

Sex Differences in Developmental Reading Disability

New Findings From 4 Epidemiological Studies

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ARE BOYS MORE LIKELY THAN girls to have reading disability? The answer to this question has both theoretical implications (with respect to possible causal mechanisms) and practical implications (with respect to service provision). If boys are truly more likely to have reading disability, this would direct research attention to uncovering the possible source of the sex difference. Also, the sex difference would offer a window into the understanding of the causal processes involved in the origins of developmental reading disability.¹ In addition, if boys are more prone to have reading disability, this should motivate educational programs to address boys' early emerging disability. Given that reading disability in childhood is associated with adjustment problems and long-term adverse outcomes in multiple life domains,² the elucidation of

See also Patient Page.

Context An influential article published in 1990 claimed that the increased rate of reading disability in boys was a consequence of referral bias.

Objectives To summarize the history of research on sex differences in reading disability and to provide new evidence from 4 independent epidemiological studies about the nature, extent, and significance of sex differences in reading disability.

Design, Setting, and Participants The Dunedin Multidisciplinary Health and Development Study comprised 989 individuals (52.1% male) in a cohort born between April 1972 and March 1973 in Dunedin, New Zealand, and followed up from age 3 years; reading performance and IQ were assessed at ages 7, 9, and 11 years using the Burt Word Reading Test and the Wechsler Intelligence Scale for Children–Revised (WISC-R), respectively. The Christchurch Health and Development Study comprised 895 individuals (50% male) in a prospectively studied cohort born in the Christchurch, New Zealand, region during a 4-month period in 1977; reading performance and IQ were assessed at ages 8 to 10 years using the Burt Word Reading Test and the WISC-R. The Office for National Statistics (ONS) Study comprised a UK nationally representative sample of 5752 children (50.1% male) aged 9 to 15 years in 1999; reading was assessed on the British Ability Scales II and IQ on the British Picture Vocabulary Scales II. The Environmental Risk Longitudinal Twin Study (E-Risk) comprised 2163 twin children from England and Wales (49.1% male) identified at birth in 1994 and 1995 and included administration of the Test of Word Reading Efficiency at age 7 years and the Wechsler Preschool and Primary Scale of Intelligence–Revised as a test of IQ at age 5 years.

Main Outcome Measure Reading performance by sex in the lowest 15% of the distribution for all 4 studies, with and without taking IQ into account.

Results In all 4 studies, the rates of reading disability were significantly higher in boys. For non-IQ-referenced reading disability: Dunedin study, 21.6% in boys vs 7.9% in girls (odds ratio [OR], 3.19; 95% confidence interval [CI], 2.15-4.17); Christchurch study, 20.6% in boys vs 9.8% in girls (OR, 2.38; 95% CI, 1.62-3.50); ONS study, 17.6% in boys vs 13.0% in girls (OR, 1.43; 95% CI, 1.23-1.65); and E-Risk, 18.0% in boys vs 13.0% in girls (OR, 1.39; 95% CI, 1.04-1.86). The rates for IQ-referenced reading disabilities were similar.

Conclusion Reading disabilities are clearly more frequent in boys than in girls.

JAMA. 2004;291:2007-2012

www.jama.com

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this disability should constitute a high priority.

The purposes of this article are (1) to summarize briefly the history of research on sex differences in reading disability to identify the source of claims and counterclaims on whether such differences are valid and (2) to provide new empirical evidence from 4 general population-based epidemiological studies with a total of almost 10 000 participants about the nature, extent, and significance of sex differences in reading disability.

Thirty years ago, epidemiological studies drew attention to the preponderance of male children with reading disability. Surveys both on the Isle of Wight and in an inner London borough³ were consistent in showing that reading disability, whether assessed through group or individual tests, was substantially more frequent in boys than in girls. Moreover, the sex difference was evident whether reading disability was considered in terms of IQ-referenced (adjusted) specific reading retardation (in which reading was markedly lower than that predicted on the basis of age and IQ) or non-IQ-referenced general low achievement in reading. Thus, in the inner London sample of 10-year-olds, the rates of specific reading retardation on group tests were 16.9% in boys compared with 7.2% in girls. Using individual testing in those with positive screens on the group reading test, the rates were 4.6% vs 2.0%. The comparable data for Isle of Wight 10-year-old boys and girls were 8.6% vs 3.7% on group tests and 5.6% vs 2.9% on individual tests.³

When non-IQ-referenced reading disability was defined as performance at least 28 months behind population norms on either reading accuracy or reading comprehension, the male-female difference on group tests was 15.9% vs 7.2% in inner London, with 22.2% vs 15.6% on the basis of individual testing of those who had positive screens. The comparable Isle of Wight data were 8.6% vs 3.7% on group testing and 10.5% vs 6.1% on individual testing. The sample sizes in both

cases were large: 1689 for the inner London 10-year-olds and 1142 for the Isle of Wight 10-year-olds.

Some 15 years later, in 1990, Shaywitz et al,⁴ reporting on a sample of 414 children aged 7 to 8 years, drew attention to their finding that the sex ratio in their epidemiological study was very much less than that in their sample of children identified on the basis of school records. Among the children in second grade, the rates were 8.7% in boys vs 6.9% in girls, and 1 year later (at a mean age of 8.7 years), the comparison was 9.0% vs 6.0%. Their findings were important in drawing attention to possible biasing effects of sampling on the basis of school records, but their findings have been widely used to infer that the sex difference was artifactual because the difference fell short of statistical significance. The latter conclusion was ill advised because the article made no mention of contrary findings from the earlier epidemiological studies based on much larger samples.

Since 1990, 2 large-scale epidemiological studies have reported findings on the sex ratio for reading disability. Flannery et al⁵ used data from the American National Collaborative Perinatal Project, involving some 32 223 women and their offspring followed up from pregnancy to children's age of 7 years. The regression method of Yule et al⁶ was used to identify children with an IQ-referenced reading disability (after exclusion of those who were blind or deaf or who had major behavior problems or an IQ \leq 80). A male-female ratio of about 2:1 was found in both the white and black subsamples, with the excess of boys being more marked in the case of severe reading disability. The researchers showed that this was not an artifact of taking IQ into account. In addition, they found that the sex difference was not explicable on the basis of inattention or overactivity.

The second large-scale study was undertaken by Katusic et al⁷ in Rochester, Minn, and was based on 5718 children born between 1976 and 1982 who remained in the area after age 5 years. Data were available from medical, school, and

tutoring sources, including individual psychological test findings as part of the records. Reading disability was defined through 2 formulas, 1 IQ-referenced and 1 non-IQ-referenced (ie, based solely on low achievement). Regardless of the method used, boys were 2 to 3 times more likely to be affected. The methods used were thorough, but the findings are limited by the outmigration of two fifths of the birth cohort before they began school and lack of detail on psychological testing.

As far as we can determine, these are the only unselected total population epidemiological studies in the English-speaking world with a sample size of 600 or greater (selecting this cutoff on the basis of power calculations).

In summary, despite continuing claims that reading disability affects boys and girls equally,⁸ the available evidence suggests that this is not the case. The goal of this report is to consider new findings from 4 recent major general population epidemiological studies to determine whether, across a range of different general populations, there is a significant excess of boys with reading disability.

To adequately test the hypothesis of a higher rate of reading disability in boys, it was essential to use representative total population samples that were not reliant on any kind of service referral and that did not involve exclusions on the basis of putative causal factors. That is what the 4 samples in this report provided.

METHODS

Dunedin Multidisciplinary Health and Development Study

This cohort of 1037 children (52.1% male) was formed at the participants' age of 3 years, when the investigators successfully enrolled 91% of the consecutive births between April 1972 and March 1973 in Dunedin, New Zealand. The participants have been followed up through age 26 years. Cohort families represent the full range of socioeconomic status in the general population of New Zealand's South Island. The study participants are pri-

marily European in origin, with 7% self-identified at age 18 years as Maori or Pacific Islander ethnicity.

Reading performance was individually assessed at ages 7, 9, and 11 years using the Burt Word Reading Test,⁹ a word recognition reading test that resembles the American Wide Range Achievement Test of reading. Assessments were made within 2 months of the children's birthdays. We combined the age-standardized measures of reading scores from the 3 age periods to form an overall score (to obtain a more valid assessment).¹⁰ At ages 7, 9, and 11 years, each child's intelligence was assessed with the Wechsler Intelligence Scale for Children-Revised (WISC-R).¹¹ We combined the WISC-R performance IQ scores from the 3 age periods to form an overall performance IQ score. The reported reliabilities of both the Burt Word Reading Test and the WISC-R exceeded 0.90.

We used 2 methods to identify reading-disabled children. First, all of the children with reading scores that placed them in the lowest 15% of the reading test distribution were classified as having a reading disability. We refer to this as a non-IQ-referenced reading disability. The 15% cutoff was used to ensure adequate statistical power to test for sex differences. Second, we measured reading disability in reference to performance IQ. This was achieved by fitting a regression model relating reading scores to the children's WISC-R performance IQ scores and computing for each child an expected reading score conditional on IQ and then classifying children whose observed reading score was more than 1 SD below their reading score predicted on the basis of WISC-R performance IQ score. This method follows that recommended by Yule et al⁶ with the exception that Yule et al recommended a cutoff criterion of 1.5 SDs below the predicted scores. We used a 1-SD cutoff to ensure sufficient base rates for what was needed in statistical analysis. Sex differences were assessed by comparing the percentage of boys vs girls with reading disability in each study. The study had 80% power

($\alpha = .05$) to detect an odds ratio (OR) of 1.6 or greater between sex and reading disability.

Christchurch Health and Development Study

Participants were part of a longitudinal study of an unselected birth cohort of 1265 children who were born in the Christchurch, New Zealand, urban region during a 4-month period in mid-1977.^{12,13} These children were studied at birth, 4 months, 1 year, and annual intervals to age 16 years, and again at ages 18 and 21 years. The sample was predominantly European, with 15% identifying themselves as New Zealand Maori or Pacific Islander ethnicity.

The present analysis is based on a sample of 895 children (50% male) for whom data on reading and IQ test scores were available for ages 8 to 10 years. This sample is substantially smaller than the original sample size of 1265 for 2 reasons. First, over the period of the study, there was attrition in the sample owing to the combined effects of refusal, outmigration, and death. The effect of this attrition was to reduce the cohort to 1067 participants by age 10 years, with these children representing 92% of the cohort who were still resident in New Zealand at that age. Second, for administrative reasons, psychometric testing was conducted only among cohort members who resided in Canterbury Province, of which Christchurch is the major urban center. The reduction in sample size was not correlated with sex, nor did it involve good readers in one sex and poor readers in the other, suggesting that selective factors did not influence the validity of the findings reported here.

Reading performance was individually assessed at ages 8, 9, and 10 years using the New Zealand revision of the Burt Word Reading Test.¹⁴ To provide an overall measure of reading ability, the reading test scores at each age were standardized and then averaged over the 3 age periods. At ages 8 and 9 years, participants were also assessed using the WISC-R.¹¹ The WISC-R performance IQ scores were averaged over the 2 peri-

ods to provide an overall measure of performance IQ. All assessments were completed within 2 months of the children's birthdays. The reliability of the Burt Word Reading Test was in excess of 0.97 at each age. The reliabilities of the WISC-R performance IQ scores ranged from 0.87 to 0.90.

Reading disability was assessed in a way similar to that used in the Dunedin cohort.¹⁰ That is, non-IQ-referenced reading disability was defined to include all children whose reading test scores placed them in the lowest 15% of the reading test score distribution; IQ-referenced disability was defined to include all whose observed reading scores were more than 1 SD below the score predicted on the basis of performance IQ. The study had 80% power ($\alpha = .05$) to detect an OR of 1.7 or greater between sex and reading disability.

Office for National Statistics Study

Participants were children involved in a national survey of child mental health carried out by the UK Office for National Statistics (ONS) in 1999.¹⁵ The full cohort of 10 438 children was formed as a representative sample of children in private households between the ages of 5 and 15 years identified via the Child Benefit Register. Child benefit is a financial allowance available to all families with children in the United Kingdom; the register should thus provide a relatively complete basis for sampling the child population. For the present analyses, children aged 9 to 15 years were included, resulting in a sample of 6524 children (50.1% male), of whom 90.6% were white.

The children were given individual assessments of their single-word reading ability using the British Ability Scales II¹⁶ and their global cognitive ability/receptive vocabulary using the British Picture Vocabulary Scales II.¹⁷ Both tests are widely used in UK research and clinical practice and show high reliability (0.89-0.97 and 0.86-0.95, respectively). Standardized scores for all measures were used to identify the groups. Complete IQ and reading test data were available for 5752 chil-

dren aged 9 to 15 years. Missing test data were more common among older participants and those with mental health problems, but test completion was unrelated to sex. Exactly the same proportions (88.1%) of both boys and girls completed IQ and reading tests. Inverse probability weights, derived from logistic regression models that included age and mental health status as predictors of test response, were used to correct for sample attrition.

Reading disability was identified by focusing on reading disability without taking IQ into account and then focusing on IQ-discrepant reading disability, defined on the basis of a regression formula, using the approach described by Yule et al.⁶ Because the sample was large, it was possible to implement 2 cutoffs for each definition: the lower 15% of the distribution (comparable with the other studies) and a more stringent lowest 5% cutoff. The survey models of STATA, version 7,¹⁸ were used for all analyses to allow for the use of weights (the standard ONS survey sample weights¹⁵ and the additional weights developed to take account of nonresponse on the cognitive tests). The study had 80% power ($\alpha = .05$) to detect an OR of 1.25 for the 15% cutoff and of 1.5 for the 5% cutoff.

The Environmental Risk Longitudinal Twin Study

The Environmental Risk Longitudinal Twin Study (E-Risk) involves 2232 twin children (49.1% male) and investigates how genetic and environmental factors shape children's development. The study follows a nationally representative sample of families with same-sex twins (56% monozygotic) born in 1994 and 1995 in England and Wales (see Moffitt¹⁹ for a full description of sampling methods). Ten percent of families are of nonwhite race/ethnicity. For the present analysis, we focused on children studied at age 5 years (when an IQ test was administered) and age 7 years (when 98% of the sample was administered a reading test).

Children's reading was individually tested at age 7 years using the Test of Word Reading Efficiency,²⁰ which mea-

sures the number of printed words that can be accurately identified in 45 seconds and provides an index of the size of the child's reading vocabulary. At age 5 years, children's IQs were individually tested using a short form of the Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R).²¹ Using 2 subtests (vocabulary and block design), children's IQs were computed following procedures described by Sattler.²² Reported reliabilities of the measures exceed 0.90.

Non-IQ-referenced reading disability was defined to include all children whose reading test scores placed them in the lowest 15% of the reading test score distribution. IQ-referenced disability was defined to include all whose observed reading score was more than 1 SD below the score predicted on the basis of their prorated WPPSI-R IQ scores.

The E-Risk study contains an enriched high-risk stratification sampling frame. To provide unbiased estimates that can be generalized to the population of children born in 1994-1995 in England and Wales, the data reported in this article were corrected with weights derived from the General Household Survey.¹⁹ In addition, analyses for the E-Risk sample are based on the Sandwich or Huber/White variance estimator,²³ a method available in STATA, version 7.0.¹⁸ Application of this technique addresses the assumption of independence of observations. It adjusts estimated standard errors and, therefore, accounts for the dependence in the data due to analyzing sets of twins. The study had 80% power ($\alpha = .05$) to detect an OR of 1.4 or greater between sex and reading disability.

RESULTS

Dunedin Multidisciplinary Health and Development Study

In the overall sample of 989 children, the rate of non-IQ-referenced reading disability was 21.6% in boys vs 7.9% in girls, with an OR of 3.19 (95% confidence interval [CI], 2.15-4.17; $P < .001$). The comparable data for IQ-refer-

enced reading disability were 24.6% in boys vs 8.9% in girls, giving rise to an OR of 3.29 (95% CI, 2.26-4.78; $P < .001$).

Christchurch Health and Development Study

In the overall sample of 895 children, the rate of non-IQ-referenced reading disability was 20.6% in boys vs 9.8% in girls, giving rise to an OR of 2.38 (95% CI, 1.62-3.50; $P < .001$). The comparable data for IQ-referenced reading disability were 19.9% vs 8.3%, for an OR of 2.76 (95% CI, 1.84-4.16; $P < .001$).

ONS Study

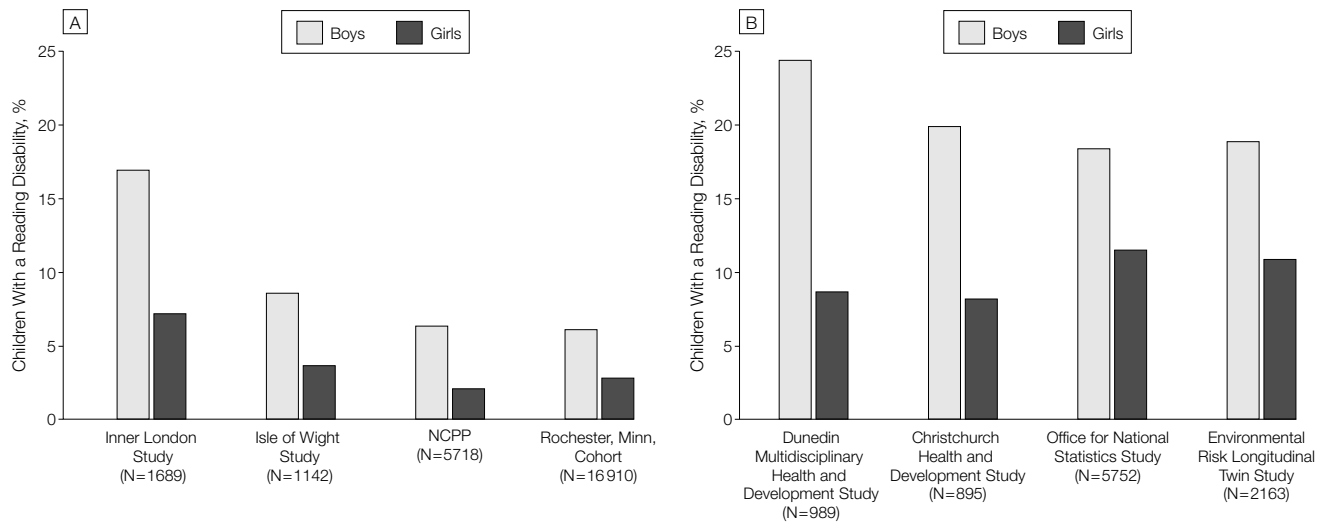
In the overall sample of 5752, 17.6% of boys and 13.0% of girls fell below the 15% cutoff point for reading disability, with an OR of 1.43 (95% CI, 1.23-1.65; $P < .001$). Boys were also overrepresented on the more stringent 5% cutoff (6.7% boys vs 3.5% girls; OR, 2.05; 95% CI, 1.59-2.6; $P < .001$). In terms of IQ-referenced reading disability, 18.5% of boys and 11.6% of girls were in the lowest 15% of the IQ-reading discrepancy distribution (OR, 1.74; 95% CI, 1.49-2.02; $P < .001$), and 7.3% of boys but only 2.8% of girls were in the lowest 5% (OR, 2.72; 95% CI, 2.09-3.55; $P < .001$).

E-Risk Study

In the overall sample of 2163 children, the rate of non-IQ-referenced reading disability was 18% in boys vs 13% in girls, for an OR of 1.39 (95% CI, 1.04-1.86; $P = .03$). The comparable data for IQ-referenced reading disability were 19% in boys vs 11% in girls, for an OR of 1.93 (95% CI, 1.42-2.62; $P < .001$).

Overall

The FIGURE, A, summarizes the findings of the 4 large-scale previously published studies and Figure, B, does the same for the new data from our 4 large-scale studies, in all 8 instances using IQ-referenced reading disability. The overall rates are higher in the 4 newly reported studies because a 1-SD cutoff was used rather than the more ex-

Figure. Sex Differences in IQ-Referenced Reading Disability

A, Prevalence of IQ-referenced reading disability in 2 English samples (the Inner London Study and the Isle of Wight Study) and 2 American studies (the National Collaborative Perinatal Project [NCPP] and a Rochester, Minn, population-based birth cohort). All studies used a regression-based method to define reading disability. In the 2 English samples and in the NCPP, reading disability was defined as reading scores 1.5 SDs below IQ-predicted scores; in the Rochester sample, reading disability was defined as scores 1.75 SDs below IQ-predicted scores. B, Prevalence of IQ-referenced reading disability in 4 new epidemiological studies. In all 4 studies, a comparable definition was used, with children classified with a disability if their reading scores were at least 1 SD below their IQ-predicted scores.

treme cutoffs in the 4 previous studies. In spite of this, the sex ratios are strikingly similar across the 8 studies.

COMMENT

The new findings from these 4 large-scale epidemiological studies are clear-cut in showing that reading disability is substantially more common in boys than in girls. This was true of both more stringent and less stringent definitions and also with respect to both IQ-referenced and non-IQ-referenced reading disability. The studies included in this report had 3 methodological strengths. First, the sample sizes were large. Second, the participation rates were high and the samples were representative of the general populations from which they were selected. Third, the findings were based on standardized testing that was in no way reliant on clinic referral or special educational services. The much earlier findings of the general population epidemiological samples in inner London and on the Isle of Wight³ and the more recent findings from 2 large American studies^{5,7} also showed that reading disability was more frequent in

boys than girls. In short, all 8 studies found that reading disability is much more common in boys than girls.

Although there was general agreement among studies that the rate of reading disability was greater in boys than girls, the size of the difference varied across studies. In particular, the 2 New Zealand studies suggested ORs of well over 2.0, whereas those in the 2 UK studies were somewhat lower. This may reflect the fact that the New Zealand studies were able to combine measures across ages (thereby probably increasing the reliability and validity of measurement) whereas both of the UK studies had to rely on a single measurement point. Insofar as this explains the difference, it is probable that the true OR is at least 2.0.

However, that may not be the full explanation. The Programme for International Student Assessment (PISA) has recently reported the findings of its survey of reading skills in 15-year-olds in 32 different countries.²⁴ In all 32 countries, the literacy levels of girls exceeded that of boys. However, the extent of the sex difference varied considerably. New Zealand had the third highest difference, whereas the United

Kingdom was seventh lowest (the ratio between the 2 was 1.8). Despite these national differences, it appears that throughout the English-speaking world (as represented by the United States, the United Kingdom, and New Zealand) boys are more likely than girls to have reading disability.

In conclusion, the epidemiological findings should now be sufficient for a firm statement that reading disability is truly more frequent in boys than girls. There now needs to be research to determine the causal influences that underlie the sex difference, because their elucidation could throw light on the processes leading to reading disability in both sexes.¹

Author Contributions: Dr Rutter had full access to all of the data in the studies and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Rutter.

Acquisition of data: Caspi, Fergusson, Horwood, Goodman, Moffitt, Meltzer.

Analysis and interpretation of data: Caspi, Fergusson, Horwood, Goodman, Maughan, Moffitt, Meltzer, Carroll.

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Statistical expertise: Caspi, Fergusson, Horwood, Moffitt, Meltzer.

Obtained funding: Caspi, Fergusson, Goodman, Moffitt.

Study supervision: Rutter.

Funding/Support: The Dunedin Multidisciplinary Health and Development Unit is supported by the Health Research Council of New Zealand. The research is supported by US National Institute of Mental Health grants MH45070 and MH49414 and the William T. Grant Foundation. The E-Risk study is funded by the UK Medi-

cal Research Council. Dr Moffitt is a recipient of a Royal Society-Wolfson Research Merit Award. The Christchurch Health and Development Study research was funded by grants from the Health Research Council of New Zealand, the National Child Health Research Foundation, the Canterbury Medical Research Foundation, and the New Zealand Lottery Grants Board. The 1999 ONS study of child mental health was funded by the Department of Health, the Scottish Executive, and the National Assembly for Wales. Dr Maughan is supported by the Medical Research Council.

Role of the Sponsors: In the case of the ONS study, a Department of Health steering committee periodically reviewed the design and conduct of the study but took no role in the collection, analysis, or interpretation of the data or in the preparation, review, or approval of the manuscript. None of the studies' other sponsors had any role in the design and conduct of the studies, in the collection, analysis, and interpretation of the data, or in the preparation, review, or approval of the manuscript.

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Philosophy is the battle against the bewitchment of our intelligence by means of language.
—Ludwig Wittgenstein (1889-1951)