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Family history of handedness and language problems in Mexican reading-disabled children

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A sample of 120 Spanish-speaking children, 60 with reading disabilities and 60 normal readers was studied. Individual and family history of handedness, language problems, and reading disabilities were analyzed in each case. The results suggest that reading disabilities are more common among boys, that associated language problems are frequent and that handedness is not a significant factor. Insofar as family history is concerned, there were more affected families and relatives in the reading disabled group than in the control group. Finally an association was established between the variables of handedness and language problems.

Keywords: Children – Dyslexia – Genetics – Reading disabilities

INTRODUCTION

A specific reading disability like dyslexia is one of the most common educational problems (Malatesha and Dougan, 1982). The schoolchildren who suffer from it are otherwise at least average in cognitive skills, and emotional and social experiences, and this disability is not attributable to other handicapping conditions (Hynd and Cohen, 1983).

Early research on reading disability gave rise to the hypothesis that an association exists between learning problems and imperfect cerebral dominance, linked mainly to a high frequency of left- or mixed-handedness (Orton, 1928, 1937). Even though there is more recent research about this subject (Porac and Coren, 1981), the questions remain unanswered. Geschwind and Behan (1982) reported an association between left-handedness, certain disorders of the immune system and dyslexia, which is stronger in males.

On the other hand, it has been established that some children with reading disability had language problems early in development (Pirozzolo, 1985). Hécaen *et al.* (1981) suggested that bilateral language representation is more common among left-handed subjects with a family history of left-handedness. Possibly, this type of representation favors a greater incidence of reading problems. Studies on the genetics of reading disability demonstrated that at least in certain subtypes, a family aggregation exists (Van Strien *et al.*, 1990; DeFries and Decker, 1992). Nevertheless, no conclusive relationship has been established between reading disability, handedness, and language problems.

Furthermore, a hypothesis exists about the relationship between the language orthography and the reading problem tipology. Taking English and Spanish, the former is a partially logographic reading system (depth ortography) and the latter uses a more graphophonemic reading system (shallow orthography). Taking account of this hypothesis, some differences in reading errors have been shown between Spanish and English speaking brain-damaged dyslexic adults (Ardila *et al.*, 1989; Ardila, 1991) and between German and English speaking dyslexic children (Wimmer, 1994). The language and cultural characteristics of the subjects may influence different variables.

We studied a sample of reading-disabled and normal readers among Mexican children (Spanish speakers). A possible association between reading disability, handedness and language problems was analyzed, as well as the family history in question. Since there are almost no studies on Spanish-speaking dyslexic children, and because the structure of the Spanish

language is different from that of English, where the spelling is more transparent (meaning that there is a high grapheme-phoneme consistency) the present studies are of particular value.

METHODS

The reading disabled group (RDG) was made up of 60 children, randomly selected from the 'Centro Psicopedagógico de Guadalajara', belonging to the 'Departmento de Educación Especial, Unidad de Servicios Educativos a Descentralizar'. They ranged from second to sixth grade of elementary school; 12 from each grade were included. WISC-RM IQ ranged from 86 to 120. All of them were diagnosed previously as specifically reading disabled, and obtained only low scores on reading and writing with the Guías de Evaluación Psicopedagógicas and PPCILEM which are unpublished Mexican tests designed to detect specific learning failures. The Control Group (CG) was made up of randomly selected children from the same sex, grade and school as that of the RDG; only children with good school performance and no recognized learning difficulties were included in the CG.

The reading profiles of the two groups obtained through the reading of a story of 290 words were considerably different in relation to the reading speed and the number of words misread but not in relation to omitted words (Table I).

TABLE I. Comparisons between the reading disabled (RDG) and control group (CG) for text reading

Variable	RDG		CG			
	Mean	S.D.	Mean	S.D.	*t*	*p*<
Words/min	51.12	22.34	86.53	26.98	−7.83	0.00001
Words misreaded	21.63	15.37	10.05	7.80	5.20	0.00001
Words omitted	7.35	20.08	2.98	3.98	1.65	N.S.

Personal and family data were obtained for each case in two ways: (1) Centro Psicopedagógico Records; (2) a questionnaire to the parents of each child, including identification data, medical, educational and personal background. With regard to the language problems, the parents were asked if their child had had a delay or problems in learning to talk and if it had undergone language therapy. Family information included: parents' identification data, educational and social level, occupation, a two-generation pedigree and reports (only by parental reference) of handedness, reading disability, and language problems in parents and siblings. This information was obtained by a questionnaire. The 120 children were examined using the following tests. First, a handedness test: hand use was evaluated with eight items to identify hand dominance, four of them required only one hand (to catch a ball, to write, to brush his or her hair, to take a spoon), and four required the participation of both hands (to twist a jar open, to open a Coke bottle, to take a hat and to put it on a doll, to thread a needle). The dominating hand in each task was registered, and a percent of handedness was calculated (number of right-hand dominant tasks/total tasks × 100 = %) and expressed as handedness coefficient (HC); those children with HC between 100 to 88 were classified as right-handed, those with 87 to 13 as 'mixed', and those with HC 12 to 0 as left-handed. Second, reading and writing tests were performed. Reading was assessed by reading of a text, and oral recovery of the text that was read by asking each child to tell the story in their own words. Writing was assessed by retelling in writing the story that was read by the examiner (Matute and Leal, 1994), and a specially designed word notion evaluation. All the results of these tests are still being processed, and will be published in other papers.

Procedure

The evaluation was carried out in two individual sessions with each child and an interview with one of the parents to obtain the information required. The data was recorded on a specially designed sheet and later computer processed. Means, averages and percentages were used to analyze the resulting frequencies, also contrasted with chi-square, Student's-*t*, and Fisher's exact tests.

RESULTS

General Data

Thirty-nine boys and 21 girls were included in the RDG, a sex ratio of 2:1 males:females was observed. The chi-square test gave a significant result ($p<0.05$). This 2:1 ratio was constant in all grades (Table I). The children's sex registration at the schools where the sample was drawn from was 898 females, and 800 males. A significant difference between the sex ratio of the RDG and the schools' attendance was found (chi-square test = $p<0.05$).

The average age was 10.43 years in the RDG and 9.60 in the CG. Student's *t* test gave $p<0.01$, a significant difference, whereas the comparison of ages related to sex between the groups (RDG × CG)

TABLE II. General data

Variables			Reading disabled group			Control group		
			n[2]	%	Mean	n[2]	%	Mean
Sex		Females	A[3] 21	35		21	35	
		Age[1]			C[4] 10.14			τ[4] 9.52
		Males	B[3] 39	65		39	65	
		Age			D[4] 10.51			δ[4] 9.77
Total			60	100	E[4] 10.43	60	100	ε[4] 9.60
Parents' education		Elementary school		62			63	
		High school		14			14	
		Others		24			23	
Parents' work	Mother	Housewife		86			77	
		Private		36			30	
	Father	entrepreneur						
		Independent worker		24			28	
Family size (mode)			3			3		
Number of sisters (mode)			1			1 or 2		
Number of brothers (mode)			1			1 or 2		

[1] Age in years.
[2] n = number of individuals.
[3] Chi-square test: A vs B = $p<0.05$.
[4] Student's t test: C vs τ = N.S.; D vs δ = $p < 0.05$; E vs ε = $p<0.01$.

showed no difference in the females, and a discrepancy in the males. These results are related to school failure, since 38 children from RDG had had to repeat grades, and none of the CG had. Moreover, no difference in school failure was found between males and females within the groups (Table II).

Since the parents' educational level and occupation, as well as siblings number and birth order were similar, no difference was found between the two groups of families (Table II).

Language problems

Eight girls and 18 boys from the RDG had suffered some kind of language problem (LP), but in the CG only three children exhibited LP (Table III). The difference between the groups is highly significant ($p<0.0001$).

Handedness

Both groups exhibited mostly right-handed children (Table IV). A tendency towards a greater frequency of mixed and left-handed subjects in the RDG than the CG was observed; however this difference did not reach statistically significant levels.

Left-handedness and language problem association in the reading disabled group

Of the 44 right-handed reading-disabled children, 16 had language problems (1:3 ratio) whereas from the 52 right-handed CG subjects, only two had language problems (1:26 ratio). The chi-square test showed a highly significant difference ($p=0.0001$); nevertheless, the other subgroups gave no significant values, owing to the small number of mixed and left-handed subjects tested (Table V).

TABLE III. Frequency of language problems (LP) in the studied groups

		Without LP		LP present		Total		Chi-square test
		n	%	n	%	n	%	$p<$
Reading disabled group	A Females	13	62	8	38	21	100	A vs B N.S.
	B Males	21	54	18	46	39	100	B vs β 0.0001
	C Total	34	56	26	44	60	100	C vs τ 0.0001
Control group	α Females	19	90	2	10	21	100	A vs α 0.05
	β Males	38	97	1	3	39	100	α vs β N.S.
	τ Total	57	95	3	5	60	100	

TABLE IV. Handedness distribution in the studied groups

		Right-handed		Mixed		Left-handed		Total		Chi-square test
		n	%	*n*	%	*n*	%	*n*	%	*p*<
Reading disabled group	A Females	17	82	2	9	2	9	21	100	A *vs* B N.S.
	B Males	27	69	10	26	2	5	39	100	B *vs* β N.S.
	C Total	44	73	12	20	4	7	60	100	C *vs* τ N.S.
Control group	α Females	19	90	1	5	1	5	21	100	A *vs* α N.S.
	β Males	33	85	6	15	0	0	39	100	α *vs* β N.S.
	τ Total	52	86	7	12	1	2	60	100	

TABLE V. Handedness and language problems in the studied groups

		Right-handed		Mixed		Left-handed		Total		*p*<
		n	Ratio	*n*	Ratio	*n*	Ratio	*n*	Ratio	
Reading disabled group	With LP[3]	16	1:3	7	1:2	3	1:1	26	1:2	A *vs* α 0.001[1]
	No LP	28	1:2	5	1:2	1	1:4	34	1:2	B *vs* β N.S.[2]
	Total	44	A	12	B	4	C	60		C *vs* τ N.S.[2]
Control group	With LP	2	1:26	1	1:7	0	0	3	1:20	
	No LP	50	1:1	6	1:1	1	1:1	57	1:1	
	Total	52	α	7	β	1	τ	60		

[1] Chi-square test.
[2] Fisher's exact test.
[3] LP = language problems.

Family history of reading disabilities and language problems

The presence of reading disabilities, language problems, and other development problems were ascertained in first degree relatives (a relative with half of their genes in common, i.e. parents and siblings). In the RDG, 58 families were anlayzed since there were two pairs of siblings. In the CG, since there were three pairs of siblings, we analyzed only 57 families (Table VI). A total ratio of a positive:negative family history was 1:3 for RDG (one of every three families has a positive history) and 1:7 for CG; the total ratio relatives/all relatives was 1:12 in the RDG, and 1:39 in the CG. The latter was statistically different ($p<0.01$) (Table VI).

Handedness in the families

The HC of the grouped children was established, but not that of their parents and siblings; they were classified by anamnesis as left or right-handed. The left-handed relatives (LHR) were located according to the children's handedness.

TABLE VI. Frequency of reading disabilities (RD) and language problems (LP) within the families from the studied groups

		Number with positive family history of:						Total		
		Total	LP	RD	LP and RD	Mixed[1]	Sub-total	Without	Ratio	Chi-square test *p*<
Reading disabled groups	A Families	58[3]	0	5	3	9	17 (c)	41	17/58 1:3	c vs τ<0.05
	B Relatives[2]	311	0	6/36	3/22	16/51	25/109(D)	202	25/311(E) 1:12	D vs δ N.S.
Control group	a Families	57[4]	5	3	0	0	8 (τ)	49	8/57 1:7	E vs ε<0.01
	b Relatives	310	5/30	3/5	0	0	8/45 (δ)	265	8/310(ε) 1:39	

[1] Mixed = LP + RD + others.
[2] Relatives = affected relatives/total relatives in the families of each subgroup.
[3] Since two pairs of siblings were in the RDG, there appears two families less.
[4] Three pairs of siblings in CG, leading us to three families less.

TABLE VII. Left-handers in the studied groups families compared with children's handedness

	Families[4]				Relatives[4]			
	Total		With LH[5] members		Total[1]		Left-handed	
	RDG[2]	CG[3]	RDG	CG	RDG	CG	RDG	CG
Right-handers *propositi*	42	49	7	5	39	27	7	5
Mixed *propositi*	12	7	2	3	8	20	4	3
Left-handers *propositi*	4	1	2	0	8	0	2	0
Total	58	57	11	8	55	47	13	8

[1] Total relatives from the left-handed families.
[2] RDG = reading disabled group.
[3] CG = control group.
[4] Chi-square test: no significant difference between the RDG and the CG.
[5] LH = Left handed.

Table VII shows that eleven out of 58 (19%) of the families RDG subjects had 13 first degree, left-handed relatives (with half of their genes in common) whereas in the CG, eight out of 57 (14%) had eight left-handed relatives. This difference is not significant.

When we considered the 19 families with left-handed relatives (11 in the RDG plus eight in the CG) we found that in the RDG, there was a ratio of 13 left-handed relatives to 42 non-left-handers, whereas in the CG, there were eight left-handed relatives to 39 non-left-handers. The difference, however, is not significant.

Similarly, a comparison was made within these 19 families, of the relationship between the subjects' HC and the number of left-handed relatives; we discovered a tendency in the mixed HC sub-group of the RDG towards a greater number of left-handed relatives (four left-handers relatives/two families), although the difference was not significant.

Regarding the frequencies of left-handed relatives according to their HC, we found that in the RDG, seven of the 42 right-handed subjects, two of the 12 mixed subjects, and two of the four left-handed subjects, had left-handed relatives. In the CG, on the other hand, five out of 49 of the right-handed subjects; three out of seven of the mixed subjects; and none of the left-handed subjects had left-handed relatives. There was a tendency towards a greater number of families with left-handed relatives within the left-handers *propositi* sub-group, but a significant difference was not reached, due to the small number of left-handed *propositi* tested.

The comparison of the number of left-handed relatives in relation to the total number of first-degree relatives for each group shows a slight tendency towards a greater number of left-handed relatives in the RDG, although the difference cannot be considered significant.

A remarkable difference between the two groups was observed in the parental generation: in the RDG, there were six couples with one or two left-handed members (in three couples the mother was left-handed, in two the father was left-handed, in one both parents were left-handed) and these six couples were the parents of one left-handed, two mixed, and three right-handed *propositi*. In the CG, only two couples had left-handed elements (in one the mother, and in the other the father), the left-handed mother had a right-handed child, the left-handed father had a mixed child. This suggests an environmental and possible genetic tendency towards left-handedness in the RDG families transmitted through the parents. On the contrary, the expected higher frequency of left-handers in the RDG filial generation was not found, leading to no difference between the total number of left-handed relatives in the RDG and CG.

DISCUSSION

Since the RDG and the CG had equal family conditions and thus similar learning opportunities, the difference between them could be biological.

The frequency of mixed and left-handed subjects recorded in this study (RDG and CG), was within the range reported in child populations. In fact in a review of 24 studies on school children, Porac and Coren (1981) reported 92.7% as right-handed, and 7.3% mixed or left-handed. Annett (1970) in a sample of 2000 children 5–15 years old, and 52 nursery school children, reported 25% as mixed.

The handedness frequencies in the RDG show more discrepancy than those of the CG in relation to the expected rate: we found less right-handers in the RDG than in the CG, but such differences were not significant.

In the study of Geschwind and Behan (1982),

10.9% of their 253 randomly selected left-handed subjects had learning disorders (dyslexia and stuttering), compared with 1.2% found in their CG of right-handers; then, they concluded to an association between learning disabilities and left-handedness. The present study, however, did not obtain the expected inverse results: that is, many left-handers in a group of subjects with reading problems selected from a captive population. There is, however, a tendency towards more left-handed subjects in the RDG (Table VI). This lack of association could reflect the disparity between the populations approached, or else the ethnic difference between the Anglo and Mexican people. In fact, Pennington *et al.* (1987) reported in 14 families of dyslexics with autosomal dominant transmission in three generations, an association with allergy problems, but not with left-handedness; moreover, they demonstrated the genetic heterogeneity of dyslexia by the linkage of dyslexia with heteromorphism of chromosome 15 in some families and not in the others. This heterogeneity must be considered, since difference ethnic groups may have different associations with dyslexia.

In recent years, new approaches have given insights into the genetic etiology of reading disability. From the Colorado and London twin studies (DeFries *et al.*, 1991), it has been calculated that a 60% reading deficit in their probands is a consequence of an inheritable influence. At least two major genes, located on chromosomes 6 and 15 were identified by linkage (Smith *et al.*, 1983, 1991) with genetic markers; the markers for chromosome 6 are within the HLA gene cluster, and this suggests a relationship between the reading disability and autoimmune diseases (DeFries and Gillis, 1993).

Furthermore, since reading-disability children are an heterogeneous group (Porac and Coren, 1981), handedness would be related to certain, but not all, reading disabilities; a characterization of the kind of reading disabilities present is then necessary for such an association to be established.

About family left-handedness, it is worth noting that the RDG was ascertained regardless of the handedness of their family members, so we considered that there is no selection bias in that respect. According to the phenotypic frequency observed in the CG and RDG for left-handed subjects, the greater frequency of left-handed parents in the RDG coincides with a greater frequency of left-handedness in the filial generation. This congruence was also observed in the CG, where we encountered a lesser proportion of left-handed parents and fewer left-handed children, a situation that supports the idea that the population of the two groups have different genetic backgrounds.

Human preference for right-handedness is considered a partially genetic trait. The hereditary character is supported by the permanence over 5000 years of a 92.6% frequency of right-handedness and 7.4% of left-handedness (Coren and Porac, 1977), and the family aggregation of left-handedness (Porac and Coren, 1981).

However, there are difficulties involved in establishing a form of inheritance that adapts itself to all cases; a simple Mendelian inheritance does not explain how two left-handed progenitors can have right-handed offspring if they are 'homozygous recessive for the left-handed gene', since 60% of the offspring of left-handed couples are right-handed (Porac and Coren, 1981). It would be difficult for a Mendelian inheritance involving two genetic loci to yield a continuous phenotypic pattern in the population. A polygenic inheritance, on the other hand, involving more than three genetic loci with additive effects, would provide an explanation that is more consistent with the reported population studies (DeFries, 1989). However, certain data cannot be explained exclusively by polygenic inheritance. This refers to the so-called 'maternal effect', by which the presence of left-handed mothers reduces the incidence of right-handed offspring by 14% (Porac and Coren, 1981). This 'maternal effect' could be a genetic imprinting in which specific modifications of the germinal line in homologous chromosomes occur in gametogenesis. These modifications endure and are replicated in the embryo, and they distinguish paternal allelic regions from the maternal ones, even in the later stages of development. This imprinted information results in different activity (function) of the parental genes; the imprint is erased during gametogenesis and new modifications are introduced by the sex of the organism (Reik, 1988; Hall, 1990).

Thus, the genetic imprinting of a group of linked genes explains the 'maternal effect' tendency. In our study, the presence of three left-handed mothers in the RDG and only one in the CG suggests that the distribution and function of the genes in the two groups are different and could be related to the right shift theory (Annett and Kilshaw, 1984).

However, the number of left-handed subjects in each group is so limited that statistical analysis is not possible, and one can only indicate tendencies (Table VII).

Considering the relationship between left-handedness and language problems, the analysis of the SG indicated a slightly greater proportion of left-handed

subjects with language problems (3/4), followed by the mixed *propositi* (7/12). And lastly, the right-handed subjects do not permit a convincing statistical analysis. We can observe a tendency that supports the hypothesis of the existence of a poor hemispherical specialization, since alterations in the left hemisphere that disturb the linguistic functions can also cause a displacement of handedness to the right hemisphere (Porac and Coren, 1981). This means that, as Lucas *et al.*, (1989) suggested for their mentally deficient population, both language and hand preference of naturally right-handed subjects are specifically affected by brain damage to the left, which produces alterations in hemispherical participation or else reduces the difference between the two hemispheres, as suggested by Annett (1970), who discovered a poorer PPVT performance for the mixed than for the left-handed or right-handed subjects in the sample group; this difference is more pronounced in the male section of the population. Furthermore, Sarma (1989) pointed out a tendency towards lower scoring in reading and language among mixed-handed males, and Dellatolas *et al.* (1990) found a higher frequency of stuttering in left-handers.

However, not all studies point in this direction. Natsopoulos and Xeromeritou (1989) concluded only a slight advantage for female subjects where verbal abilities were concerned, but neither handedness nor family history or left-handedness had any bearing on the frequency of language problems.

Turning to whether there were more boys than girls with learning problems, in the sample group we found a frequency of two boys for every girl, whereas the school register showed 1.0 boy to 1.1 girls, a statistically significant difference.

Developmental disabilities (autism, dyslexia, hyperactivity, etc.) have been reported in literature on this subject as being more common in boys than in girls (see Hynd and Cohen, 1983), and various hypotheses exist involving processes of cerebral lateralization or intrahemispheric specialization (Lewis and Christiansen, 1989) which are different for men and women, due to a development factor linked to sex, which has a differential effect on the structure of neurons in men and women.

In relation to language problems, we found a statistically significant difference between the number of children with language problems in the RDG and the CG. Furthermore, there was a tendency towards a greater amount of associated language problems in boys than in girls. This point could be related to a more general linguistic deficit that includes both oral and written language (cf. Cats, 1989), or else denote a functional–anatomic substratum that is common at least in some of the children with reading problems.

In fact, the majority of research on dyslexia (reviewed by Hynd and Cohen, 1983) agree that there are subgroups as far as this problem goes. Although, as we have confirmed in our study, a large proportion of these children have an associated language problem, their reading problem cannot in all cases be attributed to a language deficit. The tendency towards a greater number of reading disabilities in boys with language problems supports the hypothesis of a greater hemispherical 'lateralization' in the male population (McGlone, 1980), which makes them more susceptible to linguistic alterations due to early unilateral damage.

Finally, in reference to whether the reading-disabled children had more relatives with similar problems than the CG children, we discovered significantly more children with affected relatives, as well as a greater number of affected relatives in the RDG ($p<0.05$), indicating a family tendency towards learning disabilities. As we have already pointed out, handedness can constitute an underlying phenomenon of this tendency, although these learning disabilities can also be caused by one or more genes that are independent of handedness, and in which specific language processes are determined; this has been found in families with dyslexia transmitted in a dominant autosomic fashion (Pennington *et al.*, 1987) where genetic heterogeneity has been demonstrated.

One problem in analyzing the hereditary character of dyslexia is the lack of documentation on the disorder transmitted through a progenitor (Tallal *et al.*, 1990). This kind of obstacle, together with the heterogeneity of dyslexia itself, impedes any conclusive analysis in our present study with regard to the inheritance of learning disabilities.

Thus, apart from characterizing a sample group of Spanish-speaking Mexican children, we established support for the hypothesis that there are more boys than girls with reading problems, and that a large proportion of these children display language problems.

A different family topology was revealed: there was a greater proportion of affected boys and a greater number of left-handed relatives with language and learning problems in the RDG. This establishes the presence of biological factors, which have yet to be fully explained, in the heterogeneity of reading–writing problems.

It is necessary to work with homogeneous or fully-characterized families, examining members located two or three generations apart who would belong to homogeneously dyslexic sample groups so that

the subgroups can be statistically and genetically analyzed.

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REFERENCES

Annett M (1970) Handedness, cerebral dominance and the growth of intelligence. In: *Neuropsychology of Left-handedness* (Eds DJ Bakher and P Satz), pp. 61–79. University Press, Rotterdam.

Annett M and Kilshaw D (1984) Lateral preference and skill in dyslexic: Implications of the right shift theory. *Journal of Child Psychology and Psychiatry*, **3**, 357–377.

Ardila A (1991) Errors resembling semantic paralexias in Spanish-speaking aphasics. *Brain and Language*, **41**, 437–445.

Catts HW (1989) Speech production deficits in developmental dyslexia, *Journal of Speech and Hearing Disorders*, **54**, 422–428.

Coren S and Porac C (1977) Fifty centuries of right handedness: the historical record. *Science*, **198**, 631–632.

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

DeFries JC and Decker SN (1982) Genetic aspects of reading disability: a family study. In: *Reading Disorders* (Eds RN Malatesha and PG Aaron), pp. 255–279. Academic Press, New York.

DeFries JC and Gillis JJ (1993) Genetics of reading disability. In: *Nature Nurture and Psychology*. (Eds R Plomin and G McClearn), pp.121–145. American Psychological Association, Washington.

DeFries JC, Stevenson J, Gillis JJ and Wadsworth SJ (1991) Genetic etiology of spelling deficits in the Colorado and London twin studies of reading disability. *Reading and Writing: an Interdisciplinary Journal*, **3**, 271–283.

Dellatolas G, Annesi I, Jallon P, Chavance M and Lellouch J (1990) An epidemiological reconsideration of the Geschwind-Galaburda theory of cerebral lateralization. *Archives of Neurology*, **47**, 778–782.

Geschwind N and Behan P (1982) Left handedness: Association with immune disease, migraine, and developmental learning disorder. *Proceedings of the National Academy of Sciences*, USA, **79**, 5097–5100.

Hall J (1990) Genomic imprinting: Review and relevance to human diseases. *American Journal of Human Genetics*, **46**, 857–873.

Hécaen H (1981) *Les Gauchers*. Presses Universitaries de France, Paris.

Hynd G and Cohen M (1983) *Dyslexia, Neuropsychological Theory, Research, and Clinical Differentiation*. Grune & Stratton, New York.

Lewis RS and Christiansen L (1989) Intrahemispheric sex differences in the functional representation of language and praxic functions in normal individuals. *Brain and Cognition*, **9**, 238–243.

Lucas JA, Rosenstein LD and Bigler ED (1989) Handedness and language among the mentally retarded: implications for the model of pathological left-handedness and gender differences in hemispheric specialization. *Neuropsychologia*, **27**, 713–723.

Malatesha RN and Dougan DR (1982) Clinical subtypes of developmental dyslexia: resolution of an irresolute problem. In: *Reading Disorders* (Eds RN Malatesha and RG Aaron), pp.69–92. Academic Press, New York.

Matute and Leal (1994) Coherence in short narratives written by reading disabled children (submitted).

McGlone J (1980) Sex differences in human brain asymmetry: A critical survey. *The Behavioral and Brain Sciences*, **3**, 215–263.

Natsopoulos D and Xeromeritou A (1989) Verbal abilities of left and right handed children. *Journal of Psychology*, **123**, 121–132.

Orton ST (1928) Specific reading disability – strephosymbolia. *Journal of the American Medical Association*, **90**, 1095–1099.

Orton ST (1937) *Reading, Writing, and Speech Problems in Children*. Norton, New York. Ostrosky-Solís F and Ardila A (1994) *Cerebro y Lenguage*. Trillas, México.

Pennington BF, Smith SD, Kimberling WJ, Green PA and Haith M (1987) Left handedness and immune disorders in familial dyslexics. *Archives of Neurology*, **44**, 634–639.

Pirozzolo FJ (1985) Neuropsychological and neuroelectric correlates of developmental reading disability. In: *Hemispheric Function and Collaboration in the Child* (Ed. CT Best), pp. 309–326. Academic Press, New York.

Porac C and Coren S (1981) *Lateral Preferences and Human Behavior*. Springer-Verlag, New York.

Reik W (1988) Genomic imprinting: a possible mechanism for the parental origin effect in Huntington's Chorea. *Journal of Medical Genetics*, **25**, 805–808.

Sarma PSB (1989) Mixed-handedness and achievement test scores of grade school children. *Perceptual and Motor Skills*, **68**, 839–846.

Smith SD, Kimberling WJ, Pennington BF and Lugs HA (1983) Specific reading disability: Identification of an inherited form through linkage analysis. *Science*, **219**, 1345–1347.

Smith SD, Kimberling WJ and Pennington BF (1991) Screening for multiple genes influencing dyslexia. *Reading and Writing: an Interdisciplinary Journal*, **3**, 285–298.

Tallal P, Ross R and Curtiss S (1989) Unexpected sex-ratios in families of language/learning-impaired children. *Neuropsychologia*, **27**, 987–998.

Van Strien JW, Bakker DJ, Bouma A and Koops W (1990) Familial resemblance for cognitive abilities in families with P-type dyslexic, or normal reading boys. *Journal of Clinical and Experimental Neuropsychology*, **12**, 843–856.

Wimmer H and Goswami U (1994) The influence of orthographic consistency on reading development: word recognition in English and German Children. *Cognition*, **51**, 91–103.