HANDEDNESS IN THE MENTALLY HANDICAPPED

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Mentally handicapped individuals have frequently been reported to have a higher prevalence of left-handedness than normal individuals (Hildreth 1949, and see Table I). In three studies that divided the mentally handicapped into those with and without Down's syndrome, the prevalence of left-handedness was found to be higher in the non-Down's group. Since the study of individuals with trisomy-21 provides, in principle at least , a way of determining whether a gene is located on chromosome 21 (Bateman 1960), it is of some interest to know if those results can be replicated. The degree of lateralisation has also been reported to be *less* among the mentally handicapped (Pickersgill and Pank 1970, Waitt 1980) and inconsistent results have been found between those with and without Down's syndrome: Waitt found the non-Down's subjects to be more lateralised, while Pickersgill and Pank found no significant differences.

Pipe and Beale (1983), using a dichotic listening test, found that mentally handicapped children more often showed atypical direction of lateralisation, although the degree of lateralisation was not different from normal. It is also of note that several theorists have recommended that a first step in the language training of Down's children should be to increase lateralisation (*e.g.* Gibson 1978).

In the present study we have examined the direction and degree of handedness, assessed by performance, among normal pupils and two groups with mental handicap—with and without Down's syndrome.

Method

Subjects

The subjects were 130 pupils attending normal or ESN(S)* schools in the north-west district of the Inner London Education Authority. They were divided into two populations comprising: (1) 47 normal pupils aged between seven and 12 (27 male, 20 female) and (2) 83 pupils aged between seven and 18 with a moderately severe degree of mental handicap. This population was made up of two groups, identified by their teachers: (*a*) 38 with Down's syndrome (22 male, 16 female) and (*b*) 45 without Down's syndrome, whose mental handicap resulted from a variety of aetiologies (26 male, 19 female). None of the subjects had any obvious physical handicap that would influence their manual preference.

Procedure

The subjects were tested on 10 performance items which had all been used in previous studies. The criteria for including items were that they were familiar to the pupils,

*Educationally Subnormal (Severe).

TABLE I

Percentage prevalence of left-handedness

Study	*Normal*	*Mentally handicapped*	*Down's*	*Non-Down's*
Ballard (1912)	4·3	6·5	—	—
Smith (1917)	4·5	11·0	—	—
Gordon (1920)	7·3	18·7	—	—
Wilson and Dolan (1931)	3·5	6·4	—	—
Burt (1937)	4·8	11·9	—	—
Carrothers (1947)	8·2	—	—	—
Mintz (1947)	—	22·7	—	—
Trankell (1950)	8·2	—	—	—
Hardyck *et al.* (1976)	9·6	—	—	—
McManus (1983)	11·2	19·8	—	—
Murphy (1962)	—	23·0	13·0	28·0
Pickersgill and Pank (1970)	15·6	28·1	18·75	31·0
Waitt (1980)	7·5	32·5	20·0	45·0

TABLE II

Distribution of response types for 10 test items

Item	*Normal (N = 47)*			*Down's (N = 38)*			*Non-Down's (N = 45)*			χ^2
	R	*M*	*L*	*R*	*M*	*L*	*R*	*M*	*L*	
1. Drawing	87·2	—	12·8	73·7	2·6	23·7	73·3	2·2	24·4	NS
2. Writing	87·2	—	12·8	81·8	—	18·2	78·4	—	21·6	NS
3. Throwing cotton reels	36·2	36·2	27·7	35·1	35·1	29·7	34·9	44·2	20·9	NS
4. Dealing cards	69·8	7·0	23·3	28·9	55·3	15·8	45·5	29·5	25·0	***
5. Use of spoon	89·4	—	10·6	62·2	8·1	29·7	74·4	2·3	23·3	*
6. Use of toothbrush	87·2	2·1	10·6	68·4	2·6	29·9	75·0	2·3	22·7	NS
7. Use of comb	85·1	4·3	10·6	63·2	13·2	23·7	72·1	9·3	18·6	NS
8. Blowing nose with paper tissue	23·4	66·0	10·6	36·8	39·5	23·7	48·8	46·5	4·7	**
9. Throwing cotton reels	85·1	6·4	8·5	50·0	31·6	18·4	59·1	31·8	9·1	**
10. Picking a sweet	74·5	—	25·5	54·8	3·2	41·9	57·9	—	42·1	NS

*p<0·05, **p<0·01, ***p<0·001.

TABLE III

Direction of handedness, degree of handedness and age of pupils in each group

		Direction of handedness			*Degree of handedness*			*Age (yrs)*	
	N	*Left*	*Right*	*% Left*	*Total*	*Left-handers*	*Right-handers*	*Mean*	*SD*
Normal	47	5	42	10·6	0·815	0·820	0·814	10·00	1·63
Down's	38	11	27	28·9	0·670	0·613	0·695	12·70	3·75
Non-Down's	45	12	33	26·7	0·716	0·615	0·753	13·04	3·84

that they were not dangerous or frightening, and that the tests could be initiated by verbal instructions alone. The items are listed in Table II. The pupils were assessed in their classrooms, they and the investigator sitting opposite one another across a table. The experimenter produced items singly from a bag, using both hands to place the item on the table in front of the pupil, and instructing him or her verbally on the required task. Each task was carried out twice in immediate succession by each pupil, and the investigator recorded whether the right hand was used on both occasions (R), the left was used on both occasions (L) or the right was used on one occasion and the left on the other (mixed, M).

Results

Table II shows the proportion of pupils who were tested in each of the three categories on each of the tasks. For four of the 10 tasks there were significant differences between groups.

A laterality quotient (LQ) was calculated for each pupil, being the mean across tasks of the scores obtained by giving a +1 for R, 0 for M and −1 for L. Thus a score of +1 indicates consistent right-hand usage, a score of −1 consistent left-hand usage, and a score of 0 complete ambilaterality. The distribution of the LQ scores was clearly bimodal, with almost no overlap between the groups: a single pupil had a score of exactly 0. A score of greater than 0 was therefore classified as right-handed direction of lateralisation, and a score of $\leqslant 0$ was classified as left-handed direction of lateralisation. Table III shows the proportion of pupils in each of the categories. There is a significant difference in the prevalence of left-handedness between normal and mentally handicapped pupils ($\chi^2 = 5 \cdot 17$, 1 df, $p < 0 \cdot 05$), but there is no difference between Down's and non-Down's pupils ($\chi^2 = 0 \cdot 053$, 1 df, NS). There was no evidence of differences in prevalence of left-handedness between the sexes, either in the subgroups individually ($\chi^2 = 0 \cdot 015$, $1 \cdot 397$ and $0 \cdot 002$, respectively, 1 df, all NS) or combined ($\chi^2 = 0 \cdot 635$, 1 df, NS).

The degree of lateralisation was expressed as the absolute value of the LQ. A hierarchical analysis of variance and covariance was used to assess the effects of sex, direction of handedness and group upon degree of lateralisation, with age as a covariate, using option 10 of the SPSS ANOVA program package (Nie *et al.* 1975), independent variables being entered in the order described above. The effect of the covariate was not significant ($p = 0 \cdot 70$). Sex did not have a significant effect ($p = 0 \cdot 53$), although direction of handedness did ($F(1,116) = 4 \cdot 615$, $p = 0 \cdot 034$), left-handers being less lateralised then right-handers (see Table III). Subnormality group had a significant effect ($F(2,116) = 3 \cdot 912$, $p = 0 \cdot 023$), both Down's and non-Down's individuals being less lateralised than the normal children. None of the two-way or three-way interactions was significant. A subsequent analysis comparing Down's and non-Down's groups showed no difference between the two groups ($F(1,73) = 0 \cdot 369$, $p = 0 \cdot 545$), and a non-significant effect of handedness ($F(1,73) = 2 \cdot 62$, $p = 0 \cdot 110$). Analysis of the normal group alone revealed no evidence of differences in degree of lateralisation by handedness group ($F(1,42) = 0 \cdot 013$, $p = 0 \cdot 910$) or sex ($F(1,42) = 2 \cdot 76$, $p = 0 \cdot 104$).

Discussion

The cause of the increased prevalence of left-handedness in the mentally handicapped groups is of interest. It is unlikely (but not impossible) that a gene for left-handedness is located on chromosome 21, as that would result in an increased prevalence of left-handedness in the Down's syndrome group if the gene were dominant, or a decreased prevalence if it were recessive, neither of which was the case in comparison with the non-Down's group. However, if the gene is additive, as has been suggested in a genetic model of handedness by McManus (1979, 1984), then no difference in the expected prevalence of left-handedness would be found among those with Down's syndrome.

It is tempting to attribute the increase in left-handedness to 'pathological left-handedness' (*e.g.* Satz 1972, 1973). However, before so doing we must be clear about the mechanism. Satz (1972) proposed that if in a population a proportion p is left-handed, and that a proportion q of these individuals receives *asymmetric*

trauma, then on average q/2 will have their dominant hemisphere damaged, and hence will change their laterality; thus pq/2 of the population will consist of pathological right-handers. The (1-p) right-handers will have a similar rate of injury, so (1-p)q/2 of the population will consist of pathological left-handers. Hence the total manifest prevalence of left-handedness will be q(1-p)/2 + p(1-q)/2, which will be higher than p if p is less than 0·5. Therefore, in groups subject to asymmetrical trauma, there will be an increased prevalence of left-handedness. However, this mechanism is unlikely to explain the increased prevalence of left-handedness in Down's syndrome, since the neuropathology of the condition is usually diffuse and non-specific (Crome 1965). Therefore, according to the recent extension of Satz's model (Satz *et al.* 1979), this should not result in an increased prevalence of left-handedness, but instead in bimanual hypofunction and retention of 'natural' handedness. Although Satz (*e.g.* 1972, p. 122; Satz *et al.* 1979, p. 73) repeatedly stresses that it is 'natural' handedness which is modified, it does not seem to be essential in that model that handedness, or its potential, has actually been established at the time the trauma occurs. The essential feature of Satz's model is that the trauma is unilateral (albeit half the time to the left and half to the right).

An alternative mechanism for pathological left-handedness has been proposed by McManus (1979, 1984), who suggested that the form of pathological left-handedness proposed by Satz either does not exist or is exceedingly rare (McManus 1983). It was proposed that early in development, as a result of genetic mechanisms, a majority of the population shows directional asymmetry, and hence becomes right-handed. Biological insults of any form at this critical period can result in increased biological *noise* and hence a reversion to the more atavistic state of 'fluctuating asymmetry', in the ultimate form of which 50 per cent of the population is left-handed. The difference from Satz's model is that the individual has not acquired right-handedness and subsequently lost it as a result of an asymmetric lesion, but rather has never had it in the first place. It is not that there are more ex-right-handers; there are more left-handers *de novo*. Such a model can also explain the increased atypical lateralisation of hand dominance found in people with agenesis of the corpus callosum (McManus 1979, 1984) and myelomeningocele and hydrocephalus (Lonton 1976), and the increased atypical lateralisation of the viscera found after exposure to heat, cold, stress, teratogenic or radiation insults (McManus 1979, 1984).

The differences in degree of lateralisation between individuals with and without mental handicap are more difficult to explain. The pathological left-handedness model of Satz makes no clear predictions; if one hand is sufficiently hypofunctional to merit transfer of dominance to the other (non-affected) hand, then one may well expect an *increased* degree of lateralisation among the pathologically left-handed. Alternatively, it may be that normal dominance is partly maintained by a process of mutual inhibition of the opposite hemisphere, and that the bilateral hypofunction of the hemispheres to be expected in Down's syndrome results in a decreased degree of asymmetrical inhibition, and hence of lateralisation. An alternative explanation, on an entirely different level, is that the mentally handicapped have not been subjected to the same cultural pressures towards strong lateralisation as have normal individuals, either as a result of not being so dependent upon writing, the most lateralised of skills, or of not having sufficient motor ability to be able to perform myriad simple asymmetric tasks (using screw-drivers, watch-winders, scissors, *etc.*) which abound in normal everyday life.

Some of these theories may be distinguishable by the method of Bishop (1983), who has examined the relative function of the *non*-dominant hand.

Acknowledgements
We are grateful to the Inner London Education Authority for their help with this survey, and thank the head-teachers, teachers and pupils of the schools for their co-operation and assistance. We also thank Prof. T. Oppé, Prof. R. Williamson, Dr. S. Tyrrell, and Mr. M. Marland for their advice and assistance; and Miss S. Madge and Mrs. D. Challis for their secretarial help.

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JMMARY
The prevalence of left-handedness and the degree of handedness were examined in 130 normal and mentally handicapped pupils of both sexes, aged between seven and 18 years. Handedness was assessed by means of 10 performance items. The prevalence of left-handedness among normal pupils (10·6 per cent) was significantly lower than that for the mentally handicapped group (26·5 per cent). There was no significant difference in the prevalence of left-handedness between the mentally handicapped pupils with and without Down's syndrome. The degree of handedness was also reduced in the mentally handicapped group, but again there was no difference between those with and without Down's syndrome.

RÉSUMÉ
Prédominance manuelle chez les handicapés mentaux
La prévalence de la prédominance manuelle gauche et le degré de prédominance ont été examinés chez 130 élèves des deux sexes, normaux et handicapés mentaux de sept à 18 ans. La prédominance manuelle e été étudiée au moyen de dix items de performance. La prévalence de la prédominance manuelle gauche parmi les élèves normaux (10·6 pour cent) était significativement plus basse que dans le groupe des handicapés mentaux (26·5 pour cent). Il n'y avait pas de différence significative dans la prévalence de la prédominance manuelle gauche entre les élèves mentalement handicapés qu'ils soient mongoliens ou non. Le degré de prédominance manuelle était aussi diminué dans le groupe mentalement handicapé mais à nouveau sans différence entre les mongoliens et les non mongoliens.

ZUSAMMENFASSUNG
Die Händigkeit bei geistig behinderten Kindern
Bei 130 gesunden und geistig behinderten Schülern beiderlei Geschlechts im Alter zwischen sieben und 18 Jahren wurden die Häufigkeit der Linkshändigkeit und der Grad der Händigkeit untersucht. Die Händigkeit wurde anhand von 10 Aufgaben ermittelt. Die Häufigkeit der Linkshändigkeit war bei gesunden Schülern signifikant geringer (10·6 Prozent) also bei den geistig behinderten (26·5 Prozent). Es fand sich kein signifikanter Unterschied für die Häufigkeit der Linkshändigkeit zwischen den geistig behinderten Schülern mit und ohne Down Syndrom. Der Grad der Händigkeit war in der geistig behinderten Gruppe ebenfalls herabgesetzt, aber auch hierbei fand sich kein Unterschied zwischen den Kindern mit und ohne Down Syndrom.

RESUMEN
Se examinó la prevalencia de la zurdería y el grado de predominio lateral en 130 alumnos normales y con retraso mental, de ambos sexos, de siete a 18 años de edad. El predominio manual fue explorado por medio de 10 items de manipulación. El predomonio de zurdería en alumnos normales (10,6 por ciento) era significativamente más bajo que en los con retraso mental (26,5 por ciento). No había diferencia significativa en la prevalencia de la zurdería entre los alumnos con retraso mental, con o sin sindrome de Down. El grado de predominio diestro también estaba reducido en el grupo con retraso mental pero tampoco aquí habia diferencia entre los que tenían sindrome de Down y los que no.

References
Ballard, P. B. (1912) 'Sinistrality and speech.' *Journal of Experimental Pedagogy*, 1, 298–310.
Bateman, A. J. (1960) 'Blood-group distribution in persons trisomic for the ABO gene.' *Lancet*, 1, 1293–1294.
Bishop, D. V. M. (1983) 'How sinister is sinistrality?' *Journal of the Royal College of Physicians*, 17, 161–172.
Burt, C. (1937) *The Backward Child*. London: University of London Press.
Carrothers, G. E. (1947) 'Left-handedness among school pupils.' *American School Board Journal*, 114, 17–19.
Crome, L. (1965) 'Pathology of Down's disease.' *In* Hilliard, L. T., Kinman, B. H. (Eds.) *Mental Deficiency, 2nd Edn.* London: Churchill.
Gibson, D. (1978) *Down's Syndrome: the Psychology of Mongolism*. Cambridge: Cambridge University Press.
Gordon, H. (1920) 'Left-handedness and mirror writing, especially among defective children.' *Brain*, 43, 313–368.
Hardyck, C., Petrinovich, L. F., Goldman, R. D. (1976) 'Left-handedness and cognitive deficit.' *Cortex*, 12, 266–279.
Hildreth, G. (1949) 'The development and training of hand dominance: II. Developmental tendencies in handedness.' *Journal of Genetic Psychology*, 75, 221–275.
Lonton, A. P. (1976) 'Hand preference in children with myelomeningocele and hydrocephalus.' *Developmental Medicine and Child Neurology*, 18, Suppl. 37, 143–149.
McManus, I. C. (1979) *Determinants of Human Laterality*. Unpublished PhD Thesis, University of Cambridge.
— (1981) 'Handedness and birth stress.' *Psychological Medicine*, 11, 485–496.
— (1983) 'Pathologic left-handedness: does it exist?' *Journal of Communication Disorders*, 16, 315–344.
— (1984) 'Handedness, language dominance and aphasia: a genetic model.' *Psychological Medicine: Monograph Supplement* (in press).
Mintz, A. (1947) 'Lateral preferences of a group of

mentally retarded subnormal boys.' *Journal of Genetic Psychology*, **71**, 75–84.

Murphy, M. M. (1962) 'Hand preference in three diagnostic groups of severely deficient males.' *Perceptual and Motor Skills*, **14**, 508.

Nie, N. H., Hull, C. H., Jenkins, J. G., Steinbrenner, K., Bent, D. H. (1975) *Statistical Package for the Social Sciences, 2nd Edn.* New York: McGraw-Hill.

Pickersgill, M. J., Pank, C. (1970) 'Relation of age and mongolism to lateral preferences in severely subnormal subjects.' *Nature*, **228**, 1342–1344.

Pipe, M. E., Beale, I. (1983) 'Hemispheric specialisation and speech in retarded children.' *Neuropsychologia*, **21**, 91–98.

Satz, P. (1972) 'Pathological left-handedness: an explanatory model.' *Cortex*, **8**, 121–135.

— (1973) 'Left-handedness and early brain insult.' *Neuropsychologia*, **11**, 115–117.

— Baymur, L., van der Vlugt, H. (1979) 'Pathological left-handedness: cross-cultural tests of a model.' *Neuropsychologia*, **17**, 77–81.

Smith, L. G. (1917) 'A brief survey of right- and left-handedness.' *Journal of Genetic Psychology*, **24**, 19–35.

Trankell, D. (1950) *Vasterhantnet Hos Barn i Skolaldern.* Helsingfors: Forum.

Waitt, C. (1980) 'A comparison of lateral preferences in subgroups in the mentally subnormal and normal populations.' Unpublished BSc thesis, Bedford College, University of London.

Wilson, M., Dolan, L. (1931) 'Handedness and ability.' *American Journal of Psychology*, **43**, 261–268.