Inheritance of Tooth Size in Liverpool Families

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In cases of malocclusion it is often stated by clinicians that children can inherit large teeth (in crown dimensions) from one parent and small jaws from the other, thus giving rise to overcrowding. However the scientific evidence on this subject is scanty and as a first step it was decided to examine more fully the inheritance of tooth size in British families.

Though twin studies have established a high genetic component in tooth size (Lundstrom, 1948; Osborne, Horowitz, and De George, 1958), few family studies have been undertaken to elucidate the matter further. The studies of Hohl (1934) and Martin (1934) were among the first but used relatively small samples. They calculated both parent offspring and midparent offspring correlations from their data. More recently Garn, Lewis, and Kerewsky (1964, 1965a, 1966) and Garn *et al.* (1965b, 1967) have undertaken a number of studies, and these will be referred to in the discussion, as will those of Lewis and Grainger (1967).

Material and Method

It was necessary to obtain measurements of tooth crown dimensions from dental casts of parents and children old enough to have fully erupted permanent teeth so that these would be suitably comparable with adult teeth. Since it had been found in an earlier study that many parents of children of this age did not possess their natural teeth, it was difficult to obtain a random sample of families. The best that could be done was to select children, from secondary school lists, of 14 years of age, and write to their parents asking for permission to visit them in their homes to take dental impressions of the family. At the same time it was indicated tactfully that only parents with their own natural teeth were suitable. In this way 123† families were obtained, whose social distribution is indicated in Table I.

Upper alginate impressions, using standard quantities, were taken, and models were cast from them as quickly

TABLE I
PARTICIPANTS,
DIVIDED INTO SOCIAL
CLASS*

Social Group	Percentage
1	12.5
2	27.9
3	47.1
4	8.6
5	3.9

* Registrar General classification of occupations 1966.

as possible in Kaffir D stone. Measurements were made from these models by means of specially prepared sliding callipers measuring to 0.1 mm. and teeth on the right side were used. Double determinations to estimate the errors of measuring were undertaken, the standard deviation being given by the square root of the summed squared differences divided by twice the number of paired measurements (Lundstrom, 1948). When this was divided by the mean and expressed as a percentage the values came to less than 1%.

Results

Correlation coefficients between relatives have been used rather than heritabilities because they are most frequently given in the literature in human studies (Pearson and Lee, 1903; Holt, 1961; Penrose, 1949).

Many posterior teeth were found to be extracted in the parents, and so the study has concentrated on the crown dimensions of maxillary incisors and canines only.

TABLE II
PARENT/OFFSPRING CORRELATIONS FOR
MESIODISTAL CROWN WIDTHS* OF MAXIL-
LARY INCISORS AND CANINE

	I ¹		I ²		C	
	No.	r	No.	r	No.	r
Father/daughter	60	0.48	55	0.54	58	0.52
Mother/son	64	0.52	58	0.34	61	0.37
Mother/daughter	58	0.56	53	0.27	64	0.28
Father/son	58	0.45	51	0.42	56	0.32

* Mesiodistal widths are measured along the crown of the tooth in a medio-lateral way in mm.
I¹—first incisor, I²—second incisor, C—canine.

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† These included 17 families from the earlier pilot study (Goose, 1967).

Table II shows the correlation coefficients between the various relatives for these teeth.

Table III gives the midparent son and daughter correlations, and Table IV presents some additional material for sib/sib correlations. These include 19 sib pairs (12 sister/sister and 7 brother/brother) taken from the files of the orthodontic department of the Liverpool dental hospital.

TABLE III

MIDPARENT OFFSPRING CORRELATIONS FOR MESIODISTAL CROWN WIDTHS OF MAXILLARY INCISORS AND CANINE

	I ¹		I ²		C	
	No.	r	No.	r	No.	r
Midparent/son	42	0.72	31	0.45	42	0.39
Midparent/daughter	43	0.65	32	0.63	42	0.62

TABLE IV

SIB CORRELATIONS FOR MESIODISTAL CROWN WIDTHS OF MAXILLARY INCISORS AND CANINE

	I ¹		I ²		C	
	No.	r	No.	r	No.	r
Sister/sister	21	0.48	21	0.53	13	0.28
Brother/brother	16	0.60	17	0.44	14	0.52
Sister/brother	31	0.37	29	0.11	25	0.44

Discussion

The presence of assortative mating was investigated by calculating the parent/parent correlations, being for I¹ I², and C, 0.12, 0.19, and 0.16, respectively, none being significantly different from 0. It may therefore be presumed that for these characters mating was at random. Fisher (1918) showed that 0.5 was the theoretical value of the correlation coefficients between parents and children in the case of multifactorial inheritance with genes having small and additive effects without dominance (expected value of midparent/child correlation = 0.71). How do the present results conform to this picture? The figures in Table II show that none depart significantly from 0.5 at the 0.05 level. This therefore tends to confirm the suggested type of inheritance as the likely one for tooth size. In Table III the levels for I² and C for midparent/son appear low and do, in fact, differ significantly from the theoretical figure of 0.71 though none of the others do.

The presence of dominance tends to lower correlations, but this is greater in the case of parents/offspring than with sib/sib correlations. In order to look at this the sib correlations in Table IV have been added by a z-transformation, and these mean values are given along with father/son and father/daughter in Table V.

TABLE V

CORRELATIONS FOR MESIODISTAL CROWN WIDTHS OF MAXILLARY INCISORS AND CANINE

	I ¹		I ²		C	
	No.	r	No.	r	No.	r
Father/son	58	0.45	51	0.42	56	0.32
Father/daughter	60	0.48	55	0.54	58	0.52
Sib/Sib*	68	0.46	67	0.33	52	0.43

* Calculated by adding z-transformations.

It can be shown by using the data in Table V that there are no significant deviations from 0.5, and there is therefore no indication of dominance being present in the existing data, though this could be affected by the supplementation of sib/sib correlations by the extra pairs.

Garn *et al.* (1965a) have suggested that sex-linked genes may contribute to tooth size after their study of sib/sib correlations, and Lewis and Grainger (1967) partly confirmed this in their study of parent/offspring pairs. The theoretical correlations relating to one pair of sex-linked genes are as follows (Maynard-Smith, Penrose, and Smith, 1961): father/daughter and mother/son = 0.71; mother/daughter = 0.50; father/son = 0.

Table II has been laid out in order to look at this problem but does not seem to conform to this pattern. Though father/daughter values are high, father/son values do not in any way tend towards their theoretical value of 0, and for example its lowest value, the canine of 0.32, is not significantly different from the father/daughter value of 0.52. In the case of sibs the theoretical values for one pair of sex-linked genes are sister/sister 0.75; brother/brother 0.50; and sister/brother 0.35. Reference to Table IV shows that only for I² is the correct order realized and only one correlation (brother/sister for I²) is significantly different from 0.5 at 0.05 level.

Garn *et al.* (1967) also postulated a genetic control for canine sexual dimorphism showing that this effect 'spilt over' into the immediately adjacent teeth.

Table VI shows the present findings laid out in a comparable way, and this confirms their hypothesis.

TABLE VI

PERCENTAGE SEX DIFFERENCE IN MESIODISTAL CROWN WIDTHS OF MAXILLARY TEETH

	100 $\left(\frac{M}{F} - 1\right)$				
	I ¹	I ²	C	P ¹	P ²
Parents	3.4	4.5	6.4	4.3	3.4
Children	5.6	5.8	5.8	2.7	2.7

Although P^1 for children is rather low in this case, the percentage difference is higher otherwise for I^2 than I^1 and for P^1 than P^2 . They also calculated the correlation coefficients between the canine and adjacent teeth in sibships for sex differences, finding that they were higher for I^2 and P^1 . In our data only 9 complete sib pairs were available; however, again the values confirm the hypothesis, being $I^1C=0.09$, $I^2C=0.57$, $P^1C=0.89$, $P^2C=0.79$.

Environmental factors, particularly maternal influences, could also affect the correlations between parents and offspring. If this is so the maternal/offspring correlations should be higher than the paternal ones. Table II shows that only for I^1 is this so and these differences are not significant. Thus in this sample maternal factors do not appear to play a part.

Some investigators have noticed a difference in the mean tooth dimensions of parents and children (Garn, Lewis, and Walenga, 1968; Goose, 1967; Hanna, Turner, and Hughes, 1963), and so it was considered worth while to examine this in a larger sample.

TABLE VII

MEAN DIFFERENCES BETWEEN GENERATIONS FOR MESIODISTAL CROWN WIDTHS OF MAXILLARY INCISORS AND CANINE (mm.)

		Father/Son				Mother/Daughter			
		No.	Diff.	S.E.	p	No.	Diff.	S.E.	p
I^1	58	0.25	± 0.08	<0.01		58	0.26	± 0.07	<0.01
I^2	51	0.26	± 0.08	<0.01		53	0.20	± 0.09	<0.05
C	56	0.19	± 0.06	<0.01		64	0.23	± 0.06	<0.01

Table VII shows the results. In all cases the offspring are significantly larger than their parents. It has been suggested that this difference might be dietary due to the effect of welfare foods which the children would have had but which the parents would not (Goose, 1967). However it could be just due to approximal attrition in the parents making their teeth effectively smaller. In order to try and distinguish between these hypotheses the buccolingual dimensions of the premolars and molars were measured, these being relatively unaffected by attrition in modern populations. Unfortunately only the first premolars and first molars were present in sufficient numbers to measure, but these are given in Table VIII.

This seems to confirm the dietary hypothesis since again the offspring show larger measurements, all being significant except P^1 for father/son at 0.05 level.

TABLE VIII

MEAN DIFFERENCES BETWEEN GENERATIONS FOR BUCCOLINGUAL CROWN WIDTHS OF MAXILLARY FIRST PREMOLARS (P^1) AND FIRST MOLARS (M^1) (mm.)

		Father/Son				Mother/Daughter			
		No.	Diff.	S.E.	p	No.	Diff.	S.E.	p
P^1	41	0.03	± 0.10	NS		40	0.23	± 0.09	<0.05
M^1	23	0.22	± 0.09	<0.05		17	0.32	± 0.14	<0.05

Summary

Dental impressions were taken of the upper jaws of members of 123 Liverpool families, and measurements made on the models obtained from them. From these were calculated correlation coefficients of the mesiodistal widths of the incisors and canines of the right side.

The parent/offspring correlations did not differ significantly from 0.5, and 4 out of 6 midparent/offspring correlations did not differ significantly from 0.71, and are therefore compatible with a hypothesis of multifactorial inheritance with genes of small and additive effect but without dominance. The absence of dominance was suggested by the fact that sib/sib correlations were not larger than parent/offspring ones.

There was no evidence of sex-linked genes playing a part in the inheritance of mesiodistal tooth width of these teeth, but there was evidence of the canine showing the most difference between sexes and this effect 'spilling over' into the adjacent teeth.

Maternal environmental effects were not shown, but there did exist a difference between the generations, the offspring being larger than the parents. It was also found in certain bucco-lingual tooth measurements and is probably dietary in origin.

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