*Journal of the International Neuropsychological Society* (2000), **6**, 433–442.


# Male prevalence for reading disability is found in a large sample of Black and White children free from ascertainment bias

KATHLEEN A. FLANNERY,[1] JACQUELINE LIEDERMAN,[2] LIZA DALY,[2] AND JENNIFER SCHULTZ[2]

[1]Saint Anselm College, Manchester, New Hampshire
[2]Boston University

(RECEIVED June 29, 1998; REVISED April 21, 1999; ACCEPTED May 12, 1999)

**Abstract**

Male vulnerability to neurodevelopmental disorders remains controversial. For one disorder, reading disability, this sex bias has been interpreted as an artifact of referral bias. We investigated sex differences for the incidence of reading disability within a large prospective sample of White ($N = 16{,}910$) and Black ($N = 15{,}313$) children derived from the National Collaborative Perinatal Project (NCPP). Children were classified as having either *moderate* or *severe* reading disability when they had reading scores lower than 1.5 or 2.0 standard errors of prediction, respectively, given their age and intelligence. Reading disability was about twice as common in boys than girls ($p < .001$), irrespective of race, severity of disability, or exclusion of children with attentional disturbances or high activity levels. We conclude that there is a clear sex bias toward males for the incidence of reading disabilities. (*JINS*, 2000, *6*, 433–442.)

**Keywords:** Dyslexia, Sex differences, Sex ratio, Reading disability, Learning disability

## INTRODUCTION

Boys are diagnosed more often than girls with an entire spectrum of neurodevelopmental disorders, including reading disability, learning difficulties, speech and language disorders, cerebral palsy, Tourette's syndrome, and childhood autism (Abramowicz & Richardson, 1975; Gualtieri & Hicks, 1985; Nichols & Chen, 1981). Hundreds of papers have been published with reference to theories targeting the underlying mechanisms for male vulnerability. There are theories that emphasize sex differences in rates of maturation (Ounsted & Taylor, 1972), vulnerability to birth complications (Singer et al., 1968), chromosomal structure (Childs, 1965), threshold of genetic vulnerability (e.g., DeFries, 1989), gestational hormones (Geschwind & Galaburda, 1985a, 1985b, 1985c), maternal immune attack of the male conceptus (Gualtieri & Hicks, 1985), and the extreme plasticity of the male brain (Galaburda, 1997). Nonetheless, male vulnerability to neurodevelopmental disorder is controversial since some have argued that boys are simply overdiagnosed with neurological disorders. According to this account, male prevalence is an artifact of ascertainment bias and/or the statistical methods employed to define the disorder. This would have important implications for the large body of literature concerning neurodevelopmental disorders.

The argument in favor of ascertainment bias is particularly strong for one neurodevelopmental disorder, namely, reading disability. There is little question that boys are overreferred and girls are underreferred for special services to aid their reading problems. For example, Mirkin (1982) found that a significantly lower proportion of the sample referred for evaluation was male when based upon weekly "objective" evaluations of reading, spelling, and written expression (65% male) than when it was based upon the idiosyncratic criteria of the teachers (80% male). Vogel (1990) reviewed data which indicate that the average girl who does receive learning disabilities services is older and more severely impaired than her male counterpart. Thus, girls were referred 1 year later than boys and were 1.5 years more delayed in reading as measured by the Wide Range Achievement Test (WRAT) reading subtest compared to boys.

Reprint requests to: Jacqueline Liederman, Brain, Behavior and Cognition Program, Boston University, 64 Cummington Street, Boston, MA 02215. E-mail: liederma@bu.edu

One recent study received considerable media attention because the authors concluded that male prevalence for reading disability was strictly an artifact of referral bias. Shaywitz et al. (1990) obtained a longitudinal, epidemiological sample of kindergarten children attending a Connecticut public school. Shaywitz et al. (1990) compared the sex ratios of children identified with reading disability by an objective *versus* subjective criterion. The objective criterion was based on children's reading ability, which was evaluated in second grade and again in third grade by means of a reading achievement test (i.e., the Woodcock-Johnson Psycho-Educational Battery). Children whose reading performance was 1.5 standard errors of prediction below that which would be expected on the basis of their age and IQs were classified as having a reading disability. By means of this criterion, Shaywitz et al. (1990) classified 32 children as reading disabled. The subjective criterion was whether the child had been referred to special-education services by the school for a reading disability. Shaywitz et al. (1990) reported that there was no sex bias among the children identified by the objective criterion (sex ratio of 1.38; 18 boys:13 girls), but there was a sex bias favoring boys among children identified by the subjective criterion (sex ratio of 2.22; 20 boys:9 girls).

Thus, boys were somewhat overdiagnosed and girls were somewhat underdiagnosed by the school system. Shaywitz et al. (1990) attributed this referral bias to the children's behavior: Children who were identified as reading disabled by subjective criteria, but were not reading disabled by objective criteria, were rated by teachers as having significantly worse behavior than those who were identified as reading disabled by the objective but not subjective criteria. The notion was that poorly behaving boys would be overreferred for help and well-behaved girls would be underreferred. Based on this behavioral hypothesis, one would predict that differences in behavior between boys and girls should have been greater in the school identified reading disabled sample than between nondisabled children. However, the interaction between Sex $\times$ Reading Group was not significant in the Shaywitz et al. (1990) study.

The purpose of the current paper is to reexamine the issue of male prevalence for reading disability by identifying a much larger sample of children with reading disability than has previously been studied ($N = 1405$) on the basis of objective test data from the National Collaborative Perinatal Project (NCPP; $N = 32{,}223$). Since the children were recruited when their mothers were pregnant, the NCPP sample was entirely prospective. Thus, as far as it seems possible, this sample should be free from ascertainment bias and have sufficient power to examine male prevalence for reading disability according to an objective criterion. In addition, the size of our sample permitted us to examine whether the sex ratio of incidence of reading disability differed by race. The racial mixture of previous samples has often been unspecified or limited to White children. No attempt has been made to systematically address the generalizability of male vulnerability to reading disability across race.

It is also important when establishing whether there is male vulnerability for reading disorder to question whether it is affected by the severity of the reading impairment. It is fairly standard to identify children as reading disabled based on age and IQ regression discrepancy scores (Rutter & Yule, 1975). Indeed, Cone and Wilson (1981) argue that the regression discrepancy score technique is superior to all other psychometric methods of identifying reading disability. The most widely applied criterion defines reading disability as a reading score which is at least 2.0 standard errors of prediction below that expected based on age and intelligence (Finnuci et al., 1982; Rutter & Yule, 1975; Yule et al., 1974). This identifies approximately the bottom 2.5% of the sample with a reading disability. Perhaps because of their small samples, some investigators have used a more lenient criterion of 1.5 standard errors of prediction below that expected. This identifies the bottom 8% of the sample as disabled. Finnuci and Childs (1981) have suggested that smaller sex ratios among individuals with reading disability may be obtained when milder cases are included to compute the ratios.

It is also possible for us to establish whether some kind of artifact is responsible for the repeated observation that boys are more often diagnosed with reading disability than girls. There is a school of thought that male bias in vulnerability to reading disability is an artifact of the IQ-based discrepancy definition of reading disability. For example, it has been suggested by Ackerman and Dykman (1993a) and Stevenson (1992) that the IQ-based discrepancy formula biases one toward the identification of males with reading disability because boys tend to be in the higher-than-average IQ range more often than girls. Several investigators have found that the sex ratio for children with reading disability increases as the IQ increases, but each of these studies had very small sample sizes (Ackerman & Dykman, 1993b; Ackerman et al., 1991; Lovell et al., 1964).

There is another reason why the IQ-based discrepancy technique may be biased toward finding more boys than girls in the lower tail of the distribution of IQ/reading discrepancy scores. Feingold (1992, 1993) and Hedges and Friedman (1993) have suggested that boys, as a group, may be more variable in their performance than girls, and as such the distribution of their entire range of scores may differ from girls. The question that we addressed is whether boys are more likely to appear at the *upper* as well as the *lower* tail of the distribution of IQ/reading discrepancy scores.

Finally, there is one more reason why vulnerability to reading disability may be artifactually biased toward boys. Boys may be more likely than girls to be misdiagnosed with reading disability secondary to disturbances in attention or behavior, since the latter tend to be more severe in boys than girls. This hypothesis was addressed from several perspectives. It is known that reading disability and attention deficit disorder have a high comorbidity (Dykman & Ackerman, 1991). Since boys are much more likely to be diagnosed as having attentional problems (Nichols & Chen, 1981), it is possible that this underlying attentional disturbance contrib-

utes to an artifactual bias for boys to be misclassified as having a reading disability. To this end, we tested whether our sample of children with reading disability was biased toward boys when one excludes children with attentional disturbances or high activity levels.

## METHODS

### Sample

We selected the 32,223 women and their offspring (boys = 16,080; girls = 16,143) from the National Collaborative Perinatal Project (NCPP) who met our selection criteria. There were 16,910 White and 15,313 Black children. The NCPP collected medical data from about 50,000 pregnancies and then followed the offspring's cognitive, behavioral, and physical development until age 7 years. This age sample was considered adequate for the evaluation of reading disability because Share and Silva (1986) targeted a young group of children and identified severe underachievement in reading throughout grade school as early as 7 years of age.

The selection criteria were as follows: (1) present at about 7 years of age for psychological testing on the Weschler Intelligence Scale for Children (WISC); (2) present for psychological testing on the reading subscale of the (WRAT) for diagnosing reading disability; (3) in the first or second grade at the time of testing; and (4) from homes where English was the primary language. Children were excluded from this study if they were (1) blind; (2) deaf; (3) suffering from any severe behavioral problems as identified by a summary score of *abnormal* provided by clinicians when administering the NCPP Behavioral checklist (see below for a more detailed description of this inventory); or (4) below 80 in WISC Full-Scale IQ. We chose an IQ of 80 so as to eliminate those with so-called general reading backwardness and to parallel as closely as possible the selection criteria used by the Shaywitz et al. (1990) group. The average child was about 7 years old. About half of the children were in first grade and the other half were in second grade. The demographic characteristics of the sample are provided in Table 1, which includes child's age, socioeconomic status at registration, and scores on the intelligence and reading tests described below.

### Measures

#### *Socioeconomic status at the time of registration into the study (i.e., during the target pregnancy)*

At the time of entry into the study, women were assigned a socioeconomic index score, described by Myrianthopoulos

**Table 1.** Sex ratios and mean demographic and cognitive data by race and reading disability group

| | Reading group | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Severe disability | | | | Moderate disability | | | | No reading disability | | | |
| | Male | | Female | | Male | | Female | | Male | | Female | |
| Demographic | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| White children | | | | | | | | | | | | |
| Age (years) | 6.69 | 0.51 | 6.74 | 0.44 | 6.78 | 0.45 | 6.70 | 0.48 | 6.71 | 0.47 | 6.70 | 0.47 |
| SES[a] | 41.79 | 19.92 | 39.14 | 20.50 | 46.91 | 18.93 | 43.58 | 17.47 | 58.82 | 20.99 | 58.44 | 21.01 |
| IQ–Full | 92.64 | 10.31 | 93.10 | 8.59 | 95.04 | 10.03 | 92.79 | 9.05 | 105.42 | 12.03 | 104.05 | 11.78 |
| WRAT–R[b] | 16.07 | 4.84 | 16.05 | 4.60 | 21.64 | 5.39 | 21.48 | 5.32 | 39.82 | 11.42 | 41.99 | 11.30 |
| *N* | 91 | | 39 | | 375 | | 199 | | 8,181 | | 8,025 | |
| % | 70.0 | | 30.3 | | 65.3 | | 34.7 | | 50.5 | | 49.5 | |
| Sex ratio | | 2.33 | | | | 1.88 | | | | 1.01 | | |
| Chi-square | | 20.25*** | | | | 49.78*** | | | | | | |
| Black children | | | | | | | | | | | | |
| Age (years) | 6.64 | 0.50 | 6.52 | 0.50 | 6.65 | 0.49 | 6.55 | 0.50 | 6.60 | 0.50 | 6.59 | .50 |
| SES[a] | 33.98 | 16.00 | 31.52 | 15.98 | 32.99 | 15.88 | 33.35 | 16.66 | 39.68 | 17.65 | 38.91 | 17.84 |
| IQ–Full | 86.36 | 6.09 | 85.64 | 5.13 | 87.65 | 6.10 | 86.69 | 5.96 | 94.59 | 9.42 | 94.35 | 9.18 |
| WRAT–R[b] | 14.00 | 2.31 | 13.73 | 2.37 | 18.42 | 2.12 | 18.44 | 2.15 | 33.19 | 8.09 | 35.15 | 8.37 |
| *N* | 155 | | 66 | | 326 | | 159 | | 6,952 | | 7,655 | |
| % | 70.1 | | 29.9 | | 67.2 | | 32.8 | | 47.6 | | 52.4 | |
| Sex ratio | | 2.35 | | | | 2.05 | | | | 0.91 | | |
| Chi-square | | 45.29*** | | | | | 73.50*** | | | | | |

[a]SES = socioeconomic status at registration.
[b]WRAT–R scores are raw WRAT–Reading subscores.
*$p < .05$. ** $p < .01$. ***$p < .001$.

https://doi.org/10.1017/S1355617700644016 Published online by Cambridge University Press

and French (1968). The NCPP index, like the Census Bureau's, combined scores for education, family income, and occupation into a single score which had a range from zero to 95.

### *Intelligence, aptitude, and behavioral measures*

In order to make a complete diagnosis for reading disability, participants were selected who had Full-Scale IQ scores from the WISC, raw reading subscale scores from the WRAT, and a recorded chronological age. In addition, we examined data from the NCPP Behavioral Profile. The purpose of this inventory was to evaluate several aspects of behavior while the child was observed during psychological testing at about age 7 years. Clinicians rated the children on the following 15 behaviors using a 5-point scale: (1) *separation from the mother*; (2) *fearfulness*; (3) *rapport with examiner*; (4) *self-confidence*; (5) *emotional reactivity*; (6) *degree of cooperation*; (7) *level of frustration tolerance*; (8) *degree of dependency*; (9) *duration of attention span*; (10) *goal orientation*; (11) *level of activity*; (12) *nature of activity*; (13) *nature of communication*; (14) *assertiveness*; and (15) *hostility*.

## Diagnoses

### *Reading disability as defined by the IQ-reading discrepancy regression technique*

We have used the regression method advocated by Yule et al. (1974) to identify children with reading disability. To make a diagnosis of reading disability for each child, chronological age, current grade status, WISC Full-Scale IQ, and WRAT raw reading scores were required. Regression equations were then fitted for each grade level to identify children whose WRAT reading performance was either 1.5 or 2.0 standard errors of prediction poorer than that expected given their chronological ages and Full-Scale IQs. A diagnosis of severe reading disability was given to children performing 2.0 or more standard errors of prediction below that expected. A diagnosis of moderate reading disability was given to children performing between 1.5 and 2.0 standard errors of prediction below that expected.

### *Attentional disturbances*

Each NCPP Behavioral Profile item was rated on a 5-point scale; however, different characteristics were identified at each point along the scale across the NCPP items. Children were classified with attentional disturbances when they received the following ratings for these particular NCPP items: duration of attention span coded as *very brief* (1) or *short* (2) and nature of activity coded as *frequently impulsive* (4) or *extremely impulsive* (5).

### *High activity level*

The NCPP Behavioral Profile item for level of activity was utilized to identify children with atypical activity levels. Children who were rated with a code reflecting *an unusual amount of activity* (4) or *extreme overactivity* (5) were identified as exhibiting high activity levels.

### *Central nervous system abnormalities*

The following central nervous system abnormalities could be identified from the NCPP database: (1) intracranial hemorrhage; (2) hydrocephaly; (3) cerebral palsy; (4) seizures except for febrile seizures; and (5) a history of head injury resulting in either unconsciousness, vomiting, or skull fracture.

## RESULTS

### Hypothesis 1: Reading Disability Is Significantly More Prevalent in Boys Than Girls, Irrespective of the Child's Race or Severity of the Disorder

This hypothesis was confirmed. A two-way contingency table analysis was conducted to evaluate whether boys were more likely to be identified with a reading disability by the IQ-based discrepancy technique compared to girls. The two variables were reading disability with three levels of severity (*no reading disability*, *severe reading disability*, and *moderate reading disability*) and sex. Reading disability and sex were found to be significantly related in White children [$\chi^2(2, N = 16{,}910) = 69.02$, $p < .001$] and Black children [$\chi^2(2, N = 15{,}313) = 116.37$, $p < .001$]. The sex ratios of children (i.e., male:female) with no reading disability, moderate reading disability, and severe reading disability were 1.01, 1.88, and 2.33, respectively, in White children and 0.91, 2.05, and 2.35, respectively, in Black children. Thus, the sex ratios increased from moderate to severe disability.

Follow-up pairwise comparisons were conducted to evaluate the differences among these sex ratios. As can be seen in Table 1, the sex ratio for children with a severe reading disability was significantly biased toward boys compared to children without a reading disability in both White children and Black children. The sex ratio of children with a moderate reading disability was also significantly biased toward boys compared to children without a reading disability in White children and Black children.

### Hypothesis 2: The Male Bias in Vulnerability to Reading Disability Is an Artifact of the IQ-Based Discrepancy Definition of Reading Disability

This hypothesis was not confirmed by the results of two analyses. The IQ-based reading discrepancy formula would bias us toward the identification of males as reading disabled if and only if the boys in our sample had higher IQs than the girls. To address this issue, a $2 \times 3$ ANOVA was conducted to evaluate the effects of sex and three reading disability

https://doi.org/10.1017/S1355617700644016 Published online by Cambridge University Press

classifications (*none*, *moderate*, and *severe*) on Full-Scale IQ scores. The means and standard deviations for full-scale IQ scores as a function of these two factors by race are presented in Table 1. The results for the ANOVA indicated a nonsignificant interaction between Sex × Reading Disability classification [$F(2,16,904) = 0.69$, $p = .50$] for White children and [$F(2,15,307) = 0.37$, $p = .69$] for Black children. These nonsignificant findings suggest that the observed male prevalence for reading disability in this study was not confounded by sex differences in Full-Scale IQ scores among the three reading groups for either race.

Despite the demonstrated lack of difference in overall IQ between boys and girls in our sample, it was still possible that a larger proportion of boys than girls had high IQs and that this would be a bias toward the identification of males as reading disordered. The following analysis addressed the IQ question in a new way. The White and Black samples were each divided into two groups based on the median IQ of each group (*Mdn* = 104 for White, *Mdn* = 93 for Black). A series of two-way contingency table analyses were conducted to evaluate whether boys were more likely than girls to be identified with a reading disability for each IQ group within race. Irrespective of the child's IQ group or race, there were significantly more boys than girls identified as reading disabled. Table 2 shows the results for these analyses.

An additional set of analyses enabled us to compare the magnitude of the sex ratios of reading disabled children within the IQ by reading severity groups. As can be seen in Table 2, the sex ratio for children with a moderate reading disability was significantly higher in the high IQ groups than the low IQ groups for the White children but not the Black children. The sex ratio for children with a severe reading disability was not significantly affected by whether the child was in a low or high IQ group in either the White or Black subsample.

**Table 2.** Sex ratios of children identified as reading disabled by IQ strata

| | Reading ability | | |
|---|---|---|---|
| IQ strata | Severe disability | Moderate disability | No disability |
| White children | | | |
| High[a] | | | |
| Male (*n*, %) | 13 (81.3) | 77 (76.2) | 4,543 (52.7) |
| Female (*n*, %) | 3 (18.8) | 24 (23.8) | 4,080 (47.3) |
| Sex ratio | 4.33 | 3.21 | 1.11 |
| Chi-square | 5.70* | 23.59*** | |
| Low[b] | | | |
| Male (*n*, %) | 78 (68.4) | 298 (63.0) | 3,638 (52.0) |
| Female (*n*, %) | 36 (28.3) | 175 (37.0) | 3,945 (48.0) |
| Sex ratio | 2.17 | 1.70 | 1.08 |
| Chi-square | 19.15*** | 40.59*** | |
| Black children | | | |
| High[c] | | | |
| Male (*n*, %) | 26 (74.3) | 66 (71.0) | 3,815 (48.1) |
| Female (*n*, %) | 9 (25.7) | 27 (29.0) | 4,116 (51.9) |
| Sex ratio | 2.89 | 2.44 | 0.93 |
| Chi-square | 9.92*** | 19.74*** | |
| Low[d] | | | |
| Male (*n*, %) | 129 (69.4) | 260 (66.3) | 3,137 (47.0) |
| Female (*n*, %) | 57 (30.6) | 132 (33.7) | 3,539 (53.0) |
| Sex ratio | 2.26 | 1.97 | 0.89 |
| Chi-square | 36.96*** | 56.17*** | |

[a]High IQ was identified within the upper half of the White subsample as a score ≥ 104.
[b]Low IQ was identified within the lower half of the White subsample as a score < 104.
[c]High IQ was identified within the upper half of the Black subsample as a score ≥ 93.
[d]Low IQ was identified within the lower half of the Black subsample as a score < 93.
*$p < .05$. **$p < .01$. ***$p < .001$.

## Hypothesis 3: The Male Bias in Vulnerability to Reading Disability Is Secondary to Differences in the Shape of the Distribution of Scores of Boys *Versus* Girls

This hypothesis was not confirmed. The IQ-based discrepancy technique identifies children found in the lower tail of the distribution for IQ-based reading discrepancy scores. The question these analyses addressed was whether boys were more likely to appear at the *upper* as well as the *lower* tail of the IQ-based reading discrepancy score distribution. Nine different groups of reading ability at .50 intervals for IQ-based reading discrepancy scores were entered into a two-way contingency table analysis to evaluate whether boys were more likely to be identified in the lower and upper classification of reading groups. The two variables were sex and reading group based on IQ-reading discrepancy scores classified at .50 intervals, thereby creating nine groups of readers: (1) *severe reading disability* (−2.00); (2) *moderate reading disability* (−1.50); (3) *mild reading disability* (−1.00); (4) *minimal reading disability* (−.50); (5) *no reading disability or talent* (−.49 to +.49); (4) *minimal reading talent* (+.50); (5) *mild reading talent* (+1.00); (6) *moderate reading talent* (+1.50); and (7) *superior reading talent* (+2.00).

As can be seen in the top portion of Figure 1 (White children) and the bottom portion of Figure 1 (Black children), boys were significantly more likely than girls to be diagnosed as having severe, moderate, mild, or minimal reading *disability* as compared to the middle group of children with no reading disability or talent. Conversely, girls were significantly more likely than boys to be classified among those with superior, moderate, mild, or minimal reading *talent* as compared to the middle group of no reading or talent children. The only exception was superior talent among Black children, where girls exceeded boys as compared to the middle group of no reading or talent children, but not significantly so.

https://doi.org/10.1017/S1355617700644016 Published online by Cambridge University Press

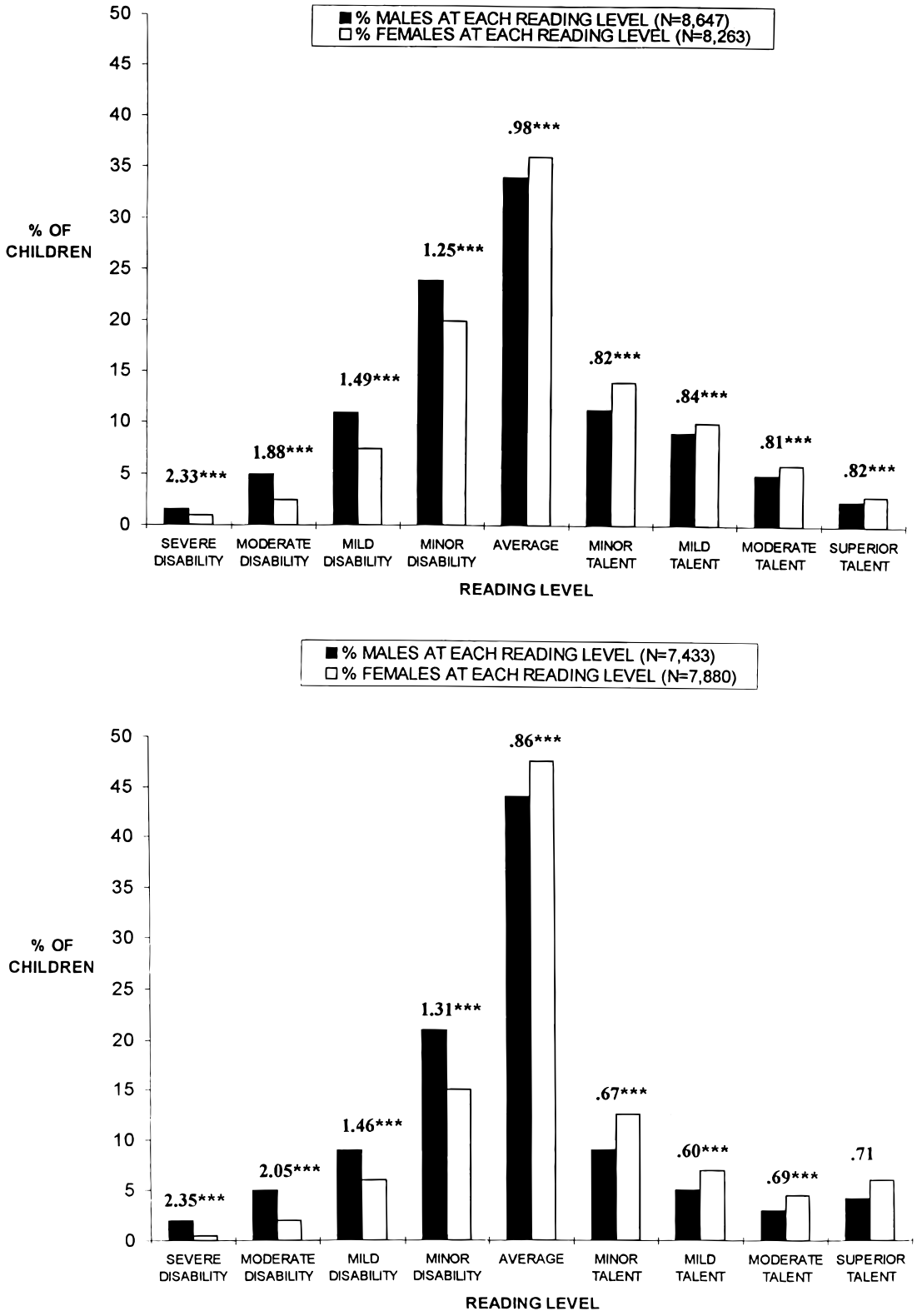


**Fig. 1.** The distribution of IQ-reading discrepancy scores for White children (top) *versus* Black children (bottom), separated by sex. IQ-reading discrepancy scores were classified at .50 intervals, thereby creating nine groups of readers: (1) *severe reading disability* (−2.00); (2) *moderate reading disability* (−1.50); (3) *mild reading disability* (−1.00); (4) *minimal reading disability* (−.50); (5) *no reading disability or talent* (−.49 to +.49); (6) *minimal reading talent* (+.50); (7) *mild reading talent* (+1.00); (8) *moderate reading talent* (+1.50); and (9) *superior reading talent* (+2.00).

https://doi.org/10.1017/S1355617700644016 Published online by Cambridge University Press

### Hypothesis 4: Male Vulnerability to Reading Disability Is Secondary to Disturbances in Attention, Behavior or Central Nervous System Abnormalities That Tend to Be More Severe in Boys than Girls

This hypothesis was not confirmed by three analyses. As can be seen in the top portion of Table 3, in the first analysis, when children with attentional disturbances were excluded from our two-way contingency table analyses, the sample of children with reading disability was still biased toward boys. The sex ratios in favor of boys being labeled as reading disabled remained essentially unchanged in both the White and Black subsamples.

Similarly, as can be seen in the middle portion of Table 3, in the second analysis, when children rated with high activity levels were excluded from our two-way contingency table analyses, the sample of children with reading disability was still biased toward boys. The sex ratios remained essentially unchanged in both the White and Black subsamples.

In the third analysis, children were omitted who had a history of central nervous system abnormalities. Children with severe abnormalities had been excluded by virtue of our criterion that children have an IQ of at least 80. Now, in addition, children with a history of cerebral palsy, seizures, or head injury resulting in unconsciousness, vomiting, or skull fracture were omitted from the sample. As can be seen in the bottom portion of Table 3, the sex ratios in favor of boys being labeled as reading disabled remained essentially unchanged in both the White and Black subsamples.

**Table 3.** Sex ratios of children identified as reading disabled when children with either attentional disturbances or central nervous system abnormalities were excluded

| Race | Reading group | | |
|---|---|---|---|
| | Severe disability | Moderate disability | No reading disability |
| Children with attentional disturbances excluded | | | |
| White | | | |
| Male (*n*, %) | 87 (70.7) | 359 (64.8) | 7,970 (50.1) |
| Female (*n*, %) | 36 (29.3) | 195 (35.2) | 7,927 (49.9) |
| Sex ratio | 2.42 | 1.84 | 1.01 |
| Chi-square | 21.36*** | 46.80*** | |
| Black | | | |
| Male (*n*, %) | 152 (71.7) | 316 (66.9) | 6,811 (47.5) |
| Female (*n*, %) | 60 (28.3) | 156 (33.1) | 7,527 (52.5) |
| Sex ratio | 2.53 | 2.03 | 0.9 |
| Chi-square | 50.28*** | 70.22*** | |
| Children with high activity levels excluded | | | |
| White | | | |
| Male (*n*, %) | 68 (67.3) | 302 (64.0) | 7,197 (49.1) |
| Female (*n*, %) | 33 (32.7) | 170 (36.0) | 7,453 (50.9) |
| Sex ratio | 2.06 | 1.78 | 0.97 |
| Chi-square | 17.20*** | 40.87*** | |
| Black | | | |
| Male (*n*, %) | 137 (69.9) | 281 (66.1) | 6,249 (46.7) |
| Female (*n*, %) | 59 (30.1) | 144 (33.9) | 7,118 (53.3) |
| Sex ratio | 2.32 | 1.95 | 0.88 |
| Chi-square | 42.29*** | 62.63*** | |
| Children with neurological abnormalities excluded | | | |
| White | | | |
| Male (*n*, %) | 86 (69.4) | 365 (65.5) | 8,014 (50.4) |
| Female (*n*, %) | 38 (30.6) | 192 (34.5) | 7,885 (49.6) |
| Sex ratio | 2.26 | 1.90 | 1.02 |
| Chi-square | 18.17*** | 50.14*** | |
| Black | | | |
| Male (*n*, %) | 151 (69.9) | 321 (67.2) | 6,836 (47.5) |
| Female (*n*, %) | 65 (30.1) | 157 (32.8) | 7,542 (52.5) |
| Sex ratio | 2.32 | 2.04 | 0.91 |
| Chi-square | 43.54*** | 72.33*** | |

*$p < .05$. **$p <$. 01. ***$p < .001$.

## DISCUSSION

The primary hypothesis tested in this study was whether reading disability is significantly more prevalent in boys than girls, irrespective of the child's race or severity of the disorder. Our database was particularly well suited to this question because it was from a very large prospective study in which each child had been objectively tested for reading ability. As a result, it was easy to evaluate whether boys were more vulnerable to reading disability than girls. Reading disability was defined as a WRAT reading score 1.5 (*moderate*) or 2.0 (*severe*) standard errors of prediction lower than that which would be expected on the basis of the child's Full-Scale WISC IQ score and age.

Results indicated a significant sex ratio of about 2.0 was obtained not only in the White subsample ($N = 16{,}910$), but also in the Black subsample ($N = 15{,}313$). As can be seen in Table 1, these two groups differed substantially in socioeconomic class, as well as overall IQ, yet approximately 70% of the children who were categorized as having severe reading disability were boys in each of the racial groups. Since these children were recruited into the original study before they were born, it is hard to see how ascertainment or referral biases could play a significant role. Thus, these data strongly suggest that there is a significant and substantial prevalence of boys with reading disability, irrespective of economic or racial differences. Ascertainment biases and referral biases may serve to exaggerate this substantial male prevalence even further, but an approximate 2:1 prevalence was found when these biases were eliminated.

As was predicted by Finnuci and Childs (1981), there was a slight tendency for the sex ratio to be lower (about 2.0, averaged across race) when milder cases were included in the computation than when only severe cases were included (about 2.3, averaged across race). Nonetheless, boys exceeded girls by at least 2:1, and this sex ratio was significant even when a lenient criterion for reading disability was used.

The results of our study match many published reports in the literature. Liederman et al. (1999) have reviewed over two dozen published studies of the sex ratios of children with reading disability. Boys were more affected than girls

https://doi.org/10.1017/S1355617700644016 Published online by Cambridge University Press

in almost all of those studies; however, the significance of this sex difference was specifically tested in very few of the studies. Liederman et al. (1999) observed that the highest overall bias towards boys (sex ratio about 3.19) was found in a weighted average of 10 studies within which children with reading disability were identified by referrals from teachers or clinicians. In contrast, a lower overall bias was found in a weighted average of eight studies within which children with reading disability were objectively evaluated on the basis of achievement tests administered to the entire subpopulation (sex ratio about 2.00). The latter sex ratio corresponds quite well to that found in the current study. It should also be noted that the sex ratio that we obtained in our sample of young grade school children was not much different from the 2:1 sex ratio reported by Lefly and Pennington (1991) in uncompensated adults with a history of childhood reading disorder.

Our conclusions clearly differ from those of Shaywitz et al. (1990). There are several reasons why this might be the case. It is important to note that the basic finding in the Shaywitz et al. (1990) study was essentially a null effect; namely, that the sex ratio of children identified as reading disabled by objective research methods was not significantly biased toward boys. However, Shaywitz et al. (1990) had a very small sample; so small, in fact, that if only *4* more of the 32 reading disabled children had been boys instead of girls, the chi-square effect would have been significant at $p < .05$, and Shaywitz et al. would have been forced to conclude that there was a significant sex bias for reading disability. In contrast, in the current study, our sample size gave us sufficient power to reexamine our results when children with attentional disturbances, high activity levels, or a history of a central nervous system abnormality were omitted from the sample. In each case, the sex ratio remained significantly biased toward males. Given the weight of the evidence in our report and in the previous literature, we conclude that Shaywitz has demonstrated that ascertainment bias inflates the number of boys identified as reading disabled. However, they have not unequivocally demonstrated that boys and girls are equivalently vulnerable when ascertainment bias is eliminated.

The other three hypotheses centered on the question of whether the observed prevalence of males with reading disability could still be an artifact of (1) the IQ-reading discrepancy regression technique; (2) a difference between boys and girls in the distribution of IQ-based reading discrepancy scores; or (3) particular behaviors that are more prevalent in boys than girls and which disrupt reading achievement but are themselves not a measure of reading ability.

Thus, Hypothesis 2 addressed statistical issues surrounding the IQ-reading discrepancy regression technique employed to define reading disability in this study. The issue centered on whether it is valid to use IQ as a standard against which to judge expected reading performance. The first way that the issue of an IQ artifact was examined was to address the repeated claim that boys may have higher intelligence quotients than girls, thereby making it more likely that they would be classified with reading disability (e.g., Rosenberger, 1992; Wadsworth et al., 1992). By this argument the discrepancy method categorizes boys as reading disabled more frequently than girls as an artifact of their higher intelligence scores. Two analyses were undertaken to examine this issue. In the first, a comparison of Full-Scale IQ scores revealed no significant Reading Group $\times$ Sex interactions. In the second, we took the median IQs of the White and Black samples and considered separately the children above and below their respective median IQs. The sex ratios for the incidence of reading disability were biased more toward boys than girls in the low as well as the high IQ groups, irrespective of race or severity of the reading disability. In addition, the sex ratio for children with a moderate reading disability was significantly higher in the high IQ groups than the low IQ groups for the White children but not the Black children. The sex ratio for children with a severe reading disability was not significantly affected by whether the child was in a low or high IQ group in either the White or Black subsample. This suggests that when using the IQ/reading discrepancy method it is safest to use the stricter criterion of a discrepancy of at least 2 standard errors, which categorizes children as severely disabled.

Hypothesis 3 examined the implications of the notion that if boys as a population are generally more heterogeneous than girls, one would predict that they would be more prevalent not only at the bottom of the IQ-based reading discrepancy distribution (in the range of disability) but also at the top of the distribution (in the range of talent). If this were the case, then boys would be found to be reading disabled more often than girls, but this would be secondary to their variability rather than their poor reading ability. Interestingly enough, in an unpublished study, Flannery and Liederman (1999) confirmed that the *superiority* of boys in spatial ability may be an artifact of their being more heterogeneous in spatial ability than girls. Based on data from the same NCPP study as was used in the current study, boys were more prevalent than girls at *both* ends of the spatial ability distribution measured in terms of performance on the Block Design subscale of the WISC. Thus, there was not only a significant male bias in the talent range (which has often been reported), but also in the deficiency range (which is not often reported).

However, in the current study, which concerned reading ability, boys were more prevalent only in the disability range, *not* in the talent range. Thus, there was a significant preponderance of girls within the three levels of reading talent. The preponderance of boys was restricted to the three levels of reading disability.

Hypothesis 4 examined the issue of whether the children who were identified with reading disability on the basis of their poor reading performance were in fact reading poorly due to attentional disturbances or high activity levels not specifically related to reading. This was important because it has commonly been observed that reading difficulties are accompanied by behavior problems (e.g., Shaywitz et al.,

1990). In our sample, the male bias toward reading disability was not secondary to disturbances in attention or high activity levels. The prevalence of reading disability was still significantly biased toward boys when children with attentional disturbances or high activity levels were excluded.

The other question examined in this series of analyses was whether the sex ratio would still be biased toward boys if children with a history of neurological abnormalities were omitted from the sample. This is relevant because boys tend to suffer from neurological abnormalities more often than girls (Gualtieri & Hicks, 1985). Results indicated that about 6% of the boys and 3% of the girls in our sample had neurological abnormalities, as defined by a history of intracranial hemorrhage, hydrocephaly, cerebral palsy, nonfebrile seizures, or head injury associated with either unconsciousness, vomiting, or skull fracture. Thus, we also found that boys in our sample were more likely to suffer from neurological abnormalities compared to girls.

When these children were excluded from the analysis, the sex ratio of reading disabled children remained significantly biased toward boys. These children were not omitted from our original sample, because it is well known that reading disability is comorbid with neurological abnormalities such as epilepsy and anomalies of cortical lamination (Galaburda et al., 1985). Thus, to be a representative epidemiological sample of reading disabled children it was important to maintain those children in our sample so long as they still had sufficient cognitive function to score greater than or equal to 80 on the WISC Full-Scale IQ.

This study, among others, now firmly establishes that there are about twice as many boys in the disabled range for reading than there are girls. Future attempts to examine the basis of male vulnerability for reading disability should focus on one paradox that emerged in Liederman et al.'s (1999) review of the literature. In the current study, ascertainment bias was limited because children were recruited into the study before they were born. A different way of controlling bias is to examine the sex ratios of family members of reading disabled probands who also have reading disability. The logic is that examination of the siblings or parents of children diagnosed with reading disability provides an unselected sample unaffected by referral bias. This second method has revealed that, despite the strong bias toward boys in the probands themselves, affected family members are much less biased toward boys. The dilemma that arises is whether this indicates heritibility of reading disability varies by sex. Carter (1965) has suggested that girls acquire the disorder principally via genetic inheritance, whereas boys are more likely to acquire it due to genetic and/or environmental insults. Thus, the related discovery that female probands have a higher percentage of affected relatives than male probands (e.g., Lewis, 1992) requires further analysis.

One problem with the family and sibling data is that the index probands themselves are often identified by referral from teachers or clinicians. This brings us back full circle, since it is reasonable to suppose that the initial population of probands with reading disability includes a significant number of males who would not be considered reading disabled if objectively identified by the IQ-based reading discrepancy technique. It is imperative that family studies be undertaken in unselected populations after children have been objectively identified as reading disabled.

In conclusion, we have demonstrated that male vulnerability to reading disability occurs irrespective of severity level in both Black and White children. We contend that this male vulnerability is not an artifact of (1) ascertainment bias; (2) the IQ-based reading discrepancy technique for identification of reading disability; (3) greater heterogeneity of reading scores in male than female populations; or (4) sex differences in behaviors that might lead to misdiagnosis of reading disability. Future research should focus on the identification of biological factors that underlie this vulnerability.

## ACKNOWLEDGMENTS

This work was supported by a grant from NIMH (R03 MH4 7409) awarded to J. Liederman. I would like to thank Neha Patel for her comments on this manuscript.

## REFERENCES

Abramowicz, H.K. & Richardson, S.A. (1975). Epidemiology of severe mental retardation in children. *American Journal of Mental Deficiency*, *80*, 18–39.

Ackerman, P.T. & Dykman, R.A. (1993a). Gender and reading disability. *Journal of Learning Disabilities*, *26*, 498.

Ackerman, P.T. & Dykman, R.A. (1993b). Phonological processes, confrontational naming, and immediate memory in dyslexia. *Journal of Learning Disabilities*, *26*, 597–609.

Ackerman, P.T., Dykman, R.A., Holloway, C., Paal, N., & York, M. (1991). A trial of Piracetam in two dyslexic subgroups enrolled in summer tutoring. *Journal of Learning Disabilities*, *24*, 542–549.

Carter, G.O. (1965). The inheritance of common congenital malformations. *Progress in Medical Genetics*, *4*, 59–84.

Childs, B. (1965). Genetic origin of some sex differences in human beings. *Pediatrics*, *35*, 798–812.

Cone, T. & Wilson, L.R. (1981). Quantifying a severe discrepancy: A critical analysis. *Learning Disabilities Quarterly*, *4*, 359–371.

DeFries, J.C. (1989). Gender ratios in children with reading disability and their affected relatives: A commentary. *Journal of Learning Disabilities*, *22*, 544–545.

Dykman, R.A. & Ackerman, P.T. (1991). Attention deficit disorder and specific reading disability: Separate but often overlapping disorders. *Journal of Learning Disabilities*, *24*, 96–103.

Feingold, A. (1992). Sex differences in variability in intellectual abilities: A new look at an old controversy. *Review of Educational Research*, *62*, 61–84.

Feingold, A. (1993). Joint effects of gender differences in central tendency and gender differences in variability. *Review of Educational Research*, *63*, 106–109.

Finnuci, J.M. & Childs, B. (1981). Are there really more dyslexic boys than girls? In A. Ansara, N. Geschwind, A. Galaburda, M. Albert, & N. Gartrell (Eds.), *Gender differences in dyslexia* (pp.1–9). Townson, MD: Orton Dyslexia Society.

Finnuci, J.M., Isaacs, S.D., Whitehouse, C.C., & Childs, B. (1982). Empirical validation of reading and spelling quotients. *Developmental Medicine and Child Neurology*, *24*, 733–744.

Flannery, K. & Liederman, J. (1999). [There is an excess of boys in both the deficit and talent ranges of the distribution of spatial ability.] Unpublished raw data.

Galaburda, A.M. (1997, January). *The toxicity of plasticity*. Paper presented at the Veterans Administration Medical Center, Jamaica Plain, MA.

Galaburda, A., Sherman, G., Rosen, G., Abotiz, F., & Geschwind, N. (1985). Developmental dyslexia: Four consecutive patients with cortical anomalies. *Annals of Neurology*, *18*, 222–233.

Geschwind, N. & Galaburda, A.M. (1985a). Cerebral lateralization: Biological mechanisms, associations and pathology: I. A hypothesis and a program for research. *Archives of Neurology*, *42*, 428–459.

Geschwind, N. & Galaburda, A.M. (1985b). Cerebral lateralization: Biological mechanisms, associations and pathology: II. A hypothesis and a program for research. *Archives of Neurology*, *42*, 521–552.

Geschwind, N. & Galaburda, A.M. (1985c). Cerebral lateralization: Biological mechanisms, associations and pathology: III. A hypothesis and a program for research. *Archives of Neurology*, *42*, 634–654.

Gualtieri, T. & Hicks, R.E. (1985). An immunoreactive theory of selective male affliction. *Behavioral and Brain Sciences*, *8*, 427–441.

Hedges, L.V. & Friedman, L. (1993). Computing gender difference effects in tails of distributions: The consequence of differences in tail size, effect size, and variance ratio. *Review of Educational Research*, *63*, 110–112.

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

Lewis, B.A. (1992). Pedigree analysis of children with phonology disorders. *Journal of Learning Disabilities*, *25*, 586–597.

Liederman, J., Kantrowitz, L., Daly, L., & Flannery, K. (1999). *Male vulnerability to reading disability is not a myth: A review of the phenomenon and its neurobiological underpinnings*. Manuscript in preparation.

Lovell, K., Shapton, D., & Warren, N.S. (1964). A study of some cognitive and other disabilities in backward readers of average intelligence as assessed by a non-verbal test. *British Journal of Educational Psychology*, *34*, 58–64.

Mirken, P. (1982). *Direct and repeated measurement of academic skills: An alternative to traditional screening, referral, and identification of learning disabled students*. (Report No. IRLD-RR-75). Washington, DC: Office of Special Education and Rehabilitative Services (ED). (ERIC Document Reproduction Service No. ED 244 191).

Myrianthopoulos, N.C. & French, K.S. (1968). An application of the U.S. Bureau of the Census socioeconomic index to a large, diversified patient population. *Social Science and Medicine*, *2*, 283–299.

Nichols, T. & Chen, T. (1981). *Minimal brain dysfunction: A prospective study*. Hillsdale, NJ: Erlbaum.

Ounsted, C.M. & Taylor, D.C. (1972). The Y chromosome message: A point of view. In C. Ounsted & D.C. Taylor (Eds.), *Gender differences: Their ontogeny and significance* (pp. 220–223). Edinburgh: Churchill-Livingstone.

Rosenberger, P.B. (1992). Dyslexia: Is it a disease? *New England Journal of Medicine*, *326*, 192–193.

Rutter, M. & Yule, W. (1975). The concept of specific reading retardation. *Journal of Child Psychology and Psychiatry*, *16*, 181–197.

Share, D.L. & Silva, P.A. (1986). The stability and classification of specific reading retardation: A longitudinal study from age 7 to 11. *British Journal of Educational Psychology*, *56*, 32–39.

Shaywitz, S.E., Shaywitz, B.A., Fletcher, J.M., & Escobar, M.D. (1990). Prevalence of reading disability in boys and girls. *Journal of the American Medical Association*, *264*, 998–1002.

Singer, J.E., Westphal, M., & Niswander, K.R. (1968). Sex differences in the incidence of neonatal abnormalities and abnormal performance in early childhood. *Child Development*, *39*, 103–112.

Stevenson, J. (1992). Identifying sex differences in reading disability: Lessons from a twin study. *Reading and Writing*, *4*, 307–326.

Vogel, S. (1990). Gender differences in intelligence, language, visual-motor abilities, and academic achievement in students with learning disabilities: A review of the literature. *Journal of Learning Disabilities*, *23*, 44–52.

Wadsworth, S.J., DeFries, J.C., Stevenson, J., Gilger, J.W., & Pennington, B.F. (1992). Gender ratios among reading-disabled children and their siblings as a function of parental impairment. *Journal of Child Psychology and Psychiatry*, *33*, 1229–1239.

Yule, W., Rutter, M., Berger, M., & Thompson, J. (1974). Over- and under-achievement in reading distribution in the general population. *British Journal of Educational Psychology*, *44*, 1–12.