child reading scores in adoptive and non-adoptive families. There was a significant correlation only in the non-adoptive families, suggesting that parent reading levels have little environmental influence on child reading abilities. They concluded that most environmental influences on reading development are at the individual, rather than parental level, including schooling and pastimes chosen by the child (Petrill, Deater-Deckard, Schatschneider, & Davis, 2005 for similar findings).

If the environment provided by parents of children with dyslexia is important in the development of literacy difficulties, one would expect that parental practices would be correlated to child literacy outcomes and that the at-risk impaired group would have parents with poorer literacy and different reading-related practices. To that end, we assessed the extent to which the literacy outcomes of participants in the study were associated with differences in parental literacy skills, as well as differences in family-literacy environment.

Reading difficulties are, in fact, a commonly cited example of likely gene–environment correlations (Stanovich, 1986; Rutter, 2005). Children with reading difficulties are thought to be more likely to choose pastimes and school subjects which do not involve large amounts of reading. In this way children with reading difficulties are likely to encounter ‘print’ less often than an average child on a day-to-day basis, perhaps leading to a ‘Matthew effect’ and a negative cycle of achievement. The present study provides an opportunity to quantify the print exposure of children at high-risk of reading difficulties with and without poor literacy outcomes. We expected young people with poor literacy to show evidence of self-selecting environments with less print exposure.

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Method

Participants

The parents of 93 children who had been assessed at all three previous assessment points (t1, t2, t3) were invited by letter to participate in the current study (t4). Those invited included families who had volunteered as ‘dyslexic’ by self-report at t1 but whose data were not included in the t3 analyses because neither parent fulfilled strict criteria for dyslexia on formal tests. Consent forms were returned from 52/73 ‘at-risk’ and 20/37 control families from the original sample. All of the consenting families were seen, the majority in their homes. Two ‘at risk’ children were subsequently excluded because of chronic medical problems.

At the beginning of the first phase, when the children were 3;09 (t1), both parents were asked to complete a set of literacy tests to assess their skills. At t4, when the children were 12–13 years old, one parent from each family (usually the mother) participated in a semi-structured interview. Sixty-six parents were interviewed, 46 from at-risk and 20 from control families. Two children from each of 4 families participated in this study (3 pairs of twins and 1 pair of siblings). We chose one child at random from each pair and the interview was conducted with reference to that child.

Tests and procedures

The present investigation was the fourth phase of a longitudinal study (t4). In the first phase, children were seen at the ages of 3;09 (t1), 6;00 (t2), 8;00 (t3). At t3, children were classified into impaired and unimpaired groups on the basis of performance on the Wechsler Objective Reading Dimensions (WORD; Rust et al., 1992); tests of untimed nonword and exception word reading (Griffiths & Snowling, 2002); and a test of decoding skills that involved reading aloud a passage comprising nonsense words (Hatcher, Snowling, & Griffiths, 2002). To assess text reading and comprehension, the final three passages from form A and the final passage from form B of the Neale Analysis of Reading Abilities (NARAII; Neale, 1989) were given; in this test the child reads the passage aloud and then answers verbally-posed questions about it. To assess reading fluency, the sight word and phonemic decoding efficiency subscales of the TOWRE (Test of Word Reading Efficiency; Torgesen, Wagner, & Rashotte, 1997) were given; these tests assess how many words or nonwords, assembled vertically in columns on a page, can be read in a 45-second time interval.

Language skills. To assess verbal ability, children were asked to complete the Vocabulary and Verbal Similarities subtests from the Wechsler Abbreviated Scale of Intelligence (WASI; Zhu & Garcia, 1999). The Vocabulary test requires words to be defined, Verbal Similarities requires description of the conceptual similarity between a set of items (e.g., red, blue, green are all colours). To assess sentence memory, participants completed the Clinical Evaluation of Language Fundamentals (CELF-III) Recalling Sentences subtest (Semel, Wiig, & Secord, 1995) which requires the immediate repetition of sentences varying in grammatical complexity. To assess phonological awareness, participants were asked to take away a phoneme from a spoken nonword in a phoneme deletion task, e.g., ‘bice’ – take away the /b/ is ‘ice’ (McDougall, Hulme, Ellis, & Monk, 1994). To assess phonological processing, participants repeated 40 nonwords, 10 of each of 2, 3, 4 and 5 syllables (Children’s Nonword Repetition Test; Gathercole, Willis, Baddeley, & Emson, 1994).

Psycho-social and behavioural measures at t4

Attention control. To identify children with problems of attention, three tests were given from the Test of Everyday Attention for Children (Manly, Robertson, Anderson, & Nimmo-Smith, 1998). SCORE! measures sustained attention by requiring the child to listen to an audiotape and count the number of irregular bleeps detected over a continuous time interval. Opposite Worlds measures switching attention and requires inhibition of a familiar response. The child tracks through a series of squares bearing the digits 1 or 2. In response to ‘1’ they are instructed to give ‘2’, and vice versa. The time to complete this task is recorded. Same Worlds (in which the child gives the conventional responses of ‘1’ and ‘2’) is included as a baseline measure of speed of processing.

Emotional and behavioural adjustment. To assess the young person’s emotional and behavioural adjustment, parents completed the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997). This scale requires parents to rate their children on 5 subscales; pro-social, hyperactive, emotional, conduct and peer problems, to state whether or not they believe their child has learning difficulties and what their impact is. To seek participant’s own views of their social, academic and physical competence they completed three scales from the Self-Perception Profile for Children (Harter, 1985): academic competence, social acceptance and athletic competence.

Measures of family literacy environment

Parental reading skills. Parents were asked to complete the Reading and Spelling subtests from the Wide Range Achievement Test III (WRAT-R; Jastak & Wilkinson, 1984) at t1, when the children were 3;09 years old. These are graded word reading and spelling tests.

Parental interview. The interview schedule was designed to elicit information concerning environmental variables that might affect the outcome of children at high risk of dyslexia. The main variables of interest, in addition to how often participants read, were family background and environment, school factors and
educational support. The specific constructs examined were: Socioeconomic background (based on the occupations of both parents), Family structure, Family literacy (how literacy is fostered/support in the home), Family aspirations (ambitions and expectations for children), School history (changes of school, special educational needs support; type, quantity, frequency), Extra support outside of school (including private tuition), Home-school liaison (interview protocol available at http://www.york.ac.uk/res/crl/).

Information was also sought concerning significant health issues, life events and family stresses that may have affected the children, supplemented with specific questions about the burden the child’s difficulties placed on the families (Goodman, 1997). The interviewed parent also completed a general health questionnaire (GHQ-12; Goldberg & Williams, 1988) to assess psychological well-being.

Print exposure. Familiarity with books and magazines was assessed using questionnaires tapping recognition of author names, book titles and magazine names (Griffiths, 1999), providing a composite measure of print exposure.

Results

It was important in view of the loss of 15 at-risk and 12 control participants between t3 and t4 first to ascertain whether there were systematic differences between the t4 retained sample and the original sample. A series of analyses compared the performance at t3 of those participants who took part in the current phase with that of the participants lost to the study on key cognitive and background variables (child’s IQ at age 6, reading and spelling skill at 8 years, socioeconomic circumstances and mother’s educational level). For the ‘at-risk’ group, there was no significant difference between consenting young people and those lost to sample on any of these variables (Fs all < 1). Thus, the reasons for ‘drop-out’ did not introduce a systematic bias in findings for children from ‘at-risk’ families. For controls, the groups differed in verbal IQ, $R^2_{(1,31)} = 6.53$, $p = .016$, but not in performance IQ, literacy skills at 8 years or in social background factors (Fs < 1). The mean Verbal IQ for the retained controls was 107.48 (SD = 13.5) and for the controls lost to sample 120.09 (SD = 14.6). Since attrition from the control group was primarily of more able children, the t4 comparisons between the at-risk and control groups are conservative.

Literacy outcomes in adolescence according to self-reported family status

Table 1 shows the performance of the entire sample of participants on standardised tests of reading and spelling at t4, according to self-reported family status at the point of recruitment. Standard scores were used to assess the number of participants from ‘dyslexic’ and control families who were literacy impaired at 12–13 years. As at t3, the criterion used to define literacy impairment was that the composite score for single word reading and spelling fell one standard deviation below the control mean. Twenty-one out of 50 (42%) of the ‘at-risk group’ were defined as literacy impaired on this criterion (11 boys and 10 girls), compared with 3/20 (15%) of the control group (all girls). The present estimate is more conservative than that at t3 and in the region of that reported by related studies.

Table 2 shows the performance on the reading tasks of the sample divided according to family risk and outcome status (at-risk literacy impaired, at-risk literacy unimpaired and control). Although it has been argued elsewhere that the risk of dyslexia is continuous (Pennington & Lefly, 2001; Snowling et al., 2003), the data are treated categorically here to be consistent with the approach taken in our previous paper and in others in the literature. For all analyses, 3 children with poor literacy skills were removed from the control group (as at t3) before proceeding to conduct between-Ss ANOVAs, followed up by Games–Howell post-hoc tests (for unequal $N$s) to investigate differences between subgroups. The size of the control group was small and therefore the power to detect subgroup differences between the at-risk unimpaired and control groups was relatively low. We therefore provide effect sizes for differences that may have reached a conventional level of significance had $N$ been higher.

There was a significant main effect of Group for all reading measures (exception and nonword reading, reading nonsense words embedded in passages, text reading accuracy, comprehension and rate), and the at-risk impaired group was impaired in comparison to controls across tasks. The at-risk unimpaired group performed at the same level as controls in the un-timed nonword reading task ($d = .37$) and in reading comprehension ($d = .11$); however, they performed significantly worse than controls in exception word reading, text reading accuracy and on all of the timed measures – their performance falling between that of at-risk impaired and control participants. The spelling variable was used in classifying the sample, therefore group differences were anticipated; the three subgroups differed from one another on this variable.
Table 2 Reading and spelling skills at t4 according to outcome status

<table>
<thead>
<tr>
<th></th>
<th>At-risk impaired (N = 21)</th>
<th>At-risk unimpaired (N = 29)</th>
<th>Control (N = 17)</th>
<th>MSE</th>
<th>F(2,64)</th>
<th>p</th>
<th>partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exception word</td>
<td>24.71</td>
<td>34.34</td>
<td>37.71</td>
<td>912.74</td>
<td>28.71</td>
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<td>4.04</td>
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<tr>
<td>Nonword</td>
<td>17.81</td>
<td>25.90a</td>
<td>27.41a</td>
<td>551.32</td>
<td>26.41</td>
<td>.001</td>
<td>.45</td>
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<tr>
<td></td>
<td>5.67</td>
<td>3.71</td>
<td>4.39</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Nonsense passage</td>
<td>103.10</td>
<td>77.86</td>
<td>112.71</td>
<td>8478.09</td>
<td>14.04</td>
<td>.001</td>
<td>.30</td>
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<td></td>
<td>34.99</td>
<td>19.38</td>
<td>15.09</td>
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<td>Sight word efficiency</td>
<td>90.00</td>
<td>99.38</td>
<td>114.00</td>
<td>3306.60</td>
<td>34.46</td>
<td>.001</td>
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<td>9.03</td>
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<td>9.43</td>
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<td>Decoding efficiency</td>
<td>87.48</td>
<td>99.83</td>
<td>114.00</td>
<td>3306.60</td>
<td>34.46</td>
<td>.001</td>
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<td></td>
<td>10.93</td>
<td>9.19</td>
<td>9.30</td>
<td></td>
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<tr>
<td>Text accuracy</td>
<td>43.86</td>
<td>73.69</td>
<td>80.47</td>
<td>7785.37</td>
<td>42.11</td>
<td>.001</td>
<td>.57</td>
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<td></td>
<td>20.34</td>
<td>9.99</td>
<td>6.93</td>
<td></td>
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<tr>
<td>Text comprehension</td>
<td>18.36</td>
<td>26.28a</td>
<td>27.12a</td>
<td>492.06</td>
<td>7.47</td>
<td>.001</td>
<td>.19</td>
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<tr>
<td></td>
<td>8.51</td>
<td>7.54</td>
<td>8.56</td>
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<tr>
<td>Text reading rate</td>
<td>66.94</td>
<td>101.25</td>
<td>121.79</td>
<td>425.02</td>
<td>35.10</td>
<td>.001</td>
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<td></td>
<td>22.76</td>
<td>21.26</td>
<td>16.16</td>
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<td>Spelling</td>
<td>82.91</td>
<td>101.55</td>
<td>109.53</td>
<td>3762.97</td>
<td>50.97</td>
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<td>.61</td>
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<td></td>
<td>7.92</td>
<td>7.12</td>
<td>11.11</td>
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</table>

Note: Values sharing the same subscript do not differ significantly.

Language skills in adolescence according to literacy outcome.

Table 3 shows the performance of the three outcome groups on measures of language and phonological awareness. There was a significant main effect of Group for all measures (WASI Similarities and Vocabulary, nonword repetition, sentence recall and phoneme awareness). With the exception of sentence recall, the at-risk unimpaired group performed at the same level as controls on these measures (however, the effect size for the subgroup difference on Vocabulary was medium ($d = .44$)). In sentence recall, the performance of the at-risk unimpaired group was significantly better than that of the at-risk impaired group but significantly worse than that of controls.

Measures of psycho-social functioning

The top rows of Table 4 show the performance of the three groups on measures of sustained attention and attention switching and the lower rows, data from the SDQ and the Harter scales assessing the socio-emotional adjustment.

Attention control. The three groups did not differ on the baseline Same Worlds measure, though the difference approached significance. There was a significant main effect of group on the two attention measures: Opposite Worlds (measuring switching attention) and Score! (measuring sustained attention). In Opposite Worlds, the at-risk impaired group scored significantly less well than the other two groups, who did not differ. On the Score! measure the at-risk impaired group differed from controls, but the at-risk unimpaired group did not differ significantly from either of the other groups (note; the effect size for the comparison between the at-risk unimpaired and the control groups was .40).

Emotional and behavioural ratings. There was a clear association between literacy outcome and whether the parents thought their child had learning difficulties as revealed by the SDQ; all of the

Table 3 Language measures at t4 according to literacy outcome

<table>
<thead>
<tr>
<th></th>
<th>At-risk impaired (N = 21)</th>
<th>At-risk unimpaired (N = 29)</th>
<th>Control (N = 17)</th>
<th>MSE</th>
<th>F(2,64)</th>
<th>p</th>
<th>partial $\eta^2$</th>
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</thead>
<tbody>
<tr>
<td>WASI Similarities</td>
<td>48.48</td>
<td>58.86a</td>
<td>60.41a</td>
<td>878.60</td>
<td>12.81</td>
<td>.001</td>
<td>0.29</td>
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<tr>
<td></td>
<td>8.74</td>
<td>7.05</td>
<td>9.58</td>
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<tr>
<td>WASI Vocabulary</td>
<td>46.81</td>
<td>57.17a</td>
<td>60.94a</td>
<td>1072.36</td>
<td>15.09</td>
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<td>0.32</td>
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<td>7.90</td>
<td>9.06</td>
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<tr>
<td>Nonword repetition</td>
<td>32.95</td>
<td>36.45a</td>
<td>37.00a</td>
<td>100.31</td>
<td>10.88</td>
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<td>3.85</td>
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<td>2.78</td>
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<tr>
<td>Sentence recall</td>
<td>7.29</td>
<td>9.41</td>
<td>11.94</td>
<td>101.82</td>
<td>20.48</td>
<td>.001</td>
<td>0.39</td>
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<td></td>
<td>2.12</td>
<td>2.03</td>
<td>2.66</td>
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<tr>
<td>Phoneme deletion</td>
<td>9.14</td>
<td>12.07a</td>
<td>12.71a</td>
<td>74.23</td>
<td>11.15</td>
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<td>1.99</td>
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Note: Values sharing the same subscript do not differ significantly.
literacy-impaired group were thought to have learning difficulties and in addition to this, so were a third of the at-risk unimpaired group. There was a main effect of Group for parental ratings of hyperactivity and emotion, but not for conduct or peer problems. The at-risk impaired group showed significantly more emotional symptoms than both the at-risk unimpaired group and the control group, who did not differ from each other in emotionality. In terms of rated hyperactivity, the at-risk impaired group were rated as significantly more hyperactive than the at-risk unimpaired group ($p = .024$) and marginally more hyperactive than the controls ($p = .068$). The two unimpaired groups did not differ from one another. On the Harter Self Perception profile, there was a significant group effect for scholastic competence but not for social or athletic competence. The at-risk impaired group rated themselves as lower in scholastic competence than either of the other two groups.

**Parental reading-related abilities**

Table 5 shows the scores of parents of the participants on tests of literacy measured at the beginning of phase 1, grouped according to outcome at $t_4$. There were three pairs of twins and one pair of siblings in the sample; one child from each of these families was excluded for the purpose of these analyses (to avoid double counting of their parents’ data).

A multivariate ANOVA indicated that there was a significant main effect of Group on mothers’ and fathers’ reading and spelling. The pattern of performance across groups was the same throughout: the control group outperformed the at-risk groups, who did not differ significantly from each other. It is noteworthy, however, that there was significantly more variability in each of the at-risk groups for reading and spelling than among controls.

A series of bivariate correlations examined the relationships between parental literacy skills and literacy outcomes for children in at-risk and control families separately. Examination of the respective scatterplots revealed that the data were well distributed for both at-risk and control groups and there was neither a restriction in range nor presence of outliers that could have affected the size of the correlations. In control families, there was a robust relationship between the literacy skills of mothers and fathers (reading: $r = .69$; spelling $r = .55$); as expected this did not hold for at-risk families in which at least one parent was dyslexic (reading: $r = .25$; spelling $r = -.014$). Literacy composite scores, representing the average of reading and spelling attainments on standardised tests, were used to examine parent–child correlations. For controls, there was a high correlation ($r = .71$) between the parent literacy composite score (averaged across both parents) and child literacy at $t_4$; the correlation was somewhat weaker when the relationship was assessed between the literacy skills of the parent with poorer spelling and the child ($r = .52$). For at-risk cases, neither correlation was significant (average parent–child: $r = .13$; poorer spelling parent and child: $r = .12$). Thus, although there is a strong relationship between parent and child literacy skills in normally reading families, there is only a weak
relationship in families in which there is a history of dyslexia. It should be noted that selective sample attrition from the control group may have contributed to this difference.

**Family environmental factors**

Interview responses were coded using ordinal or categorical scales, as appropriate. Composite scores were formed for four areas by standardising the scores for each of the relevant questions and calculating the mean z score: i) family socioeconomic background, ii) parent reading behaviour, iii) family literacy behaviours, iv) child reading behaviour.

**Family literacy.** Two composite scores provided measures of family literacy environment: parent reading behaviour (how frequently the father and mother read books, newspapers or magazines) and family literacy behaviours (how often the family bought books and gave books as presents). Although there was a trend for the parents of impaired children to read less than those of controls, there was no statistically significant main effect of group differences in how often the family bought books and gave books as presents (F(2,58) = 8.77, p = .007); while there was no statistically significant effect of socioeconomic background on literacy outcome (F(2,58) = 2.69, p = .076). Similarly, there were no group differences in how often the family bought books and gave books as presents (F(2,58) = 1.41, p = .25).

**Family structure.** There was no association between family size or structure and literacy outcome. There was a trend for those in the at-risk impaired group to be later-born children (χ²(4) = 8.77, p = .067); while this may be an artefact of sample selection, with some at-risk children volunteering because of an impaired older sibling, it is possible that this could be an experiential factor specifically related to reading disability (Stevenson & Fredman, 1990).

**Socioeconomic background.** A composite variable measuring family socioeconomic background comprised data based on father and mother qualifications, education and occupation. There was no statistically significant effect of socioeconomic background on literacy outcome (F(2,58) = 2.89, p = .064), although there was a trend for control families to be of higher socioeconomic status and educational background than both at-risk groups.

There was a low incidence of significant life events and major health issues in the sample and no association between these and literacy outcomes.

**Child’s own reading behaviour.** Two measures provided information on how often the index case chose to read. There were significant group differences in the composite score reflecting how often the young person read books, magazines or newspapers, (F(2,58) = 5.45, p = .007); participants in the at-risk impaired group read less than those in the at-risk unimpaired and control groups, who did not differ from each other. There were also between-group differences in print exposure (F(2,60) = 12.29, p < .001); at-risk impaired individuals had poorer knowledge of books and authors than controls; there were no significant group differences between impaired and unimpaired at-risk participants or between unimpaired young people and controls.

**Educational factors**

**School history.** There was no association between literacy outcome and the type of school attended (χ²(4) = 7.04, NS).

**Literacy support.** First, parents were asked whether they felt that their child had any learning difficulties. If they thought that they might do, they were asked questions concerning the amount and type of extra help the child had received. Thirty-five parents out of the 66 asked felt that their child had or might have some kind of learning difficulty. This is therefore more inclusive than the criterion measure of low literacy attainment used to classify cases into impaired and unimpaired; all of the parents of the at-risk impaired cases felt that their child had learning difficulties. Importantly, however, 11 of those defined as having unimpaired literacy levels were thought to have learning difficulties, as well as three children from the control group.

Of the children thought to have difficulties, 68.6% had been on the Special Needs Register of their school at some point, indicating that their learning difficulties were identified. The same number had received literacy support at some time in the past. Only 14.3% of this group were currently receiving extra help with their difficulties outside of school.

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Table 5 Standard scores of parents of at-risk and control children on Wide Range Achievement Test-III (Jastak & Wilkinson, 1984)

<table>
<thead>
<tr>
<th></th>
<th>At-risk impaired (N = 19)</th>
<th>At-risk unimpaired (N = 27)</th>
<th>Control (N = 17)</th>
<th>F (2,60)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mother</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>90.84a, 13.33</td>
<td>93.93a, 13.46</td>
<td>110.65, 7.75</td>
<td>13.95</td>
<td>.001</td>
</tr>
<tr>
<td>Spelling</td>
<td>92.89a, 16.89</td>
<td>95.52a, 15.53</td>
<td>115.65, 8.01</td>
<td>13.66</td>
<td>.001</td>
</tr>
<tr>
<td><strong>Father</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>84.58a, 16.40</td>
<td>89.59a, 18.97</td>
<td>109.76, 7.77</td>
<td>12.71</td>
<td>.001</td>
</tr>
<tr>
<td>Spelling</td>
<td>80.11a, 18.02</td>
<td>83.41a, 22.88</td>
<td>111.47, 10.12</td>
<td>15.46</td>
<td>.001</td>
</tr>
</tbody>
</table>

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The impact of learning difficulties

There were some indications that learning difficulties had an impact on the family as a whole: 51.4% of the parents whose children were thought to have learning difficulties felt that the difficulties had had some impact on family life, and 14.3% felt that it had had ‘a lot’ or ‘a great deal’ of impact (the proportion was 74.3% for the at-risk impaired group). The mothers of the at-risk impaired cases also showed higher levels of stress and depression, as illustrated by significantly higher scores on the General Health Questionnaire ($F(2,59) = 6.72, p = .002$). There was no significant difference between the scores of at-risk unimpaired and control cases, suggesting that literacy difficulties do have some impact on the home life and family environment.

Discussion

This study was a follow-up in early adolescence of children at family risk of dyslexia previously seen at the ages of 3;09, 6 and 8 years of age. Forty-two percent of the ‘high risk’ sample had literacy problems of long standing; these were associated with poor educational attainments across the curriculum, including in mathematics and science (unpublished data). The high-risk families, suggestive of heritability of reading and spelling skills, this was not the case for the at-risk families. This is a surprising finding, suggesting an unusual route for literacy development in children with a family history of dyslexia; in contrast to what might be expected, it does not seem to be the case that more severely affected parents have more severely affected offspring. Rather, the lack of association between parental and child literacy level suggests a complex interaction of multiple genetic effects acting through different environments to produce heterogeneity in literacy outcomes.

Although there was a trend for the parents of at-risk literacy-impaired adolescents to read less than those with normal literacy skills, and for the at-risk parents of both groups to be of lower socioeconomic standing, there were no clear associations between child outcomes within the ‘at-risk’ group and the behaviours or skills of their parents with dyslexia. Against this backdrop of relatively homogenous family environments, a significant finding was that the young people with the poorest literacy outcomes read less than their contemporaries. Most of the children with literacy difficulties had been identified and had received support in school; literacy difficulties were considered to have impacted on the classroom learning of impaired young people and to some extent on their families;
and they were associated with poorer maternal
well-being.

In a study such as the present one, it is difficult to
ascertain the causal pathways through which the
family risk of dyslexia is expressed. It seems that in
the volunteer sample of primarily middle-class children,
the family environment offered many opportunities to
promote literacy, and parents also ensured that
appropriate learning support was in place for those
who required it. Notwithstanding this, young people
in these families with poor literacy preferred not to
participate in literacy-related activities. Thus, the
micro-environments surrounding these young people
were self-selecting and arguably, neither conducive to
literacy progress nor to learning in school.

Thus, our findings confirm the heightened risk of
dyslexia among the offspring of parents with dys-
exia, and the literacy outcomes of the children in the
high-risk group were unrelated to home, family or
school environmental factors. However, there was
evidence of group differences in factors that may be
considered a consequence of the learning difficulty
itself; poor readers read less than average readers,
and their parents more often went to their children’s
schools with worries about their progress. In addi-
tion, parental expectations of the educational pros-
pects of their children were lower and more signs of
maternal depression were reported for this group. A
limitation of the present study was its small sample
size. Examination of group means suggested that, in
addition to impairments in reading fluency and
orthographic skills, young people at family risk of
dyslexia who were not classified as poor readers
showed weaker un-timed nonword reading and
vocabulary knowledge than controls, and their abili-
ty to sustain attention was somewhat poorer. These
findings underline the continuous nature of the risk
of reading, language and related attentional prob-
lems in families with a history of dyslexia; the extent
to which these relate to similar problems in the
parental generation deserves further investigation.

The increased risk of dyslexia in adolescence in
at-risk families extends previous findings that have
followed children at family risk through the pre-
school and early school years. The present findings
confirm that reading difficulties of developmental
origin tend to persist rather than resolve, and this is
true even for children who grow up in family envi-
ronments that are favourable in terms of the oppor-
tunities they provide for literacy development.
Together these findings may appear to suggest that
the genetic risk of dyslexia is deterministic. On the
contrary, the present findings highlight the role of a
gene–environment correlation, as evidenced by the
small amounts of time the poor readers spend
reading, as compared with average readers from
families of similar risk status. Furthermore, the lack
of relationship between parental literacy levels and
those of their offspring in the at-risk families is
striking when compared to the strong relationship
observed in control families. This weak relationship
between parent and child literacy levels suggests a
multi-factorial pattern of inheritance, such that the
genetic risk of dyslexia is continuous and may be
modified by mechanisms that depend on factors
either intrinsic to the child or ambient in their
environment (Rutter, 2005). Professionals involved
in the management of children with reading diffi-
culties need to be mindful of the likely persistence of
reading difficulties and should take steps to ensure
such children remain motivated to engage in reading
and writing activities.

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