0141-5587/80/004?00135:02.00

European Journal Orthodontics 2 (1980) 13-18

Family likeness as a basis for facial growth prediction

W. J. B. Houston and W. A. B. Brown

Royal Dental Hospital, London, England, and Department of Anatomy, King's College, London, England

Summary. The concept that family resemblance might offer a basis for the prediction of facial growth is examined. The present results support the view that a number of cranio-facial features are under polygenic control but this is not relevant to the prediction of facial growth. If family resemblance is to be used for prediction it must be shown that, with growth, a child becomes more like its parents in the relevant features. The results of the present study indicate that this is not the case.

It is well established that many craniofacial dimensions have an inherited component (Smith and Bailit, 1977). Common observation shows that members of families resemble one another racially and it is a matter for comment if a child does not bear some resemblance to each parent. Numerous twin studies and the few family line studies have provided convincing evidence of the importance of genetic factors in the determination of a number of cranial and facial skeletal variables. Discontinuous characteristics, such as blood groups, are under single gene control and the mode of their inheritance is well understood. While continuous variables such as stature and craniofacial dimensions could theoretically be under single gene control with environmental interaction, there is good evidence that at least within the normal range of variation, they are under polygenic control: in other words, a number of genes each has an effect.

Where a physical characteristic is under polygenic control, the theoretical relationship between a child and each parent is expressed by a correlation coefficient of 0.5 (Fisher, 1918). The expected correlation coefficient between the child's and the midparental value is 0.7 (Susanne, 1975). Environmental factors superimposed on the genetic background and random sampling effects may modify this and measurement errors will reduce the correlation coefficient. However, it has been shown for certain body measurements (Susanne, 1975) and for some craniofacial measurements (Brown, 1973), that in fact the correlation between children and each parent is close to 0.5, It is not the purpose of this paper to pursue the various theories of the mode of inheritance of different characteristics but this topic has been reviewed recently bv Smith and Bailit (1977).

Wasson (1963), Nakata et al. (1973), Harris (1975), Harris et al. (1975), Harris and Kowalski (1976) and Popovich et al. (1977) have all concluded that family resemblance could be of value in predicting future facial growth in the child. For example, Harris and Kowalski (1976) stated that 'within a given family it is possible to distinguish between patients with favourable or unfavourable growth potentials by examining the severity of malocclusion presented by other members of the families'. It seems to have been overlooked, in all the studies concerned with the prediction of facial growth from family resemblance, that we already know what the child looks like. To this extent we can make a fairly reliable estimate of what his future facial pattern will be. In so far as family likeness is already expressed in the child, this will not be of value in predicting the ultimate facial pattern. Only if the child comes to resemble his parents more closely as he gets older will information about the parents improve the prediction of growth. It is possible that some genetic influences on facial growth are first expressed at the time of puberty and, to this extent, knowledge about the parents' facial patterns might be used in predicting changes in facial pattern. However, this question does not seem to have been investigated previously.

The purpose of the present paper is to examine whether, for a number of cranio-facial variables, older children resemble their parents more closely than do younger children. Unless this is the case, studies of family resemblance offer little hope of improving prediction of facial growth in the individual child.

Subjects and methods

This study is based on records collected by one of the authors (WABB) from 45 Northern Irish families, each of which included both parents and at least four children over seven years of age. For this study, the measurements made by Brown (1973) have been re-analysed. Only the dimensions of more immediate interest to the orthodontist have been included in the present paper (Fig. 1). Some of the adults were edentulous and so measurements of jaw relationships were not included. Full details of the measurements were given by Brown (1973).

For the present study, four subgroups were constructed, one child being selected where possible from each family, to represent young boys (7-12 years), older boys (over 16 years), young girls (7-10) and older girls (over 14 years). Children within 2 years of the average time of the peak of the adolescent growth spurt were not included, nor were

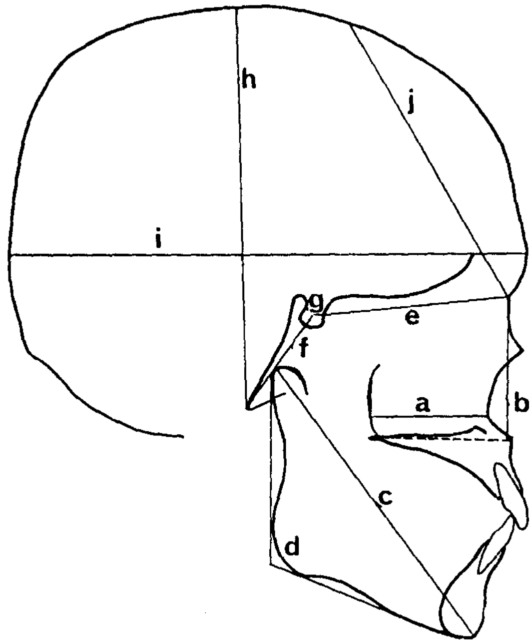

Figure 1 The measurements analysed: (a) Maxillary length; the distance between the posterior wall of the maxillary antrum and the point of greatest concavity on the anterior nasal aperture, (b) Maxillary nasal height; the perpendicular distance from nasion to the maxillary plane, (c) Mandibular length: the maximum distance between the symphysis and the outline of the condylar head. (d) Gonial angle: the angle between the tangents to the lower and posterior borders of the mandible, (e) Anterior cranial base length: nasion sella distance, (f) Posterior cranial base length: sella basion distance, (g) Cranial base angle: nasion sella basion angle, (h) Cranial height: the maximum distance from basion to the exocranial outline of the parietal bone. (i) Cranial length: the maximum length of the exocranial outline, (j) Frontal chord: nasion bregma distance.

Table 1 Ages (in years) of parents and children

Group	N	Mean	Standard deviation
Mothers	45	44.3	6.3
Fathers	45	48.0	7.9
Sons older	20	19.3	3.1
Sons younger	23	8.8	1.4
Daughters older	31	18.4	3.3
Daughters younger	18	9.5	2.2

Table 2 Partial correlations between parents and children for a number of craniofacial variables

	Father				Mother				Mid-parent			
	Son		Daughter		Son		Daughter		Son		Daughter	
	y	o	y	o	y	o	y	o	y	o	y	o
Maxilla length	0.09*	0.35	0.69	0.43	0.41	0.53	0.53	0.36	0.37*	0.59	0.74	0.52
Maxilla nasal height	0.39	0.33	0.40	0.21	0.46	0.64	0.34	0.36	0.62	0.65	0.49	0.38*
Mandible length	0.20	0.56	0.12	0.00*	0.31	−0.41*	0.42	0.26	0.31*	0.18*	0.44	0.20*
Gonial angle	0.47	0.56	−0.04*	0.57	−0.13*	0.03*	0.10	0.36	0.36*	0.45	0.05*	0.59
N-S	−0.20*	0.35	0.27	0.19	0.34	0.52	0.26	0.27	0.11*	0.58	0.52	0.39
S-Ba	0.46	0.23	0.37	−0.13*	0.63	0.06*	−0.39*	−0.06*	0.67	0.19*	−0.02*	−0.11*
N-S-Ba	−0.12*	0.18	0.25	0.08*	0.08*	0.45	0.42	0.35	−0.04*	0.47	0.71	0.32*
Cranial height	0.29	0.24	0.50	0.22	0.02*	0.36	0.50	0.34	0.19*	0.38	0.62	0.36*
Cranial length	0.43	0.13	0.44	0.54	0.19	0.19	−0.05*	0.25	0.39*	0.20*	0.32*	0.50
Frontal chord	−0.02*	0.42	0.51	0.32	−0.05*	0.42	0.02*	0.33	−0.04*	0.55	0.40	0.41*

Note: y = young, o = old.
*indicates that the coefficient is significantly different at the 5 per cent level from the expected value of 0.5 for a single parent and 0.7 for mid-parent.

children under 7 years of age. Where more than one child from a family could have been included in a particular subgroup, only one was allocated by random selection. However, children from one family could be included in different subgroups. Details of the subgroups are given in Table 1. Partial correlation coefficients were calculated, age of child being controlled statistically. Thus, age variation among the children in each subgroup was compensated.

Results

Correlation coefficients for parent-child associations are presented in Table 2. Z transformations have been calculated for the differences between the theoretical values of 0.5 for single parent and 0.7 for mid-parent correlations, and those found in the present study. Although the correlation coefficients vary considerably, few differ significantly from those expected with polygenic inheritance. In very few cases do the coefficients for younger and older children differ even at the 5% level of significance because, with the relatively small numbers in the samples, the confidence limits are wide. While this must be remembered when examining the results, certain trends are worthy of comment.

Maxillary nasal height shows no definite pattern and the values are generally consistent with a polygenic mode of inheritance. In boys, but not in girls, the correlations for maxillary length, nasion sella length, cranial base angle, cranial height and frontal chord length all tend to increase with age but, for most of these variables, the differences are quite small. Correlations for cranial length and gonial angle tend to increase with age in girls but not in boys. For mandibular length, sons resemble their fathers, and daughters their mothers but the results are variable. This may in part be due to errors in locating the condylar head.

Any more detailed analysis of the results is not justified. The most obvious feature is their variability and the lack of any strong tendency for older children to resemble their parents more closely than do younger children,

Discussion

This analysis was undertaken to discover whether older children resemble their parents more closely than do younger ones. Theoretically this is possible if some genetic influences on these features are first exerted at the time of puberty. If the mode of inheritance had been the concern of the present study, the results would have been analyzed in a different way. However, for most of the variables examined in this study, the results do not conflict with the hypothesis that they are under polygenic control. Some of the coefficients are significantly lower than would be expected with polygenic inheritance. This could be due to sampling effects, measurement error, the influence of dominant genes or of environmental interaction. However, the clinical application of such results is subject to exactly the same problems. Efforts were made to control measurement errors in the present study and it is not to be expected that these will be less in the clinical situation; and, whatever the mechanism of inheritance, unless a child grows to resemble its parents more closely, information on parental characteristics is not of practical application to the prediction of facial growth. Thus the present analysis should give a realistic indication of the possible value of family resemblance to orthodontic diagnosis.

There is little published data on facial resemblance between parents and children, and none where comparisons have been made for older and younger children as has been done in the present analysis. Hunter et al. (1970) reported on the heritability of five facial dimensions in parents and adult children. Two of their measurements, mandibular and anterior cranial base lengths, were included in the present study. The correlations for fathers with sons were similar to those found here but they were lower for both sons and daughters with their mothers. Nakata et al. (1973), studied eight facial variables, five of which were measured in the present work. The correlation coefficients varied considerably but any differences from those found in this study could be attributed to sampling variations. Susanne(1975)inastudy of]25 Belgian families found that the correlations between parents and their adult children were generally lower for head dimensions than for a number of other body measurements, being less than expected for a polygenic mode of inheritance. Although direct, not radiographic, measurements were used, the mid-parent to adult child relationships were similar to those of the present study (i.e. 0.39 for head length, 0.55 for head height and 0.32 for nose height).

Harris (1975) used multiple correlation techniques to investigate the relationships between craniofacial variables in family groups. When the same characteristic was taken for both parents together with a male and female child, the multiple correlation coefficient for the angle ANB in brothers with Class II division 1 malocclusions was 0.98. Values almost as high were reported for several other variables. Harris stated that 'it seems clear that the incorporation of familial information has much to offer the clinician and should therefore play a prominent role in the clinical decision making process'. But even if the findings were valid, they would be of no value in growth prediction because they exclude the possibility of an appreciable increase in family likeness with growth. From genetic theory, the correlation for a polygenic variable between a child and both parents should be in the region of 0.7, in the absence of environmental effects and measurement errors. However, once the parents have been accounted for the inclusion of other relatives should not increase the correlations because all the genetic information has already been utilized. The very high correlations reported in Harris's study can probably be accounted for by sampling variation unique to this group. In fact, the reported multiple correlation coefficient for the angle ANB in that sample cannot possibly be the true population value because this would imply that knowing only the values for angle ANB of the parents, a son and daughter, one could predict the angle ANB for any Class II, division 1 male sibling within extremely narrow limits; and furthermore, the ANB values for all other male siblings would fall within these very narrow limits. This in turn would conflict with polygenic theory because the correlation between siblings should only be at the level r = 0.5. If further evidence were needed, it should be remembered that the correlation coefficient for the angle ANB in the same boys at the ages of 12 and 20 is only at the level of r -- 0.86 (Bjork and Palling, 1955).

Although there is little further relevant evidence on parent-child correlations for facial dimensions, some work of interest has been published for stature. Livson et al. (1962) pooled estimates from a variety of sources on parent-child correlations in stature from birth to maturity. Although there was a tendency for these correlations to increase with age, the ' changes in correlation coefficient between 8 and 18 years were very small indeed. Tanner et al. (1970) reported the correlation coefficients for mid-parent with child stature to be in the region of 0.5 for children between 2 and 9 years of age with no evidence of an increasing trend over this period. In Susanne's (1975) study, the correlation between mid-parent and adult child was 0.63 for stature. This suggests that there may be a correlation between the parents statures and growth in their children over the adolescent period but it is bound to be small and would thus make little contribution to reducing the confidence limits of the prediction. Tanner et al. (1975) suggested an adjustment for parental height in predicting the adult stature of a child but the residual standard deviation is reduced by only about 2 mm (6%). In fact, the main use of parental values in the prediction of a child's adult stature is to indicate whether an unusually small child is genetically small or whether there are other causes (Tanner et al., 1970).

It seems therefore that forecasting of facial growth will not be improved by taking account of the facial pattern of other members of the family. The possibility remains that the growth pattern of a child might resemble the growth pattern of his parents, and so the orthodontist who possessed cephalometric records of the parents when they were children might be in a better position to forecast future growth of their offspring. However, this would be almost impossible to test, let alone to apply. Family photographs are more readily available but rarely would they be suitable for analysis. It might be more realistic to investigate whether the growth patterns of older children offered a worthwhile guide to the future growth of their younger sibs. However, in view of the very limited clinical application of these methods, their interest must remain largely academic.

The present results and a re-examination of previously published papers lead to the conclusion that family resemblance does not offer a sound basis for the prediction of facial growth in the individual child.

Address for correspondence
Professor W. J. B. Houston,'
Orthodontic Department, Royal
Dental Hospital, Leicester Square,
London WC2 H7LJ

References

Brown, W. A. B. (1973). Forty-five Northern Irish families: a cephalometric radio-graphic study. *American Journal of Physical Anthropology,* 39: 57-85.

Bjork, A. and Palling, M. (1955). Adolescent age changes in sagittal jaw relation, alveolar prognathy and incisal inclination. *Acta Odonlologica Scandinavica,* 12: 201-232

Fisher, R. A. (1918). The correlation between relatives on the supposition of Mendelian inheritance. *Transactions of the Royal Society of Edinburgh,* 52: 399-433.

Harris, J. E. (1975). Genetic factors in the growth of the head. *Dental Clinics of North America,* 19: 151-160.

Harris, J. E., Kowalski, C. J. and Walker, S. J. (1975). Intrafamilial dentofacial associations for Class II Division 1 probands. *American Journal of Orthodontics, 67:* 563-570.

Harris, J. E. and Kowalski, C. (1976). All in the family: use of familial information in orthodontic diagnosis case assessment, and treatment planning. *American Journal of Orthodontics, 69:* 493-510.

Hunter, W. S., Balbach, D. R. and Larophiear D. E. (1970). The heritability of attained growth in the human face. *American Journal of Orthodontics,* 58: 128-134.

Livson, N., McNeill, D. and Thomas, K. (1962). Pooled estimates of parent-child correlations in stature from birth to maturity. *Science,* 138: 818-820.

Nakata, M., Yu, P., Davis, B. and Nance, W. E. (1973). The use of genetic data in the prediction of craniofacial dimensions. *American Journal of Orthodontics,* 63: 471-480.

Popovich, F., Thompson, G. W. and Saunders, S. (1977). Craniofacial measurements in siblings of the Burlington Growth Centre sample. *Journal of Dental Research,* 56; Special issue A. Abstract.

Smith, R. J., and Bailit, H. L. (1977). Problems and methods in research on the genetics of dental occlusion. *Angle Orthodontist,* 47: 65-77.

Susanne, C. (1975). Genetic and environmental influences on morphological characteristics. *Annals of Human Biology,* 2: 279-28.

Tanner, J. M., Goldstein, H. and Whitehouse, R. H. (1970). Standards for children's height at ages 2-9 years allowing for height of parents. *Archives of Disease in Childhood,* 45:755-762.

Tanner, M. J., Whitehouse, R. H., Marshall, W. A. and Carter, B. S. (1975). Prediction of adult height from height, bone, age, and occurrence ofmenarche at ages 4 to 16 with allowance for midparent height. *Archives of Disease in Childhood,* 50: 14-26.

Wasson, J. L. (1963). Evaluation of a method of predicting craniofacial growth that compares cephalometric roentgenograms of children and parents. *American Journal of Orthodontics,* 49: 864. Abstract.