THE INFLUENCE OF THE AGE OF THE PARENT AT BIRTH OF CHILD ON EYE-COLOUR, STATURE AND INTELLIGENCE.

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We have already considered, in previous papers, the influence of parental age, on birth, marriage, sex, susceptibility, and reaction to bacterial invasion, evidence having been produced which lends support to the belief that this factor does modify the organism in its behaviour with respect to the attributes considered. It is therefore reasonable to extend the enquiry, and examine whether these variations are accompanied by modifications in structural attributes. In the present paper the characters studied are, eye-colour, stature and intelligence.

Eye-colour was selected on account of its interest and comparative ease of observation; stature as a measure of growth; and intelligence, judged by scholastic standard, as a prime factor in the success of man in the eternal conflict between man and his animate or inanimate competitors.

Eye-colour.

Any general consideration of the enormous literature treating this subject is unnecessary; the work has already been done in great detail by Pearson, Nettleship and Usher, in their monograph on Albinism. All that is needful in the present instance is a reference to such works as have a direct bearing on the points discussed.

Before considering the actual data, some comment must be made on the tacit assumption that eye-colour is a fixed character, apparently not modified during the life of the individual. It should be remembered that all are born with blue eyes of varying shades, and that a proportion change to brown, grey, etc. The method by means of which this change is achieved is somewhat doubtful, and may be explained in two ways:

(*a*) by the deposit of a new layer of pigment in front of the choroidal layer, or (*b*) by the pigment already present undergoing a physical change, that is, the intracellular granules change from a molecular to a granular state. There is no histological evidence in favour of the former supposition, nor does direct observation of the iris reveal appearances which would lend credence to the belief that an anterior layer of pigment was being deposited.

The second hypothesis is in accord with the physical appearance of many substances when in different states. It is easily conceived that with such a pigment, placed in a semitranslucent or whitish stroma, with a slight tinge of red dependent on the capillary circulation, any known eye-colour could be obtained.

The rate at which this change takes place in childhood varies, and there is some evidence that even in adults the same tendency is observed.

The cause is doubtful, though the fact that the central areas of the iris are darker than the peripheral portions, does suggest that intensity of illumination is a factor in its production.

Pearson has already shown that even between the 5th and 20th years, there is a tendency for the eyes to darken in colour.

He gives the following values:

Virchow's data.	Age and	Eye-colour		$C_r = \cdot 027$
Pletgour's	,,	,,	,,	$C_r = \cdot 451$
Urchida	,,	,,	,,	$C_r = \cdot 096$

The values seem to vary according to the number of years considered; he suggests that a selective death rate may explain the result.

The material here dealt with was collected in Middlesbrough from various sources and refers to females only. The standard selected was the number of blue-eyed persons in groups of different ages. They were reached in the following ways.

Infants through the Notification of Births Act.

School children through the Education Act (1908) and

Adults through the attendance of parents consequent on the above.

The groups, though not true random samples, are not selected with respect to the character under investigation, and hence should be suitable for analysis.

The results were as follows:

TABLE I.

Females only.

Age	No. examined	Blue eyes
At birth	1000	100 %
6th year	387	54 %
9th ,,	488	41 %
10th ,,	391	41 %
13th ,,	400	38 %
15th to 29th year	80	32 %
31st ,, 40th ,,	543	30 %
41st ,, 45th ,,	320	28 %
46th ,, 55th ,,	269	26 %

From these figures it is safe to conclude either that a tendency for the eye to darken exists through life, being most marked at birth and becoming less as time advances, or that death is strongly selective for this character. The former hypothesis is the more reasonable one. In later life a further alteration occurs which can be attributed to the loss of translucency of the stroma. It is obvious that eye-colour cannot be strictly regarded as a fixed character, so that some information as to age is necessary. In the adolescent period the change however is not marked.

There is of course no apparent reason why age of parent at birth should influence eye-colour, so that the result of an investigation of such a point must be *a priori* incapable of prediction.

The subject therefore under consideration resolves itself into the question of the existence rather than the nature of such a biological sequence.

For this purpose blue eyes were chosen and the number occurring in the various groups noted, all details as to shade or formation being ignored.

The data were collected in Middlesbrough and Barking through the opportunities afforded by the Medical Inspection of School Children. The first series are taken from Barking and consist of children in their 7th and 13th years, in the proportion of three to one. The mother's eye-colour was also taken so as to correct for any tendency of a particular type of eye-colour being more fertile and hence occurring more frequently than would be expected in a true random sample.

The tables are as follows:

TABLE II.

All Children.

		Child. Blue	Not blue	Totals
		88	55	143
Mother:	Blue	64	247	311
	Not blue	152	302	454

$r = \cdot 5966 \pm \cdot 0253$.

TABLE III.

Age of Parent at Birth and Child's Eye-colour.

Age of parent at birth	Child's eye-colour: Blue	Not blue	Totals
16—20	4	7	11
21—24	38	67	105
25—28	36	74	110
29—32	29	66	95
33—36	23	47	70
37—40	8	23	31
41—44	10	14	24
45—48	3	3	6
Totals	151	301	452

$r = \cdot 0961 \pm \cdot 0334$.

$\eta = \cdot 1031$ and if corrected, indeterminate[1].

TABLE IV.

Age of Parent at Birth and her own Eye-colour.

Age of parent at birth	Mother's eye-colour: Blue	Not blue	Totals
16—20	5	6	11
21—24	35	63	98
25—28	25	76	101
29—32	26	59	85
33—36	20	41	61
37—40	8	19	27
41—44	6	6	12
45—48	1	4	5
Totals	126	274	400

$r = \cdot 0034 \pm \cdot 0337$.

$\eta = \cdot 0611$ and if corrected, indeterminate.

[1] Pearson, K. (1912). A correction to be made to the Correlation Ratio. *Biometrika* VIII. 254.

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The coefficients are:

Age of mother at birth of child (1) and child's eye-colour (2)

$$r_{12} = \cdot096 \pm \cdot033.$$

Age of mother 9 years after birth of child (1) and her own eye-colour (3)

$$r_{13} = \cdot003 \pm \cdot034.$$

Eye-colour of mother (3) and child (2)

$$r_{23} = \cdot597 \pm \cdot025.$$

Making eye-colour of mother (3) constant then:—

Age of mother at birth of child (2) and child's eye-colour (1)

$$_3r_{12} = \cdot13 \pm \cdot03.$$

This result suggests that children born of young mothers have a tendency to blue eyes, or that the change dependent on age is delayed. The values of the correlation ratios were found to be, mean of child's eye-colour for arrays of age at birth, $\eta = \cdot103 \pm \cdot033$, and if corrected becomes indeterminate; the same with means of mother's eye-colour $\eta = \cdot061 \pm \cdot034$, and is also indeterminate if corrected by Pearson's method.

To test the data for any bias in the method of collection, the eye-colour of the child was correlated with a different mother from its own.

The data are as follows:

TABLE V.

	Random mother		
Child:	Blue	Not blue	Totals
Blue	49	91	140
Not blue	103	207	310
Totals	152	298	450

$r = \cdot0362 \pm \cdot0302.$

TABLE VI.

Age of Random Parent at Birth and Child's Eye-colour.

Age of parent at birth	Random child		
	Blue	Not blue	Totals
16—20	2	4	6
21—24	20	33	53
25—28	21	30	51
29—32	10	24	34
33—36	12	12	24
37—40	8	7	15
41—44	2	6	8
45—48	1	0	1
Totals	76	116	192

$r = -\cdot0306 \pm \cdot0477.$

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Age of random parent at birth (1) and child's eye-colour (2)

$$r_{12} = -\cdot031 \pm \cdot048.$$

Eye-colour random mother and child

$$r_{13} = \cdot036 \pm \cdot031.$$

Hence. Age of random parent at birth and child's eye-colour—parent constant

$$_3r_{12} = -\cdot03 \pm \cdot05.$$

A result that suggests that the sample taken is not subject to any great error in collection.

In the second series of the data, collected in Middlesbrough, the age period was restricted to children of a particular age (8th to 9th year, *i.e.* born in year 1900). The sexes are dealt with separately and in each case the eye-colour of the mother is recorded, so as to remove any bias due to stock. The data are as follows:

TABLE VII.

Age of Mother at Birth of Child and her own Eye-colour.

Based on girls :	Mother's eye-colour		
Age of mother	Blue	Not blue	Totals
20 and under	9	24	33
21—25	38	78	116
26—30	42	100	142
31—35	26	81	107
36—40	23	51	74
41 and over	3	13	16
Totals	141	347	488

$r = \cdot0171 \pm \cdot0303.$

$\eta = \cdot118 \pm \cdot029$ and if corrected $= \cdot0607.$

TABLE VIII.

Based on boys :	Mother's eye-colour		
Age of mother	Blue	Not blue	Totals
20 and under	7	15	22
21—25	35	71	106
26—30	36	97	133
31—35	21	64	85
36—40	13	43	56
41 and over	3	20	23
Totals	115	310	425

$r = \cdot0494 \pm \cdot0299.$

$\eta = \cdot1592 \pm \cdot0334$ and if corrected $= \cdot1262.$

TABLE IX.

Age of Mother at Birth of Child and Child's Eye-colour (Girls).

Age of mother at birth	Child's eye-colour: Blue	Child's eye-colour: Not blue	Totals
Under 20	12	21	33
21—25	56	60	116
26—30	58	84	142
31—35	41	66	107
36—40	30	44	74
41 and over	4	12	16
Totals	201	287	488

$r = \cdot0355 \pm \cdot0302$.
$\eta = \cdot1289 \pm \cdot0299$ and if corrected $= \cdot0798$.

TABLE X.

Boys.

Age of mother at birth	Child's eye-colour: Blue	Child's eye-colour: Not blue	Totals
20 and under	13	9	22
21—25	46	60	106
26—30	53	80	133
31—35	30	55	85
36—40	21	35	56
41 and over	5	18	23
Totals	168	257	425

$r = \cdot0537 \pm \cdot0301$.
$\eta = \cdot2409 \pm \cdot0324$ and if corrected $= \cdot2151$.

TABLE XI.

Boys. 7—8 years.

Mother:	*Child.* Blue	*Child.* Not blue	Totals
Blue	79	34	113
Not blue	88	223	311
Totals	167	257	424

$r = \cdot5868 \pm \cdot0216$.

TABLE XII.

Girls. 7—8 years.

Mother:	*Child.* Blue	*Child.* Not blue	Totals
Blue	104	36	140
Not blue	103	240	343
Totals	207	276	483

$r = \cdot6211 \pm \cdot0193$.

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From these figures for boys we have:

Age of mother at birth of child (1) and child's eye-colour (2)

$$r_{12} = \cdot 054 \pm \cdot 030.$$

Age of mother at birth of child (1) and her own eye-colour (3)

$$r_{13} = \cdot 049 \pm \cdot 03.$$

Child's and mother's eye-colour

$$r_{23} = \cdot 587 \pm \cdot 023.$$

Making mother's eye-colour constant

$${}_3r_{12} = + \cdot 03 \pm \cdot 03.$$

The correlation ratios are:

Mean of eye-colour, child, for arrays of mother's age

$$\eta = \cdot 24 \pm \cdot 03 \text{ and if corrected} = \cdot 21.$$

Mean of eye-colour, mother, for arrays of her age

$$\eta = \cdot 16 \pm \cdot 03 \text{ and if corrected} = \cdot 13.$$

In the case of girls, we have:

Age of mother at birth of child (1) and child's eye-colour (2)

$$r_{12} = \cdot 036 \pm \cdot 030.$$

Age of mother at birth of child (1) and her own eye-colour (3)

$$r_{13} = \cdot 017 \pm \cdot 03.$$

Eye-colour, mother (3), eye-colour, child (2)

$$r_{23} = \cdot 621 \pm \cdot 019.$$

Making mother's eye-colour (3) constant

$${}_3r_{12} = \cdot 04 \pm \cdot 03.$$

The correlation ratios for arrays of mother's age at birth and mean of child's eye-colour

$$\eta = \cdot 13 \pm \cdot 03 \text{ and if corrected} = \cdot 08.$$

For arrays of mother's age and her own eye-colour

$$\eta = \cdot 12 \pm \cdot 03 \text{ and if corrected} = \cdot 06.$$

The values found in the south (Barking) are not identical with those found in the north (Middlesbrough). In the first, a small significant positive correlation exists; in the second series the value is still positive for both sexes, but it is not significant. The differences may be dependent on the fact that making the mother's eye-colour constant does not completely remove the effects that may arise from the different reproductive habits that are to some extent associated with eye-colour.

Although these results are of interest and suggest that some biological difference may exist of the nature suggested, they do not justify any definite assertion.

If we now consider age with respect to age of grandmother at birth of mother, taking the eye-colour of mother and child (the actual material is the same as in the previous series) we have:

TABLE XIII.

Age of Grandmother at Birth. Eye-colour of Mother and Child.

	Mother's eye-colour		
	Blue	Not blue	Totals
Mother born at 20 years and under	35	97	132
„ „ 21—25	60	157	217
„ „ 26—30	74	161	235
„ „ 31—35	46	129	175
„ „ 36—40	26	75	101
„ „ 41 and over	15	38	53
Totals	256	657	913

$r = \cdot 002 \pm \cdot 021$. $\eta = \cdot 06$ and if corrected, indeterminate.

TABLE XIV.

	Child's eye-colour		
	Blue	Not blue	Totals
Mother born at 20 years and under	16	39	55
„ „ 21—25	73	149	222
„ „ 26—30	78	179	257
„ „ 31—35	47	145	192
„ „ 36—40	36	94	130
„ „ 41 and over	6	33	39
Totals	256	639	895

$r = \cdot 032 \pm \cdot 021$. $\eta = \cdot 123$ corrected. $\eta = \cdot 098$.

From these observations we find:

Age of grandmother at birth of mother, and eye-colour of child

$$r = \cdot 032 \pm \cdot 021.$$

Age of grandmother at birth of mother, and eye-colour of mother

$$r = \cdot 002 \pm \cdot 021.$$

The correlation ratios are:

Mean of child's eye-colour for arrays of grandmother's age

$$\eta = \cdot 123 \pm \cdot 02 \text{ and if corrected} = \cdot 098.$$

Mean of mother's eye-colour for arrays of grandmother's age

$$\eta = \cdot 061 \pm \cdot 021 \text{ and if corrected, indeterminate.}$$

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From this series it would seem as if there was no significant association between age of parent at birth and the eye-colour of an adult, hence from the previous observations, which suggest some association, it is possible that the rate at which the eye-colour develops from its initial blueness to its subsequent tint is modified, the change being more rapid in the later born. The subject could be more easily investigated by observing the alteration of tint in the first year of life. On the whole, however, we must regard the result of this investigation as purely negative.

Stature or Growth.

The relationship of growth or stature to age at birth has received considerable attention from different observers, amongst whom may be mentioned Gini, Marro, Stamini, Fourman, Budin, Ribemont, Schartzel, Hecker, and collected series of observations are also given in Vierordt's *Anatomische Daten u. Tabellen*, and in Prinzing's *Handb. d. medizinischen Statistik.*

The major portion of the work done by these observers has concerned itself with the development of the human infant at birth. Beyond the crude analysis of the figures little attempt has been made to separate the numerous factors that must necessarily play a more or less prominent part in modifying the development of the offspring. Analysis of the work of these observers shows that the variations are statistically significant, but concordance is wanting.

Thus according to age at birth, the mean weight and length of the infant increases, as age of mother at birth advances, whilst in association with order, the first or earlier born have the advantage. The influence appears to vary, according to whether the observations do or do not include those more comfortably placed economically. It is possible that the differences can be explained by the fact that the earlier born come in an undue proportion from the smaller families and those of the better social grades.

It has been shown by Arkle and many others that social position is associated with a better physical development so that should order be made constant, the apparent effect of age becomes more marked.

Further it has been suggested that the length of the puerpural period increases as age advances, hence the infant must not be regarded as starting life at the time of birth. Gini, comparing the expected weight of an infant making the observed order constant, shows that there is no significant variation with respect to age at birth, but his method does

not allow for the physical development of the parents, and in so far as the earlier numbers are of a more heterogeneous type than the later, the process of calculation adopted cannot be said to have eliminated the disturbing factor of order.

In the following series of observations the age of both parents has been recorded. It was hoped that by making the age of mother constant for given age of father, that nutritive influences dependent on age of mother would be removed.

As will be seen no significant alteration is made in the final result. The material was collected in Middlesbrough under the Education Act, Administrative Provision, 1907.

TABLE XV.

Age of Father at Birth of Child and its Height.

Boys.

	Inches														
Years	35	36	37	38	39	40	41	42	43	44	45	46	47	48	Totals
16—19	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20—23	1	1	4	5	8	20	13	6	6	2	—	—	—	—	66
24—27	2	2	3	11	20	43	33	16	7	8	—	4	3	—	152
28—31	—	4	6	12	17	20	28	22	23	13	—	—	2	—	147
32—35	2	1	2	7	10	21	24	23	12	9	2	—	1	—	114
36—39	1	1	3	7	18	15	16	10	8	2	1	2	—	—	84
40—43	—	—	3	1	12	16	9	12	3	2	—	1	—	—	59
Over 43	—	1	2	2	3	6	9	4	4	1	1	—	—	—	33
Totals	6	10	23	45	88	141	132	93	63	37	4	7	6	—	655

$\sigma_{\text{height}} = 2{\cdot}0083$. $\sigma_{\text{age}} = 1{\cdot}2572$. $r = {\cdot}0213 \pm {\cdot}0261$. $\eta = {\cdot}0722 \pm {\cdot}022$.

TABLE XVI.

Age of Father at Birth of Child and its Height.

Girls.

	Inches														
Years	35	36	37	38	39	40	41	42	43	44	45	46	47	48	Totals
16—19	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20—23	—	3	2	8	7	11	21	9	5	—	—	—	—	—	66
24—27	—	5	10	10	12	29	19	14	14	6	5	1	—	—	125
28—31	4	1	1	6	23	19	41	18	5	7	1	—	—	—	126
32—35	2	1	5	11	12	27	26	14	9	2	2	—	—	—	111
36—39	1	2	5	6	11	15	13	10	8	4	—	—	2	—	77
40—43	1	1	—	6	6	18	12	9	3	2	1	2	—	—	61
Over 43	—	—	1	—	—	1	2	2	—	—	—	—	—	—	6
Totals	8	13	24	47	71	120	134	76	44	21	9	3	2	—	572

$\sigma_{\text{height}} = 2{\cdot}0054$. $\sigma_{\text{age}} = 1{\cdot}2743$. $r = {\cdot}0522 \pm {\cdot}0278$. $\eta_{\text{height}} = {\cdot}1263 \pm {\cdot}019$.

Boys and girls together, $r = {\cdot}0367 \pm {\cdot}0210$.

TABLE XVII.

Age of Mother at Birth of Child and its Height.

Girls.

Years	Inches 35	36	37	38	39	40	41	42	43	44	45	46	47	48	Totals
16—19	—	3	—	—	3	5	3	1	2	—	—	—	—	—	17
20—23	1	3	5	10	10	22	19	16	8	4	3	—	—	—	101
24—27	1	2	8	7	14	38	39	22	6	6	2	1	—	—	146
28—31	4	2	4	15	23	16	31	15	12	6	2	2	—	—	132
32—35	1	1	5	10	11	23	26	8	8	—	—	—	2	—	95
36—39	—	2	1	1	6	10	10	11	5	1	—	—	—	—	47
40—43	—	—	4	2	4	6	4	5	2	2	1	—	—	—	30
Over 43	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Totals	7	13	27	45	71	120	132	78	43	19	8	3	2	—	568

$\sigma_{height} = 1{\cdot}9115$. $\sigma_{age} = 1{\cdot}2985$. $r = {\cdot}0675 \pm {\cdot}0287$. $\eta_{height} = {\cdot}1622 \pm {\cdot}015$.

TABLE XVIII.

Age of Mother at Birth of Child and its Height.

Boys.

Years	Inches 35	36	37	38	39	40	41	42	43	44	45	46	47	48	Totals
16—19	—	—	2	3	4	8	2	—	6	1	—	—	—	—	26
20—23	2	3	4	9	17	26	25	17	7	7	—	—	—	—	117
24—27	1	4	4	15	13	41	29	26	22	14	2	—	1	1	173
28—31	—	1	6	6	19	23	34	19	8	12	—	5	2	—	135
32—35	2	1	—	6	17	16	20	17	10	1	1	1	1	—	93
36—39	—	1	5	4	13	20	16	4	7	—	—	1	—	—	71
40—43	—	—	2	2	6	6	6	11	4	3	1	—	—	—	41
Totals	5	10	23	45	89	140	132	94	64	38	4	7	4	1	656

$\sigma_{height} = 2{\cdot}0419$. $\sigma_{age} = 1{\cdot}3261$. $r = {\cdot}0266 \pm {\cdot}0259$. $\eta = {\cdot}1178 \pm {\cdot}018$.

Boys and girls together, $r = {\cdot}0471 \pm {\cdot}0211$.

TABLE XIX.

Age of Father and Mother at Birth of Child.

Age of mother in years	Age of father in years: 20 and under	21—25	26—30	31—35	36—40	41 and over	Totals
20 and under	7	26	7	4	—	—	44
21—25	6	92	76	17	7	2	200
26—30	—	18	123	92	17	6	256
31—35	—	1	21	78	41	21	162
36—40	—	—	4	4	61	51	120
41 and over	—	—	—	1	6	43	50
Totals	13	137	231	196	132	123	832

$\sigma_{mother} = 1{\cdot}2900$. $\sigma_{father} = 1{\cdot}3368$. $r = {\cdot}7858 \pm {\cdot}015$.

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The coefficients evaluated are:

Age of father at birth of child (1) and its height (2)

$$r_{12} = \cdot037 \pm \cdot020.$$

Age of mother at birth of child (3) and its height (2)

$$r_{23} = \cdot047 \pm \cdot019.$$

Age of father (1) and age of mother (3)

$$r_{13} = \cdot768 \pm \cdot008.$$

Age of father and height of child, age of mother constant

$$_3r_{12} = \cdot001 \pm \cdot021.$$

Age of mother and height of child, age of father constant

$$_2r_{13} = \cdot030 \pm \cdot020.$$

η (mean of child's height for arrays of mother) $= \cdot14 \pm \cdot02$.
η (mean of child's height for arrays of father) $= \cdot10 \pm \cdot02$.

It would seem from these figures that there is no reason to believe that age *per se* has any effect on growth, but the environmental influence of the pre-natal period may have some effect. It is to be observed that the correlation ratios are significant, which suggests that the concomitant factors associated with age may be so arranged as to neutralise each other when viewed as a whole. It is necessary, therefore, to examine the matter in more detail before concluding that the effect of age at birth is negligible. This cannot be done without further material.

Age of Parent at Time of Birth and Intelligence.

The general literature on factors relative to intelligence is quite outside the scope of the present enquiry and that directly relevant to the subject matter seems to be limited to certain Italian writers, amongst whom are Lombroso, Orchansky, Marro, and Gini.

The conclusions arrived at by these writers are first that the influence of the mother's age predominates over that of the father's, and second that children born of younger parents seem to be more intelligent than those born of older parents. In the present paper the means of introduction were the same as in the previous sections, namely, through the Education Act of 1907. The standard of intelligence for parent and child was the ordinary scholastic test of proficiency; that is to say the age of the child and his or her standard; the mother's age on leaving

school and her standard; and her age when the child under consideration was born were the details taken. It is to be noted that the object is to consider all children as produced by a uniform mother. To neutralise the disturbing factors noted above, we should reduce the data to such as would be produced by a common ancestry, which has not been done; so that we cannot claim that the possibility of race variations has been neutralised by removing any association that may be dependent on peculiarities of the mother. Two series were collected, firstly, a group of those in their 6th year (born 1903) and those in their 13th year (born 1895). No separation was made as to the sex in calculating coefficients. The data are as follows:

TABLE XX.

Age of Mother at Birth of Child and her own standard on leaving school (child in 5th year).

	Standard on leaving school				
	Standard VII		Other standards		
Age at birth of child	Boys	Girls	Boys	Girls	Totals
20 and under	4	6	10	16	36
21—25	34	30	45	48	157
26—30	43	45	56	74	218
31—35	24	9	35	38	106
36—40	7	11	21	25	64
41 and over	2	3	6	1	12
Totals	114	104	173	202	593

$r = -\cdot2983 \pm \cdot0251.$

TABLE XXI.

Age of Mother at Birth of Child and her own standard on leaving school (child in 13th year).

	Standard VII		Other standards		
Age at birth of child	Boys	Girls	Boys	Girls	Totals
20 and under	1	7	5	6	19
21—25	23	23	24	30	100
26—30	20	23	21	27	91
31—35	12	14	19	16	61
36—40	6	6	5	4	21
41 and over	5	6	2	2	15
Totals	67	79	76	85	307

$r = -\cdot2609 \pm \cdot0364.$

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TABLE XXII.

Age of Mother at Birth of Child and its standard in 5th year.

Age at birth of child	Class I		Other classes		Totals
	Boys	Girls	Boys	Girls	
20 and under	9	20	3	3	35
21—25	58	65	28	20	171
26—30	88	81	30	32	231
31—35	47	46	19	15	127
36—40	20	34	12	8	74
41 and over	5	7	3	3	18
Totals	227	253	95	81	656

$r = \cdot 0525 \pm \cdot 0274.$

TABLE XXIII.

Age of Mother at Birth of Child and its standard in 13th year.

Age at birth of child	Standard of child				
	Standard VII		Other standards		Totals
	Boys	Girls	Boys	Girls	
20 and under	1	6	4	6	17
21—25	14	17	29	37	97
26—30	12	14	22	30	78
31—35	4	4	22	20	50
36—40	2	1	5	5	13
41 and over	1	2	2	1	6
Totals	34	44	84	99	261

$r = \cdot 067 \pm \cdot 0387.$

TABLE XXIV.

Standard of Mother on leaving school, and class of Child in 5th year.

Standard of mother	Class of child				
	Class I		Other classes		Totals
	Boys	Girls	Boys	Girls	
Standard VII	88	77	28	25	218
Other standards	122	148	61	46	377
Totals	210	225	89	71	595

$r = \cdot 534 \pm \cdot 0207.$

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TABLE XXV.

Standard of Mother on leaving school, and standard of Child in 13th year.

Standard of mother	Standard of child: Standard VII — Boys and girls	Standard of child: Other standards — Boys and girls	Totals
Standard VII	43	34	77
Other standards	60	120	180
Totals	103	154	257

$r = \cdot 331 \pm \cdot 0354$.

TABLE XXVI.

Age of Mother when leaving school, and her standard (child in 5th year).

Age of mother	Standard VII	Other standards	Totals
14 years	149	114	263
13 ,,	45	144	189
12 ,,	25	85	110
11 ,,	3	31	34
10 ,,	—	8	8
9 ,,	—	2	2
Totals	222	384	606

$r = + \cdot 4975 \pm \cdot 0231$.

TABLE XXVII.

Age of Mother when leaving school, and her standard (child in 13th year).

Age of mother	Standard VII: Boys	Standard VII: Girls	Other standards: Boys	Other standards: Girls	Totals
14 years	16	26	21	27	90
13 ,,	15	13	27	29	84
12 ,,	1	5	21	24	51
11 ,,	2	0	12	10	24
10 ,,	—	—	—	3	3
9 ,,	—	—	1	1	2
8 ,,	—	—	—	1	1
Totals	34	44	82	95	255

$r = + \cdot 4334 \pm \cdot 0327$.

TABLE XXVIII.

Age of Mother when leaving school, and standard of Child in 5th year.

Age of mother	Class I	Other classes	Totals
14 years	192	64	256
13 ,,	130	51	181
12 ,,	81	29	110
11 ,,	22	10	32
10 ,,	6	1	7
9 ,,	2	0	2
Totals	433	155	588

$r = + \cdot 0129 \pm \cdot 0275$.

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TABLE XXIX.

Age of Mother when leaving school, and standard of Child in 13th year.

Age of mother	Standard VII	Other standards	Totals
14 years	26	49	75
13 ,,	31	39	70
12 ,,	10	34	44
11 ,,	5	12	17
10 ,,	2	—	2
9 ,,	—	1	1
8 ,,	1	—	1
Totals	75	135	210

$r = \cdot 0184 \pm \cdot 0477.$

TABLE XXX.

Age of Mother at Birth of Child and her age on leaving school (child in 5th year).

Age of mother at birth of child	Age of mother on leaving school: 14 years	13 years	12 years	11 years	10 years	9 years	Totals
20 years and under	15	14	4	2	1	—	36
21—25	71	49	26	7	5	1	159
26—30	89	71	47	10	1	—	218
31—35	45	24	27	9	—	1	106
36—40	33	27	4	4	—	—	68
41 and over	8	—	2	2	—	—	12
Totals	261	185	110	34	7	2	599

$r = - \cdot 031 \pm \cdot 027.$

TABLE XXXI.

Age of Mother at Birth of Child and her age on leaving school (child in 13th year).

Age of mother at birth of child	Age of mother on leaving school: 14 years	13 years	12 years	11 years	10 years	9 years	Totals
20 years and under	4	5	4	2	—	—	15
21—25	30	34	19	12	1	—	96
26—30	31	22	15	5	2	—	75
31—35	17	18	10	3	—	1	49
36—40	3	5	1	3	—	—	12
41 and over	4	2	1	—	—	—	7
Totals	89	86	50	25	3	1	254

$r = - \cdot 082 \pm \cdot 038.$

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The values found for children in the 5th and 13th years were as follows:

		Children in 5th year	Children in 13th year
Age of mother on leaving school (1) and her own standard (2)	r_{12} =	·498 ± ·023	·433 ± ·033
Age of mother on leaving school (1) and class of child in 5th and 13th years (3)	r_{13} =	·013 ± ·028	·018 ± ·048
Age of mother at birth of child (4) and its class in 5th or 13th year (3)	r_{43} =	·053 ± ·027	·067 ± ·039
Age of mother at birth of child (4) and her own standard (2)	r_{42} =	− ·298 ± ·025	− ·261 ± ·035
Standard of mother on leaving school (2) and class of child in 5th or 13th year (3) ...	r_{23} =	·534 ± ·021	·331 ± ·035
Age of mother on leaving school (1) and age of mother at birth of child (4)	r_{14} =	− ·031 ± ·027	− ·082 ± ·038

The two series show a fair agreement, although the associations revealed are small. The following inferences may be drawn.

I. That there is a significant association between the age at which the mother left school and the standard she had attained. With respect to her child's intellectual standard, it is not significant.

II. That the age of the mother when the child was born is associated with her own intellectual grade, the sign being negative; that is, those who reproduce in late life are of a lower intellectual grade. With respect to the child's standard, the association is positive, but very small.

III. That the intellectual standards taken are highly correlated in mother and child, and on that account are probably a fair test of the point under investigation. It is worthy of note, that the association between mothers and children is greater in the fifth year than in the thirteenth year. This is due either to the fact that the latter group is selected from children of more careful parents than the former, or that children are promoted according to age rather than ability.

The intellectual grading of children in our elementary schools has been investigated statistically by Pearson and Jones (*Biometrika*, Vol. VII. p. 542). Mrs Frances Wood has also dealt with this subject in the Barking area, and she has kindly allowed me to use her results —as yet unpublished. The two investigations placed side by side are:

	Barking, North St School	Pearson and Jones
r, age and standard ... ... =	+ ·73	+ ·94
r, intelligence and standard ... ... =	+ ·40	− ·06
r, age and intelligence ... ... =	− ·215	− ·183
r, intelligence and standard with age constant =	+ ·83	

The value obtained for ${}_{a}r_{is}$ (+ ·83) points to a very definite system of promotion according to ability. Further $r_{is} = + \cdot 40$ would suggest that the more able children tended to pass into the higher classes, irrespective of age, for the correlation between age and intelligence is −·215.

The trend of these results rather suggests that promotion depends upon the personnel of the school, and on the accommodation. The former hardly needs comment. It is obvious that in a series of classrooms to hold 60 children and every classroom full, promotion according to age irrespective of intelligence must occur. On the other hand if classrooms accommodate 60 children and the average size of class is 40, grading according to intellect becomes possible. In the Middlesbrough area in which the data of this paper were collected, the overcrowding of the schools was considerable.

IV. The fourth value is what would be expected; that is, mothers who reproduce late, tend to have left school early.

We can now proceed to remove the disturbing factors, but it must be remembered that, with a mother of constant intelligence, racial effects have not been removed, but only reduced.

Making age at which the mother left school, and her standard constant (that is, considering the problem as if all children came from mothers of constant intelligence), then the correlations between age of mother at birth of offspring and its intellectual grade are, for children in the 5th year $r = \cdot 32 \pm \cdot 04$ and for children in the 13th year

$$r = \cdot 17 \pm \cdot 03.$$

It is seen that a crude correlation of ·05 is increased to approximately ·25 when the character examined is made constant for the female parent. The same point has been noted before, namely, that the effect of parental age can only be measured when the various compensating factors are removed.

The remaining partial coefficients are given in the following table.

	2nd order	
	Child in 5th year	Child in 13th year
${}_{34}r_{12}$	·59 ± ·02	·45 ± ·02
${}_{32}r_{42}$	− ·44 ± ·03	− ·30 ± ·03
${}_{32}r_{41}$	·24 ± ·04	·06 ± ·03
${}_{21}r_{13}$	− ·38 ± ·03	− ·14 ± ·03
${}_{21}r_{43}$	·32 ± ·04	·17 ± ·03
${}_{14}r_{23}$	·65 ± ·02	·35 ± ·02

It is to be noted that the correlation between age of mother at birth and age of mother on leaving school, with other factors constant, is

higher for children in the 5th year than in the 13th. This is an expected result, as reproduction in late life means a larger family, and the withdrawal from school at the earliest opportunity of children approaching the 13th year. It is obvious that data of this kind are subject to many curious influences which are extremely difficult to remove and, in fact, cannot be completely neutralised. It must therefore be with extreme hesitation that any inferences are drawn from the data collected in this way.

GENERAL CONCLUSIONS.

I shall now briefly summarise the conclusions I feel justified in drawing from the evidence submitted in the series of communications, of which the present is the fourth, reserving a full discussion for another occasion.

It appears, then, that as the age of the parent at the birth of the child increases, (*a*) the average length of life of the offspring decreases; (*b*) the fertility of the offspring increases; (*c*) the offspring react less characteristically to zymotic infections; (*d*) the proportion of males born increases; (*e*) the rate of change from congenital to ultimate type of eye-pigmentation of the offspring increases; (*f*) the intellectual grade of the offspring as defined by a scholastic standard rises.

Each of these conclusions depends upon the discovery of statistical constants significant with regard to an estimated error of sampling, but in no single case is the absolute intensity of the relation between the variables measured large, with two exceptions each of which is suspect, owing to the necessary ambiguity of the measures chosen by, or rather imposed upon, the investigator by the nature of the case.

In effect, the evidence that the populations of children born to parents of greater or less age are differentiated is inconclusive in any particular case taken by itself, but when we remember that a large variety of disparate attributes has been studied, that the particular fallacies inherent in each special investigation are likewise different, and that nevertheless all the results tend in the same direction, it is, I think, legitimate to infer that the populations are really differentiated.

Now we can suppose that the age of the parent may affect the characters of the offspring in the following ways.

Directly. In that (*a*) the primordial germ cells formed in late life partake of the senescence characterising the somatic cells, (*b*) the germ cell up to fertilisation is unaffected by senile somatic changes but thereafter suffers from nutritive effects dependent upon the soma.

Indirectly. In that the parental populations are differentiated, that those persons who bear or procreate children late in life are of a different type from others.

With respect to the second group of possibilities, we have already seen that in practice there is an economic differentiation which seriously complicates our analysis, for the more wealthy and educated classes marry later and cease to bear children earlier than the poorer members of the community. A good deal of statistical work in these papers has been undertaken with the object of eliminating this indirect factor, how far successfully is for the reader to judge, but the author recognises that the attempted neutralisation, particularly in the case of intelligence dealt with in the last part of the present paper, may well be deemed partly successful only.

Reverting to the direct effects, it may be said that although the Weismannian tradition, that of the inviolability of the germ plasm, has been notably weakened by the impact of hostile researches, yet even now the possibilities scheduled under (*b*) will seem to most of us the more inviting.

We may, however, assert that the (*b*) factors cannot suffice to account for all the facts. Thus, in all the quantitatively measurable characters studied, it has been found that the children of the younger or elder parents show changes in variability that cannot be attributed to maternal influence, which, of course, (*b*) covers completely. The data grouped in this way (taken from the peerage and referring to eldest born sons) are as follows:

Standard deviation of age of son at death, when born

before and including 31st year	32nd year or later
7·0865 ± ·1647	7·8033 ± ·1909

Diff. ·7168 ± ·2521. Ratio 2·84.

Age of father at death who reproduced

before and including 31st year	32nd year or later
7·0378 ± ·1327	6·3474 ± ·1514

Data with respect to the female parent are not forthcoming in the case of the peerage, but the variability in the number of children dying in a working class family is:

Standard deviation of number of children dying of mothers, born of grandparent

less than 30 years of age	more than 30 years of age
1·828 ± ·0344	1·888 ± ·0456

The difference is not significant and the suggestion is that the foregoing results can hardly be explained by reference to the female parent.

It may be of interest to examine the other characters dealt with from this point of view, taking growth, and dividing our data at the 30th year.

Standard deviation of height of mothers who reproduced a child

before and including 30th year	after 30th year
2·3550 ± ·0479	2·1326 ± ·0540

Height of children in 9th year—reproduced

before and including 30th year	after 30th year
2·3428 ± ·0479	2·4436 ± ·0618

Diff. ·1008 ± ·078. Ratio 1·4.

It is worthy of remark that the increased variability of the later born is itself a differentiation and a rather unexpected one. By the nature of the case the parents who reproduce late in life are a selection, a certain portion of the whole frequency of the parents being excluded. This kind of selection will tend to diminish the variability of the parental generation and to a less extent that of the filial generation. The stringency of the selection is not so intense nor the force of heredity so great in the case of the variables studied that we should expect any great reduction of variability; assuredly, however, we should not anticipate an increase which nevertheless we find.

There is however one apparent exception to the above. It is as follows (peerage data):

Standard deviation of number of offspring of son born

before 32nd year of father	after 32nd year of father
3·7127 ± ·0762	3·4561 ± ·073

Diff. ·256 ± ·091. Ratio 2·4.

This is contrary to what would have been expected as the increased variability of the life period of later born sons should lead to an increase in variability in the number of offspring produced. With respect to the female parent (working class data) the same trend is shown but the difference is not significant.

Standard deviation of number of children of daughter born

before 30th year of mother	after 30th year of mother
2·878 ± ·0499	2·7503 ± ·0572

Diff. ·12 + ·07.

This exception may be a special adaptation and not a true exception to what seems to be a general rule.

It agrees however with the following series in one respect, namely that an increase of the standard deviation is not accompanied by a corresponding change in the mean[1]. In these cases the characters of the parental generation could not be obtained.

Standard deviation of the age of attack of scarlet fever, of persons born

before 30th year of mother	after 30th year of mother
3·7072 ± ·0559	4·4227 ± ·0793
Mean 7·27 ± ·03 years	7·29 ± ·04 years

Standard deviation of the age of attack of diphtheria, of persons born

before 30th year of mother	after 30th year of mother
3·5635 ± ·0833	3·8769 ± ·1117
Mean 6·07 ± ·04 years	5·92 ± ·05 years

Standard deviation of the age of attack of small pox, of persons born

before 30th year of mother	after 30th year of mother
2·6977 ± ·1103	2·8933 ± ·1255

With the steady improvement of the method of compiling and presenting anthropometric data consequent upon the enlargement of the scope of public health administration, we may look to the provision of material fit to provide a basis for a more complete and searching investigation than I have found possible. In the meantime these results will be of service to those who wish to inquire into a fascinating and, it may be, sociologically important subject.

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