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THE PROBLEM OF ALIEN IMMIGRATION INTO GREAT BRITAIN, ILLUSTRATED BY AN EXAMINATION OF RUSSIAN AND POLISH JEWISH CHILDREN.

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PART III.

CONTENTS.

E. *Environment and Ocular Characters.*

(i) *Remarks on Parental Sight.* Before we treat of the influence of environment on the ocular characters, it would be fitting to introduce a section on the influence of parental heredity in the case of our Jewish children. Unfortunately it is one of the most difficult tasks to get ocular characters measured in parents and children. There are two obvious ways of doing it: (*a*) from the records of ophthalmological surgeons, and (*b*) by testing mothers who bring children to eye clinics*. Both are likely to lead to erroneous results because (i) the parents and their offspring are probably at different ages, and because (ii) the parents and offspring in the first and certainly the offspring† in the second are actually selected because of sight trouble. Thus difficult and disputable corrections have to be made for selection, and those who start with a preconceived idea and no knowledge of statistical theory are only too ready to suppose others have like ideas and bend their theory to demonstrate their prejudgments. In the present case it was clearly hopeless to endeavour to get the parents to come and have their eyes examined. All the home-visitors could do was to inquire as to the sight of father and mother and whether they wore spectacles or not. The answers received were—as might be expected from a population with a large percentage of illiteracy—very unsatisfactory. We obtained such results as "normal," "good," "very good," "fair," "poor," "very poor," "long-sighted," "short-sighted" or merely "wears glasses." The answers were too vague to admit of scientific classification. All we could do was to make a crude classification of "Good" and "Bad." As a result, we were able to elicit crude information in the case of 386 mothers, 393 fathers and 385 pairs of parents whose sons had been examined fully for sight. We accordingly obtained four tables for the data for acuity of vision: see Table CCLXIV A–D.

* The Galton Laboratory started an investigation of this kind just before the war, but had to discontinue it owing partly to the war, but chiefly because it had to be done by voluntary labour, the Laboratory having no funds for lengthy and expensive investigations of this kind.

† The parents indirectly because they are parents of at least one child with sight trouble.

Table CCLXIV. *Acuity of Vision in Son and Parental Sight.*

Acuity of Vision in Son	A. Mother's Sight			B. Father's Sight			C. Parents' Sight			D. Biparental Sight			
	Good	Poor	Totals	Good	Poor	Totals	Good	Poor	Totals	Both Good	Good One and Poor One	Both Poor	Totals
1·50	1	2	3	2	1	3	3	3	6	1	1	1	3
1·40	3	—	3	2	1	3	5	1	6	2	1	—	3
1·29	45	13	58	44	14	58	89	27	116	37	15	6	58
1·11	92	27	119	90	30	120	182	57	239	79	24	16	119
·91	62	19	81	56	27	83	118	46	164	47	23	11	81
·75	31	8	39	24	14	38	55	22	77	21	12	5	38
·58	24	5	29	28	5	33	52	10	62	21	8	—	29
·37	16	9	25	19	7	26	35	16	51	14	6	5	25
·25	8	1	9	8	1	9	16	2	18	8	—	1	9
·14	9	1	10	8	2	10	17	3	20	7	3	—	10
·08	6	—	6	4	2	6	10	2	12	4	2	—	6
·04	3	1	4	4	—	4	7	1	8	3	1	—	4
Totals	300	86	386	289	104	393	589	190	779	244	96	45	385
Mean Vision of Son	·8975	·9266	·9040	·8937	·9184	·9002	·8956	·9221	·9021	·8976	·8990	·9524	·9044

Now, if the reader will examine the row of means at the foot of the table, he will notice a very singular result. Although the differences of the means are not of marked significance, yet in every case where the mother, the father, either parent, or both have "poor" sight the son has *greater* acuity of vision. In other words, if we were to judge goodness of sight by acuity of vision in childhood, we reach the paradox that it is an advantage to the child to have parents of "poor" sight. On second thoughts, however, we should be inclined to do one of two things, i.e. to hold

Table CCLXV. *Parents' "Sight" and Refraction Class of Offspring.*

Refraction Class of Offspring

A. Father's Sight	Hypermetropic Astigmatism	Hypermetropia	Emmetropia	Myopia	Myopic Astigmatism	Mixed Astigmatism	Totals
Good	44	28	341	99	26	6	544
Bad	14	23	139	29	9	3	217
Totals	58	51	480	128	35	9	761
B. Mother's Sight							
Good	47	35	352	111	21	6	572
Bad	11	16	120	16	11	3	177
Totals	58	51	472	127	32	9	749
C. Parents' Sight							
Good	91	63	693	210	47	12	1116
Bad	25	39	259	45	20	6	394
Totals	116	102	952	255	67	18	1510
D. Parents' Sight							
Both Good	41	22	284	85	17	5	454
One Good, one Bad	9	19	118	37	11	2	196
Both Bad	8	10	67	4	4	2	95
Totals	58	51	469	126	32	9	745

that our measure of parental sight is so vague that it screens heredity, or to believe that some physiological principle is involved which again screens heredity; this principle might be summed up by saying that children with marked acuity of vision are likely in adult life to have poor sight. This is a point which might with advantage be further investigated, at present it is only a suggestion to explain the anomalous character of the table. It must be noted, of course, that the correlations are very small; thus Table CCLXIV C gives a tetrachoric correlation of − ·0519 with the dichotomic line between ·91 and ·75, and Table CCLXIV D gives a value of − ·0256 with the dichotomic lines between ·91 and ·75 and between both parents with good sight and one only*. Both these results are really non-significant, but assuming them zero and that our loose categories of parental sight do mean something, the remarkable fact is that the physiological correlation, if it exists, between acute vision in childhood and poor sight in adult life should be so intense as to destroy completely the hereditary factor.

To test the matter further we tabled the sight of the parents and the refraction class of the child. The data are given in Table CCLXV A–D.

The discrepancies in the totals arise from the sight of mother or father being occasionally recorded when that of father or mother is wanting. The percentages obtained from the last two tables are as follows:

Percentages of Refraction Classes in Offspring.

Refraction Class in Offspring

C. Parents' Sight	Hypermetropic Astigmatism	Hypermetropia	Emmetropia	Myopia	Myopic Astigmatism	Mixed Astigmatism
Good	8·2	5·6	62·1	18·8	5·3	
Bad	6·3	9·9	65·7	11·4	6·6	
All Parents	7·7	6·8	63·0	16·9	5·6	
D. Parents' Sight						
Both Good	9·0	4·8	62·6	18·7	4·8	
One Good, one Bad	4·6	9·7	60·2	18·9	6·6	
Both Bad	8·4	10·5	70·5	4·2	6·3	

These tables—although little stress can be laid on the data owing to the manner in which they had to be collected—do not indicate that "Bad" sight in one or both parents influences the sight of children of school age. In fact, for Hypermetropic Astigmatism and for Myopia, the parents with "Good" sight have the larger percentage of children affected. In both ways of approaching the subject, i.e. when we table every parent or when we table every pair of parents, those with bad sight have more emmetropic children than those with good sight. In the case of the myopic and mixed astigmatisms there is a larger percentage of children born of parents of bad sight. The numbers in the categories with small frequency are, however, such that but little stress can be laid on the small differences of these percentages. The conclusion, if any at all is justifiable, is that with loose categories there is no evidence that "sight" in adult parents is markedly correlated with sight in their offspring at school ages.

It appeared worth while inquiring into the value of this category of parental "sight," by seeing if it had any relation to home conditions. If some correlation exists, then there may be value in the category. We selected accordingly the two characters: "Lighting of Rooms" and "Cleanliness of Home." To obtain statistically workable tables on our sparse material we had to take

* Triserial r gives − ·0482, of scarcely greater significance.

dichotomic planes in both cases between "Good" and "Fair." We have the following tetrachoric tables:

Table CCLXVI. *Lighting of Rooms and Parental Eye-Sight.*

Lighting of Rooms				Lighting of Rooms			
Mother's Sight	Very Good, Good	Fair, Poor, Very Poor	Totals	Father's Sight	Very Good, Good	Fair, Poor, Very Poor	Totals
Good	169	149	318	Good	170	133	303
Not Good	49	45	94	Not Good	50	63	113
Totals	218	194	412	Totals	220	196	416

From these tables we deduce:

$$\text{Mother's Sight and Lighting of Rooms: } r_t = +\cdot 0149 \pm \cdot 0578.$$
$$\text{Father's Sight and Lighting of Rooms: } r_t = +\cdot 1779 \pm \cdot 0544.$$

Turning now to Cleanliness of Home, we have the following tables:

Table CCLXVII. *Cleanliness of Home and Parental Eye-Sight.*

Cleanliness of Home				Cleanliness of Home			
Mother's Sight	Very Good, Good	Fair, Poor, Very Poor	Totals	Father's Sight	Very Good, Good	Fair, Poor, Very Poor	Totals
Good	146	177	323	Good	146	165	311
Not Good	39	57	96	Bad	43	71	114
Totals	185	234	419	Totals	189	236	425

These fourfold tables give:

$$\text{Mother's Sight and Cleanliness of Home: } r_t = +\cdot 0678 \pm \cdot 0573.$$
$$\text{Father's Sight and Cleanliness of Home: } r_t = +\cdot 1396 \pm \cdot 0546.$$

Although Mother's sight is positively related to the Lighting of the Rooms and their Cleanliness, the correlation is non-significant. In the Father's case the first correlation is probably and the second quite possibly significant; they are not very intense, but considerably greater than those for the Mother. Yet in many cases the Mother must be more in the home than the Father. Apparently the condition of the home affects her sight less than that of the Father, and very probably not at all. The paradox is, we think, to be explained in a manner indicated on another occasion. These low correlations indirectly result from other factors; the Father's poor sight handicaps the quantity and quality of his work, he gets less wage, and as a result his home, whether from situation (involving lighting), or from poverty (involving disorder and uncleanliness), is of a lower type.

(ii) *Personal Cleanliness and Ocular Characters.*

(*a*) *Personal Cleanliness and Visual Acuity.* The cleanliness of body and hair may be looked upon as a factor of environment largely depending on habits of parents, and so a measure of parental neglect. We were only able to tabulate 298 cases, and we had then the following table:

Table CCLXVIII. *Cleanliness of Body and Hair and Binocular Vision.*

Cleanliness, Hair Grade	Body Grade	Vision 1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	Totals
1	1	—	—	7	7	6	—	2	1	1	1	—	—	25
	2	—	—	11	25	20	8	8	7	3	2	1	1	86
	3	—	—	1	4	3	5	5	1	—	—	—	—	19
	4	—	—	—	—	—	—	—	—	—	1	—	—	1
		—	—	19	36	29	13	15	9	4	4	1	1	131
2	1	—	—	—	1	1	—	—	—	—	—	1	—	3
	2	1	1	8	29	21	8	3	4	2	4	1	2	84
	3	—	1	3	12	4	3	4	1	—	1	—	1	30
	4	—	—	—	—	2	—	—	—	1	—	—	—	3
		1	2	11	42	28	11	7	5	3	5	2	3	120
3	1	—	—	—	—	1	—	—	—	—	—	—	—	1
	2	—	—	3	6	8	2	—	1	—	1	—	—	21
	3	—	—	4	3	3	2	1	2	—	—	—	—	15
	4	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	—	7	9	12	4	1	3	—	1	—	—	37
4	1	—	—	—	—	—	—	—	—	—	—	—	—	—
	2	—	1	1	2	2	1	1	—	—	—	1	—	9
	3	—	—	—	—	—	—	—	—	1	—	—	—	1
	4	—	—	—	—	—	—	—	—	—	—	—	—	—
		—	1	1	2	2	1	1	—	1	—	1	—	10
	Totals	1	3	38	89	71	29	24	17	8	10	4	4	298

We can form three tables from these data: (i) for hair only, (ii) for body only, and (iii) for combined cleanliness*. These are provided in the following scheme and beneath (p. 6) we give the mean visions for the different grades with their probable errors.

Table CCLXIX. *Binocular Vision and Cleanliness.*

Vision	Cleanliness of Body					Cleanliness of Hair					Hair and Body Cleanliness combined				
	1	2	3	4	Totals	1	2	3	4	Totals	A	B	C	D	Totals
1·50	—	1	—	—	1	—	1	—	—	1	—	1	—	—	1
1·40	—	2	1	—	3	—	2	—	1	3	—	1	1	1	3
1·29	7	23	8	—	38	19	11	7	1	38	18	9	6	5	38
1·11	8	62	19	—	89	36	42	9	2	89	33	33	18	5	89
·91	8	51	10	2	71	29	28	12	2	71	27	25	12	7	71
·75	—	19	10	—	29	13	11	4	1	29	8	13	5	3	29
·58	2	12	10	—	24	15	7	1	1	24	10	8	4	2	24
·37	1	12	4	—	17	9	5	3	—	17	8	5	2	2	17
·25	1	5	1	1	8	4	3	—	1	8	4	2	—	2	8
·14	1	7	1	1	10	4	5	1	—	10	3	4	3	—	10
·08	1	3	—	—	4	1	2	—	1	4	2	1	—	1	4
·04	—	3	1	—	4	1	3	—	—	4	1	2	1	—	4
Totals	29	200	65	4	298	131	120	37	10	298	114	104	52	28	298

* We used the same classes as in the first part of this memoir, i.e. A = 1 + 1, 1 + 2, 2 + 1; B = 2 + 2, 3 + 1, 1 + 3; C = 3 + 2, 2 + 3, 4 + 1, 1 + 4; and D = 3 + 3, 2 + 4, 4 + 2, 4 + 3, 3 + 4, 4 + 4, the first figure referring to body and the second to hair grade. See *Annals of Eugenics*, Vol. I, pp. 96, 97 for definitions.

Mean Vision for Arrays and Totals.

Cleanliness of Body	Cleanliness of Hair	Combined Body and Hair
1. ·9376 ± ·0419	1. ·8727 ± ·0197	A. ·8842 ± ·0211
2. ·8872 ± ·0160	2. ·8873 ± ·0206	B. ·8784 ± ·0221
3, 4. ·8599 ± ·0272	3, 4. ·9183 ± ·0329	C. ·9098 ± ·0313
All Grades ·8861 ± ·0131	All Grades ·8861 ± ·0131	D. ·8750 ± ·0426
		All Grades ·8861 ± ·0131

At first it seemed from the means for Cleanliness of Body that the vision was increasingly worse as the body got dirtier, but when the Cleanliness of Hair was considered it appeared as if the vision improved as the hair was less clean. But an examination of the probable errors indicates that there are really no arrays with means significantly different from that of the general population. In fact, the vision of the largest class, i.e. Grade 2, must be very nearly that of the mean, and if we deal with three categories only, one of the other two must be above and one below the mean, or we are almost certain from random sampling to get results such as we have found for Cleanliness of Body and of Hair.

Using the "Biserial r" method* we find for the three tables respectively:

$$r_{bV} = +\cdot 0599 \pm \cdot 0539,$$
$$r_{hV} = -\cdot 0630 \pm \cdot 0589,$$
$$r_{cV} = -\cdot 0280 \pm \cdot 0525,$$

none of which is significant having regard to their probable errors. The third table was checked for the correlation result by a correlation ratio:

$$\eta'^2_{V.C} = \cdot 005{,}286, \qquad \bar{\eta}^2_{V.C} = \cdot 010{,}067,$$

thus η'^2 is not significant with regard to $\bar{\eta}^2$.

It is clear that personal cleanliness neither in itself, nor as a measure of parental care, can be regarded as at all an influential factor in the determination of visual acuity. It is possible, however, that some one or other of the ocular characteristics which contribute to the acuity of vision will be found to have higher association with personal cleanliness and to these we now turn.

(*b*) *Personal Cleanliness and Refraction Class.* We have considered it sufficient to deal with the combined classes of Cleanliness of Hair and Body, A, B, C, D, as defined above (p. 5 ftn.).

Table CCLXX. *Refraction Class and Cleanliness of Body and Hair.*

Refraction Class

Grades of Cleanliness	Hypermetropic Astigmatism	Hypermetropia	Emmetropia	Myopia	Myopic Astigmatism	Mixed Astigmatism	Totals
A	16	10	142	27	11	4	210
B	15	20	137	44	7	5	228
C	11	11	56	19	7	—	104
D	8	5	35	9	2	1	60
Totals	50	46	370	99	27	10	602

As a first consideration of the table we found its uncorrected mean square contingency. We have:

$$\phi'^2 = \cdot 029{,}224,$$

while

$$\bar{\phi}^2 = \cdot 038{,}206.$$

* The dichotomic line between 2 and 3 and B and C grades as the case may be.

There is accordingly no evidence of any association whatever, ϕ'^2 being less than the mean value $\bar{\phi}^2$ when there is no relationship at all. We now made a fourfold table taking the normal against the remainder and the dichotomic line for cleanliness between B and C.

This gave the following fourfold table, leading to the tetrachoric correlation coefficient:

$$r_t = \cdot 0128 \pm \cdot 0469.$$

	Normal	Non-normal	Totals
Clean: A + B	279	159	438
Unclean: C + D	91	73	164
Totals	370	232	602

Again therefore we see that divergence from normality in refraction is not sensibly associated with want of cleanliness, or, what amounts to much the same thing, careless habits in the parents.

If percentages on such small numbers might be safely used, we could show such correlation as exists in the following manner:

Percentages of Refraction Classes.

	Hypermetropic Groups	Emmetropia	Myopic Groups*
Clean Population	13·9	63·7	22·4
General Population	15·9	61·5	22·6
Dirty Population	21·3	55·5	23·2

These figures show a slight betterment of sight in the clean as compared with the dirty population. But even if it be safe to lay stress on the differences of this order, they indicate such a small association that the poorer sight might be the source of such difference in cleanliness as occurs.

(*c*) *Personal Cleanliness and General Refraction.* The table below gives our data. We have dealt with it in two different ways.

First, we have found the means paying attention to positive and negative signs. We have:

Table CCLXXI. *Cleanliness of Person and General Refraction.*

General Refraction in Dioptres

Cleanliness of Hair and Body	+6·00	+5·25	+4·50	+3·75	+3·00	+2·25	+1·50	+0·75	0·00	−0·75	−1·50	−2·25	−3·00	−3·75	−4·50	−5·25	−6·00	−6·75	...	−12·75	...	−15·75	Totals
Grade A	1	—	1	5	—	6	4	42	114·5	14	10·5	3	1	4	—	2	—	2	...	—	...	—	210
,, B	—	2	—	2	4	11	9	45	103	25	9	8	4	—	—	3	—	1	...	—	...	—	226
,, C	—	—	1	1	—	4	7	21	44	17	2	3	—	1	—	—	—	1	...	1	...	1	104
,, D	1	—	1	2	—	5	2	14	25	2	2	4	1	1	—	—	—	—	...	—	...	—	60
Totals	2	2	3	10	4	26	22	122	286·5	58	23·5	18	6	6	—	5	—	4	...	1	...	1	600

Cleanliness Class	Mean Refraction
A	$+ \cdot 0250 \pm \cdot 1060$
B	$+ \cdot 0763 \pm \cdot 0740$
C	$- \cdot 1731 \pm \cdot 1090$
D	$+ \cdot 3750 \pm \cdot 1436$
Whole Population:	$+ \cdot 0450 \pm \cdot 0454$

* The small group of mixed astigmatism was included in these.

Grades A, B and C give no refraction differing sensibly from the population value. The mean of Grade D differs by less than 2·2 times the probable error of the difference from the population value. It is accordingly not safe to assert that the dirtiest individuals have really a somewhat higher positive refraction. The biserial correlation coefficient, r_b, for division between Grades B and C is given by

$$r_b = \cdot 0088 \pm \cdot 0494,$$

and is accordingly not significant.

Secondly, we separated the positive from the negative refractions, placing the zeros with the latter, and found:

Cleanliness Class	Positive Refraction Mean	Negative Refraction Mean
A	1·3602 ± ·0978	− ·4967 ± ·0816
B	1·3972 ± ·0879	− ·5539 ± ·0810
C	1·2794 ± ·1288	− ·8786 ± ·1198
D	1·7100 ± ·1502	− ·5785 ± ·1694
Whole Population:	1·4057 ± ·0543	− ·5905 ± ·0496

None of these means, having regard to their probable errors, can be considered to differ with definite significance from the population mean. For biserial correlations we have:

$$\text{Positive Refractions: } r_b = \cdot 0441 \pm \cdot 0836,$$
$$\text{Negative Refractions: } r_b = \cdot 0927 \pm \cdot 0625,$$

which again are non-significant considering their probable errors. We fail therefore to find any evidence of General Refraction being significantly associated with personal cleanliness.

(*d*) *Personal Cleanliness and Corneal Refraction.* We have worked out this material solely for the observations of *A* and *B*, excluding those of *C*. This reduces the total number of cases with which we have to deal to 258, but at the same time we feel more confident of the result than if we combine these with *C*'s records. The following table contains the data:

Table CCLXXII. *Personal Cleanliness and Corneal Refraction.*

Corneal Refraction in Dioptres (Central Values)

Cleanliness (Body and Hair) Grades	38·125	38·625	39·125	39·625	40·125	40·625	41·125	41·625	42·125	42·625	43·125	43·625	44·125	44·625	45·125	45·625	46·125	46·625	47·125	Totals
A	—	—	—	—	3	1	1	1	4	8	7	9	13	5	3	5	6·5	1·5	—	68
B	1	—	—	—	4	1	3	5	6	6	7	24	12	12	8	5	7	2	1	104
C	—	—	—	—	2	—	—	1	2	4	9	4	8	5	5	—	4	—	—	44
D	—	—	—	—	—	—	2	5	5	4	2	4	5	3	6	4	2	—	—	42
Totals	1	—	—	—	9	2	6	12	17	22	25	41	38	25	22	14	19·5	3·5	1	258

The means run as follows:

Cleanliness	Mean Corneal Refraction (Dioptres)
Grade A	43·790 ± ·126
„ B	43·707 ± ·102
„ C	43·761 ± ·156
„ D	43·625 ± ·160
General Population:	43·725 ± ·064

Standard Deviation of General Population: 1·5353 ± ·046.

The differences of the array-means are clearly insignificant. Taking a biserial correlation coefficient we find:

$$r_b = -\cdot 0179 \pm \cdot 0706.$$

This is non-significant and if it were significant would be of no importance; it would indicate that the higher corneal refraction followed the cleaner persons. We conclude, therefore, that Corneal, like General Refraction, appears to be uninfluenced by Personal Cleanliness.

(*e*) *Personal Cleanliness and General Astigmatism.* Our data are contained in the following table:

Table CCLXXIII. *Personal Cleanliness and General Astigmatism.*

General Astigmatism in Dioptres

Grades of Cleanliness	+ 3·00	+ 2·25	+ 1·50	+ 0·75	0·00	− 0·75	− 1·50	− 2·25	− 3·00	− 3·75	− 4·50	− 5·25	Totals
A	—	—	0·5	7·5	161	28·5	6·5	1	2	3	—	—	210
B	—	—	—	17	168	23	3	10	1	4	—	—	226
C	—	—	2	7	77	5	6	7	—	—	—	—	104
D	—	1	—	7	38	5	2	3	—	2	1	1	60
Totals	—	1	2·5	38·5	444	61·5	17·5	21	3	9	1	1	600

We have the following means for Astigmatism:

Grades of Cleanliness	Mean Astigmatism paying Attention to Sign	Mean Astigmatism paying No attention to Sign
A	$-\cdot 2107 \pm \cdot 035$	$\cdot 2714 \pm \cdot 035$
B	$-\cdot 2190 \pm \cdot 033$	$\cdot 3319 \pm \cdot 034$
C	$-\cdot 1947 \pm \cdot 049$	$\cdot 3534 \pm \cdot 050$
D	$-\cdot 3875 \pm \cdot 065$	$\cdot 6375 \pm \cdot 066$
General Population*:	$-\cdot 2288 \pm \cdot 021$	$\cdot 3450 \pm \cdot 021$

These results suggest that there is something significant about the high value of the astigmatism in the dirtiest (D) class; the low value in the cleanest class is less certainly significant. We can indicate this also in another way:

Cleanliness Grades	A	B	C	D	All Grades
% Astigmatism against the Rule	3·8	7·5	8·7	13·3	7·0
% Astigmatism with the Rule	19·5	18·1	17·3	23·3	19·0
% Astigmatism either way	23·3	25·6	26·0	36·6	26·0

These percentages seem to suggest an Astigmatism against the rule, continually increasing with dirtiness of person. On the other hand, Astigmatism with the rule appears to decrease with dirt until we come to the extremely dirty in D; it then rises somewhat, but with doubtful significance. The total Astigmatism does rise from Grade A to C, but with hardly any practical importance; the great rise is again in Grade D. It would be of interest to discover by further investigation whether in some mysterious manner Astigmatism against the rule is more influenced by dirt than Astigmatism with the rule.

Dividing between Grades B and C we find for biserial r_b, when no attention is paid to sign:

$$r_b = +\cdot 1221 \pm \cdot 0483.$$

This is a small but quite possibly significant coefficient of correlation. Diagram 129 shows graphically the results when we pay no attention to the sign of the Astigmatism. Will these results be confirmed by Corneal Astigmatism?

* Standard Deviation: with attention to sign, ·7445 D.; without attention, ·7556 D.

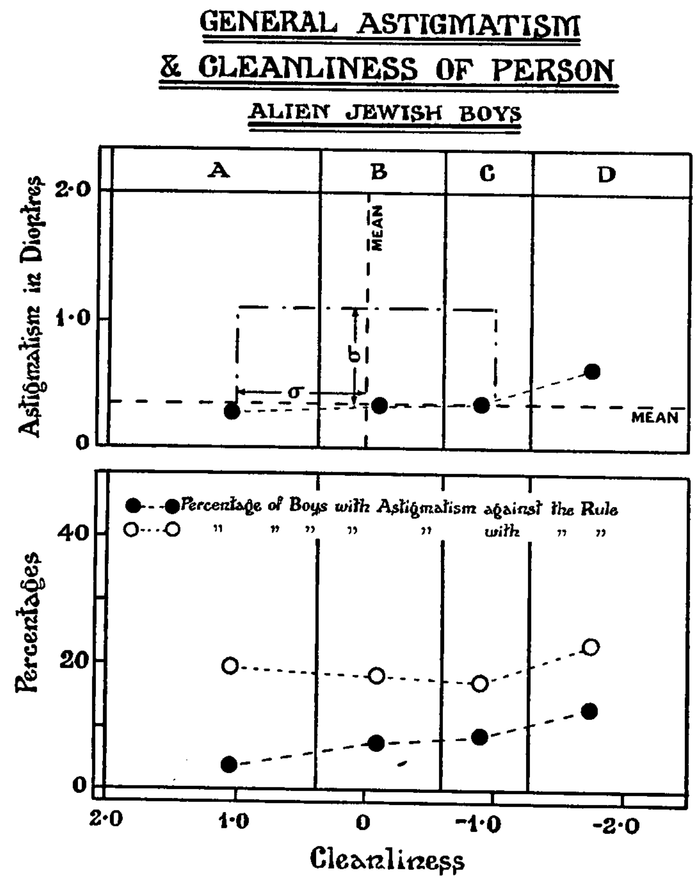

Diagram 129.

(*f*) *Personal Cleanliness and Corneal Astigmatism.* The association was determined first for the observations of *A*, *B* and *C* combined. We may again pay attention or not to the sign of the Corneal Astigmatism. The table is given below:

Table CCLXXIV. *Personal Cleanliness and Corneal Astigmatism.*

Corneal Astigmatism in Dioptres

Grades	*A*, *B* and *C*'s Observations												(*b*) *A* and *B*'s Observations only										
	−2·25	−1·50	−0·75	0·00	+0·75	+1·50	+2·25	+3·00	+3·75	+4·50	+5·25	Totals	−1·50	−0·75	0·00	+0·75	+1·50	+2·25	+3·00	+3·75	+4·50	+5·25	Totals
A	—	—	5	112	81	17	15	4	—	—	2	236	—	4	18	33	5	5	2	—	—	1	68
B	1	4	1	106	100	15	12	5	6	—	—	250	2	1	35	54	1	3	4	4	—	—	104
C	—	2	2	51	39	14	5	1	—	—	—	114	2	2	9	18	9	4	—	—	—	—	44
D	—	—	2	21	30	8	4	—	1	2	2	70	—	2	6	22	5	3	—	1	1	2	42
Totals	1	6	10	290	250	54	36	10	7	2	4	670	4	9	68	127	20	15	6	5	1	3	258

Dealing first with *A*, *B* and *C*'s data we find:

Grades of Cleanliness	Mean Corneal Astigmatism in Dioptres paying Attention to Sign	Mean Corneal Astigmatism in Dioptres paying No attention to Sign
A	·5879 ± ·0395	·6197 ± ·0367
B	·6120 ± ·0384	·6840 ± ·0357
C	·5263 ± ·0568	·6053 ± ·0528
D	·9321 ± ·0725	·9750 ± ·0674
General Population*:	·6224 ± ·0235	·6784 ± ·0218

* Standard Deviation: with attention to sign, ·8999 D.; without attention, ·8358 D.

It is clear that whether we pay attention to the sign of the Astigmatism or not, the result is the same, i.e. that while there is very little or no relationship between Grades A, B and C, there is a significant increase of Corneal Astigmatism with the rule in Grade D, of the boys with the minimum of personal cleanliness.

If we make a four-array correlation ratio of Astigmatism (without regard to sign) on Cleanliness, we find:

$$\eta'^2_{A.C} = \cdot015{,}195, \qquad \bar{\eta}^2_{A.C} = \cdot004{,}478 \pm \cdot002{,}459;$$

$\eta'_{A.C}$ is accordingly significant. The corrected correlation ratio would be about ·14. We next proceeded to find the biserial correlation coefficient with the dichotomy between Grades B and C. There resulted:

$$r_b = \cdot0666 \pm \cdot0346,$$

which is hardly significant, probably owing to the fact that it is only Grade D which gives definite evidence of the possible influence of dirt.

Turning now to the observations of *A* and *B* only we obtain the following system of means, when we neglect the sign of the Astigmatism:

Grades of Cleanliness	% Astigmatic	Mean Corneal Astigmatism (paying no attention to Sign)
A	73·5	·8493 ± ·0774
B	66·3	·7644 ± ·0626
C	79·5	·9205 ± ·0962
D	85·7	1·2143 ± ·0985
General Population*:	73·6	·8866 ± ·0397

A and *B*'s records give a more consistent result for Grade C, but the reduction of the number of observations still leaves only Grade D diverging from the mean value.

The value of the biserial coefficient now mounts up and we have:

$$r_b = \cdot1718 \pm \cdot0674,$$

which is just over 2·5 times its probable error.

Thus we see that Corneal Astigmatism confirms the result obtained for General Astigmatism: there is a small but probably significant association between personal cleanliness and Astigmatism. Of course our data are too sparse to stress this conclusion heavily; it depends upon a small group of boys with high Astigmatism being very dirty. We must leave it to our readers to consider whether it is more probable that the dirt in some unexplained manner produces the Astigmatism, or the Astigmatism means that the boys' sight is such that they do not appreciate their own uncleanliness.

CORNEAL ASTIGMATISM & CLEANLINESS OF PERSON (OBSERVERS A & B ONLY)

ALIEN JEWISH BOYS

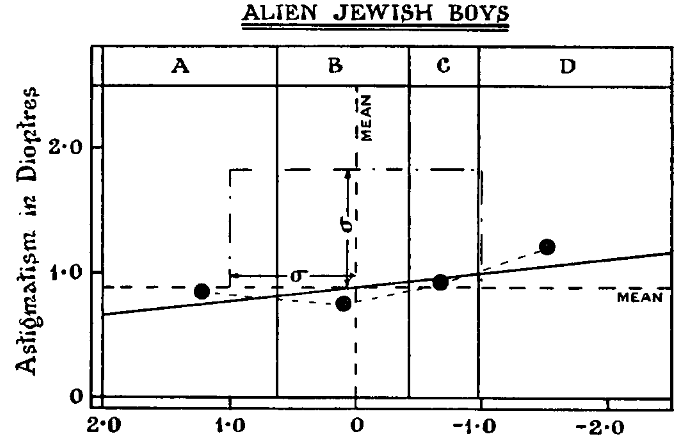

Diagram 130.

(iii) *Cleanliness of Home and Ocular Characters.*

(*a*) *Cleanliness of Home and Visual Acuity* (*Binocular*). The accompanying table gives our data.

* Standard Deviation = ·9460 D.

Table CCLXXV. *Cleanliness of Home and Visual Acuity* (*Binocular*).

Visual Acuity

Cleanliness of Home	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	Totals
Very Good	—	—	1	4	5	3	1	—	2	1	—	—	17
Good	2	1	24	48	26	15	13	11	2	3	2	3	150
Fair	1	2	22	54	40	14	15	11	4	4	1	1	169
Poor and Very Poor	—	—	9	13	9	7	4	4	1	2	—	—	49
Totals	3	3	56	119	80	39	33	26	9	10	3	4	385

We have:

Mean Vision = ·9046; Standard Deviation = ·3264;

Biserial coefficient, dichotomy between Good and Fair, $r_b = -\cdot 0160 \pm \cdot 0449$.

This result shows no indication of any correlation between Visual Acuity and the Cleanliness of the Home.

The means of the arrays tell the same tale:

Cleanliness of Home	Acuity of Binocular Vision
Very Good	·8088 ± ·0534
Good	·9091 ± ·0180
Fair	·9111 ± ·0169
Poor and Very Poor	·8941 ± ·0315
General Population*:	·9046 ± ·0112

None of the array-means is significantly different from that of the General Population. If the results were to be considered as significant the most cleanly homes would provide the boys with least acuity of vision.

We must, we hold, conclude that cleanliness of home is not an important factor in determining the acuity of vision of the children.

(*b*) *Cleanliness of Home and Refraction Class.* Our records provide the following table:

Table CCLXXVI. *Cleanliness of Home and Refraction Class.*

Home Cleanliness	Emmetropia	Hypermetropia	Hypermetropic Astigmatism	Mixed Astigmatism	Myopic Astigmatism	Myopia	Totals
Very Good	19	8	2	1	1	5	36
Good	185	18	15	3	16	61	298
Fair	213	18	34	4	16	41	326
Poor and Very Poor	58	10	7	1	—	16	92
Totals	475	54	58	9	33	123	752

As a first indication we took a fourfold table, the dichotomies being between Good and Fair and Emmetropic and the remainder. We have:

Refraction

Cleanliness of Home	Emmetropic	Not Emmetropic	Totals
Good and Very Good	204	130	334
Fair, Poor and Very Poor	271	147	418
Totals	475	277	752

* Standard Deviation = ·3264.

This gave: $r_t = -\cdot0621 \pm \cdot0395$,

that is, there was no significant association, and if it had been significant the better sight would spring from the dirtier homes.

Percentages give us the following results:

Cleanliness of Home	Hypermetropic Groups		Emmetropia		Myopic Groups	
Very Good	27·8	12·9	52·8	61·1	19·4	26·0
Good	11·1		62·1		26·8	
Fair	16·0	16·5	65·3	64·8	18·7	18·7
Poor and Very Poor	18·5		63·0		18·5	
General Population	14·9		63·2		21·9	

If we could trust these percentages as being really significant, we should have to say that there were few emmetropic and more myopic children in the cleaner homes, while there were more hypermetropic children in the dirtier homes. But the differences are of very doubtful significance, and to get a measure of whether there was any really significant association we turned to the method of mean square contingency and found:

$$\phi'^2 = \cdot045{,}1504, \qquad \bar{\phi}^2 = \cdot030{,}585 \pm \cdot006{,}309.$$

These results indicate that ϕ'^2 can hardly be considered significant as compared with $\bar{\phi}^2$, the value for zero association, and when we come to trace the contributions to ϕ'^2 on which any significance might depend we are puzzled to give them an orderly interpretation; they are:

(i) In homes of Very Good cleanliness a redundancy of hypermetropes;

(ii) In homes of Good cleanliness a redundancy of myopes and a deficiency of hypermetropic astigmatics;

(iii) In homes of doubtful, i.e. "Fair" cleanliness, a redundancy of hypermetropic astigmatics and a deficiency of myopes;

(iv) In homes of the dirtiest grade a deficiency of myopic astigmatics.

It is difficult to believe that these results correspond to anything but the deviations of random sampling; they appear to exhibit no nomic relations. We are accordingly forced to conclude that our data do not show that Cleanliness of Home is a causal factor of refraction class.

(c) *Cleanliness of Home and General Refraction.* The records are tabulated below and the several means for cleanliness grades follow.

Table CCLXXVII. *Cleanliness of Home and General Refraction.*

Refraction in Dioptres

Cleanliness of Home	+6·75	+6·00	+5·25	+4·50	+3·75	+3·00	+2·25	+1·50	+0·75	0·00	−0·75	−1·50	−2·25	−3·00	−3·75	−4·50	−5·25	−6·00	−6·75	..	−12·75	..	−15·75	Totals
Very Good	—	—	—	—	2	2	—	—	12	15	1	1	1	—	2	—	—	—	—	..	—	..	—	36
Good	—	—	—	2	3	3	8	4·5	52·5	149	35	18	12	4	—	—	3	—	2	..	1	..	1	298
Fair	1	3	3	1	5·5	0·5	17·5	13	56·5	172	27	8·5	8·5	2	3	—	2	—	2	..	—	..	—	326
Poor and V. Poor	—	—	1	—	1	—	3	3	25	43	10	2	3	—	1	—	—	—	—	..	—	..	—	92
Totals	1	3	4	3	11·5	5·5	28·5	20·5	146	379	73	29·5	24·5	6	6	—	5	—	4	..	1	..	1	752

*Means of Arrays**.

Grade of Cleanliness	All Refractions	Positive Refractions‡	Negative Refractions‡
Very Good	+ ·2917 ± ·1773	+ 1·4062 ± ·2081	− 2·4000 ± ·5989
Good	− ·1900 ± ·0616	+ 1·2791 ± ·0974	− 2·0487 ± ·1536
Fair	+ ·2301 ± ·0589	+ 1·6671 ± ·0828	− 1·7618 ± ·1840
Poor and Very Poor	+ ·1957 ± ·1109	+ 1·1818 ± ·1449	− 1·3125 ± ·3348
General Population†:	+ ·0623 ± ·0388	+ 1·4496 ± ·0558	− 1·8425 ± ·1093

There is very little evidence of anything but the variations of random sampling here. None of the array-means except that for the doubtful or Fair Cleanliness of Home shows significant deviation from the General Population value. Yet we have to notice that statistically the numbers in the highest and lowest grades of cleanliness are too few to give certain results. There is also a noteworthy and continuous *decrease* in negative refraction as the homes get dirtier, which may be mere chance on our figures, or may be worth pursuing on more ample material.

If we take all refractions without regard to sign, then the mean of the Very Good and Good homes takes the value − ·1841, and of the Fair and Poor homes the value + ·2225, or a total change of about ·4 of a dioptre. This suggests applying the biserial method with a division between Good and Fair, and we find:

$$r_b = -\cdot 1429 \pm \cdot 0376.$$

A fourfold table with the divisions between Good and Fair and 0·00 and 0·75 dioptres, i.e.

	Very Good, Good	Fair, Poor and Very Poor	Totals
+ 0·75 D. and over	89	134	223
0·00 D. and under	245	284	529
Totals	334	418	752

led to:

$$r_t = -\cdot 0982 \pm \cdot 0406.$$

Although this is hardly significant it at least confirms the sign of r_b, and thus we see there is a slight tendency for boys from the cleaner homes to have negative refraction. This is in accordance with our result of the previous section where we found a redundancy of myopes in the large class of Good home cleanliness. We trust that no reader will suppose that we suggest§ that cleanliness in the home produces myopia! What the result shows is that dirty homes, which are indicative of parental neglect, are not in themselves a source of myopia.

(*d*) *Cleanliness of Home and Corneal Refraction.* Table CCLXXVIII gives the data for *A* and *B* only.

Unfortunately the numbers are very small and the only correlational method that could be satisfactorily applied seemed to be the biserial. From this, with the division between Good and Fair, we find:

$$r_b = +\cdot 0595 \pm \cdot 0649,$$

or the correlation is insignificant, although it points in the same direction as for General Refraction.

* Zero refraction is excluded from both positive and negative refractions.

† Standard Deviations: all refractions = 1·5772 D.; positive refractions = 1·2343 D.; negative refractions = 1·9855 D.

‡ The division into positive and negative general refractions is we think from the physiological and also the anthropometric side extremely questionable, because the choice of zero refraction appears to be so arbitrary. We have simply followed current and convenient practice.

§ A more reasonable suggestion to account for this small association of myopia and the cleaner homes would be that these are the better homes where the boys are kept from the streets and rendered more studious. We shall investigate this suggestion from other aspects later.

Table CCLXXVIII. *Cleanliness of Home and Corneal Refraction (A and B only).*

Corneal Refraction in Dioptres

Cleanliness Grades	38·125	..	40·125	40·625	41·125	41·625	42·125	42·625	43·125	43·625	44·125	44·625	45·125	45·625	46·125	46·625	47·125	Totals
Very Good	—	..	—	—	—	—	—	2	4	5	8	1	2	—	—	—	—	22
Good	—	..	3	—	—	1	5	12	10	19	17	9	7	6	8	2	1	100
Fair	1	..	3	1	5	6	7	9	9	9	15	14	10	8	6	1	—	104
Poor and Very Poor	—	..	2	1	1	2	—	2	4	4	2	6	8	1	5	1	1	40
Totals	1	..	8	2	6	9	12	25	27	37	42	30	27	15	19	4	2	266

The means of the arrays are as follows:

Cleanliness Grade	Corneal Refraction in Dioptres	
Very Good	43·807 ± ·216	43·924 ± ·092
Good	43·950 ± ·101	
Fair	43·654 ± ·099	43·781 ± ·084
Poor and Very Poor	44·113 ± ·160	
General Population*:	43·847 ± ·062	

It is clear that none of these means presents a really significant difference, and accordingly if general refraction be associated with home conditions, corneal refraction does not sensibly contribute to that association.

(*e*) *Cleanliness of Home and General Astigmatism.* The following table provides our results:

Table CCLXXIX. *Cleanliness of Home and General Astigmatism.*

Astigmatism in Dioptres

Cleanliness Grade	+ 3·00	+ 2·25	+ 1·50	+ 0·75	0·00	− 0·75	− 1·50	− 2·25	− 3·00	− 3·75	−4·50	− 5·25	Totals
Very Good	—	—	2	1·5	23	8·5	—	1	—	—	—	—	36
Good	—	—	1·5	18	218	38	6·5	11	1	4	—	—	298
Fair	0·5	1·5	—	11·5	238	41·5	11	13·5	2·5	2	3	1	326
Poor and Very Poor	—	—	—	7	75	6	2	1	1	—	—	—	92
Totals	0·5	1·5	3·5	38	554	94	19·5	26·5	4·5	6	3	1	752

First dividing between Good and Fair we calculated the correlation coefficient by the biserial method. It gave the quite non-significant value:

$$\dot{r}_b = \cdot 0126 \pm \cdot 0389,$$

this being based on disregard of the sign of the astigmatism. If we turn to array-means, we find:

Cleanliness Grades	Astigmatism in Dioptres: Without regard to Sign	With regard to Sign
Very Good	·3542 ± ·0826	− ·1250 ± ·0783
Good	·3247 ± ·0287	− ·2189 ± ·0272
Fair	·3842 ± ·0275	− ·3014 ± ·0260
Poor and Very Poor	·1957 ± ·0517	− ·1087 ± ·0490
General Population†:	·3361 ± ·0181	− ·2379 ± ·0171

Only one of these values differs by as much as 2·5 times the probable error from one or other of the General Population means. If this result be considered significant we should have to conclude that there was least astigmatism in the dirtiest homes. We think it safest to conclude that on our data there is no sign of association between astigmatism and a dirty environment.

(*f*) *Cleanliness of Home and Corneal Astigmatism.* It remains to check our results for General Astigmatism by considering Corneal Astigmatism in some detail. We shall discuss Corneal

* Standard Deviation: 1·5023 D.

† Standard Deviations: without regard to sign = ·7348 D.; with regard to sign = ·6969 D.

Astigmatism independently of its sign, because we have now learnt from experience that the higher associations are found by disregarding sign. We shall, however, consider separately the data determined by *A*, *B* and *C* and again by *A* and *B* alone. We were at first inclined to drop *C*'s observations with the ophthalmometer altogether as we were more satisfied with the accuracy of *A* and *B*, but there is such a paucity of available material when we drop *C* that we retain his data*. As we shall see there is no difference in the final conclusion on the two series.

Table CCLXXX. *Cleanliness of Home and Corneal Astigmatism.*

Corneal Astigmatism in Dioptres

Cleanliness Grades	*A*, *B* and *C*'s Observations												
	− 2·25	− 1·50	− 0·75	0·00	+ 0·75	+ 1·50	+ 2·25	+ 3·00	+ 3·75	+ 4·50	+ 5·25	+ 6·00	Totals
Very Good	—	2	—	11	18	7	5	1	—	—	—	—	44
Good	—	2	5	156	113	17	20	3	3	—	2	1	322
Fair	1	1	5·5	154	129·5	32	17	7	4	3	2	—	356
Poor and Very Poor	—	2	3	48	45	5	1	2	—	—	—	—	106
Totals	1	7	13·5	369	305·5	61	43	13	7	3	4	1	828

Cleanliness Grades	*A* and *B*'s Observations										
	− 1·50	− 0·75	0·00	+ 0·75	+ 1·50	+ 2·25	+ 3·00	+ 2·75	+ 4·50	+ 5·25	Totals
Very Good	2	—	1	14	3	1	1	—	—	—	22
Good	1	5	32	48	3	7	—	3	—	1	100
Fair	—	5	26	46	11	8	2	2	2	2	104
Poor and Very Poor	2	3	8	24	2	1	—	—	—	—	40
Totals	5	13	67	132	19	17	3	5	2	3	266

Applying the biserial method to these tables and paying no attention to sign, we obtain:

For *A*, *B* and *C*'s observations: $r_b = -\ {\cdot}0038 \pm {\cdot}0371$,

For *A* and *B*'s observations: $r_b = \ {\cdot}0683 \pm {\cdot}0647$.

Both these series of observations lead to non-significant associations, and thus confirm the result already reached for General Astigmatism.

If we turn to the means of the arrays we find the following values:

Grades of Home Cleanliness	Mean Astigmatism without regard to Sign: *A*, *B* and *C*'s Data	Mean Astigmatism without regard to Sign: *A* and *B*'s Data only
Very Good	·9375 ± ·0878	1·0568 ± ·1348
Good	·6172 ± ·0324	·7800 ± ·0632
Fair	·7058 ± ·0309	1·0168 ± ·0620
Poor and Very Poor	·5165 ± ·0566	·7125 ± ·1000
General Population†:	·6594 ± ·0202	·8853 ± ·0388

Not one of the results for *A* and *B*'s data reaches significance; of those for *A*, *B* and *C* together the first and the last approach significance. But they amount to saying that the boys from homes of very good cleanliness have most and those from homes of poor and very poor cleanliness have least Corneal Astigmatism! This, as far as the latter statement is concerned, confirms our result for General Astigmatism.

To sum up: the environmental factor Cleanliness of Home has practically no association with ocular characters; the trifling relationship found between those characters and a dirty environment, although of no importance, seems to indicate that boys with the worst sight come from the cleaner and therefore better homes.

(iv) *Lighting of Rooms and Ocular Characters.*

(*a*) *Lighting*‡ *of Rooms and Acuity of Vision* (*Binocular*). For the special eye examination we have only 377 cases providing the following table:

* See *Annals of Eugenics*, Vol. II, pp. 117, 133, 156, 161 and 305.

† Standard Deviations: *A*, *B* and *C*'s data ·8636 D.; *A* and *B*'s data ·9372 D.

‡ For remarks on appreciation of lighting, see p. 109 of the first part of this memoir.

Table CCLXXXI. *Lighting of Rooms and Acuity of Vision (Binocular).*

Acuity of Vision

Grades of Lighting	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	Totals
Very Good	—	2	1	1	7	5	—	—	1	1	—	1	19
Good	3	1	29	51	35	16	17	12	6	3	1	1	175
Fair	—	—	20	45	26	13	11	13	2	4	2	2	138
Poor and Very Poor	—	—	5	18	11	5	3	1	—	2	—	—	45
Totals	3	3	55	115	79	39	31	26	9	10	3	4	377

The difficulty here is the paucity of entries under the extreme grades. The biserial method seemed the most appropriate and dividing between Good and Fair we found:

$$r_b = + \cdot 0116 \pm \cdot 0546,$$

showing no significance in the association.

For the means of the arrays we have:

Lighting Categories	Means of Arrays
Very Good	·8289 ± ·0511
Good	·9075 ± ·0169
Fair	·8815 ± ·0190
Poor and Very Poor	·9462 ± ·0332
General Population*:	·9021 ± ·0115

There is accordingly no significance in any of these means, and we conclude that the lighting of the home is not associated with visual acuity. As we have said, there is no significance in the results, but as they stand (without regard to the probable errors) the boys with best vision come from the worst lighted homes and those with the worst vision from the best lighted homes!

Table CCLXXXII. *Refraction Class and Lighting of Home.*

Refraction Class

Grades of Lighting	Emmetropic	Hypermetropic	Hypermetropic Astigmatism	Mixed Astigmatism	Myopic Astigmatism	Myopia	Totals
Very Good	21	5	1	—	3	10	40
Good	213	34	26	5	16	56	350
Fair	160	10	27	2	9	48	256
Poor and Very Poor	65	5	3	2	4	9	88
Totals	459	54	57	9	32	123	734

(*b*) *Lighting of Rooms and Refraction Class.* Proceeding by mean square contingency we found:

$$\phi'^2 = \cdot 034{,}208, \qquad \bar{\phi}^2 = \cdot 031{,}335 \pm \cdot 006{,}576,$$

and accordingly there is no significant association.

The most contributory term to ϕ'^2 is due to a slight redundancy of hypermetropic boys from homes with Fair lighting: compare our p. 13.

Next we tried a fourfold table thus:

	Emmetropic	Non-emmetropic	Totals
Very Good and Good	234	156	390
Fair, Poor and Very Poor	225	119	344
Totals	459	275	734

* Standard Deviation = ·3305.

This led to: $$r_t = -\cdot 0893 \pm \cdot 0397,$$
a scarcely significant result but indicating that the normal sighted came rather from the homes with poorer lighting.

(*c*) *Lighting of Rooms and General Refraction.* The following table gives the requisite data:

Table CCLXXXIII. *Lighting of Rooms and General Refraction.*

General Refraction in Dioptres

Grades of Lighting	+ 6·75	+ 6·00	+ 5·25	+ 4·50	+ 3·75	+ 3·00	+ 2·25	+ 0·75	0·00	− 0·75	− 1·50	− 1·25	− 2·25	− 3·00	− 3·75	− 4·50	− 5·25	− 6·00	− 6·75	..	− 12·75	..	− 15·75	Totals
Very Good	—	—	—	—	1	1	1	—	15	9	9	—	—	—	2	—	—	—	—	..	1	..	1	40
Good	—	2	2	1	2	3·5	18·5	12	74·5	168	29	20	11	2·5	1	—	1	—	2	..	—	..	—	350
Fair	1	1	2	2	8	1	7	5	41	135	25·5	6·5	11	4	3	—	4	—	1	..	—	..	—	258
Poor and V. Poor	—	—	—	—	—	—	2	2	13	57	7	2	2	—	—	—	—	—	1	..	—	..	—	86
Totals	1	3	4	3	11	5·5	28·5	19	143·5	369	70·5	28·5	24	6·5	6	—	5	—	4	—	1	—	1	734

The biserial method, with dichotomy between Good and Fair, again seemed the appropriate process and we found:
$$r_b = \cdot 0176 \pm \cdot 0392,$$
a non-significant result.

We next investigated the array-means:

Grades of Lighting	Array-Means in Dioptres
Very Good	$-\cdot 5625 \pm \cdot 1697$
Good	$+\cdot 1543 \pm \cdot 0575$
Fair	$+\cdot 0567 \pm \cdot 0668$
Poor and Very Poor	$-\cdot 0262 \pm \cdot 1157$
General Population*:	$+\cdot 0598 \pm \cdot 0396$

Only the first of these can be considered to differ significantly from the population value. It would indicate that the boys from the best lighted homes have on the average half a dioptre more myopia than the boys from the general population.

(*d*) *Lighting of Rooms and Corneal Refraction* (*A and B*).

Table CCLXXXIV. *Lighting of Rooms and Corneal Refraction.*

Central Values of Corneal Refraction in Dioptres

Grades of Lighting	38·125	38·625	39·125	39·625	40·125	40·625	41·125	41·625	42·125	42·625	43·125	43·625	44·125	44·625	45·125	45·625	46·125	46·625	47·125	Totals
Very Good	—	—	—	—	—	—	—	2	2	2	4	5	4	7	2	3	3	—	—	34
Good	1	—	—	—	2	2	2	4	6	15	12	17	21	11	17	9	7	1	1	128
Fair	—	—	—	—	6	—	3	1	3	6	7	7	7	6	6	1	6	1	—	60
Poor and Very Poor	—	—	—	—	—	—	1	2	1	1	2	5	8	4	2	2	3	2	1	34
Totals	1	—	—	—	8	2	6	9	12	24	25	34	40	28	27	15	19	4	2	256

In this case we have dealt only with *A* and *B*'s records. The means of the arrays are as follows:

Grades of Lighting	Means of Corneal Refraction in Dioptres
Very Good	$44\cdot 051 \pm \cdot 177$
Good	$43\cdot 840 \pm \cdot 091$
Fair	$43\cdot 525 \pm \cdot 133$
Poor and Very Poor	$44\cdot 272 \pm \cdot 177$
General Population†:	$43\cdot 852 \pm \cdot 064$

* Standard Deviation = 1·5911 D.

† Standard Deviation = 1·5265 D.

None of the differences of the means can be considered as significant.

Proceeding to a biserial coefficient of correlation, we find:

$$r_b = -\cdot 0360 \pm \cdot 0687,$$

which is again non-significant. Thus Corneal Refraction confirms General Refraction in giving no indication of the lighting of the home being a source of refractional errors.

(*e*) *Lighting of Rooms and General Astigmatism.* The necessary data are provided in the following table:

Table CCLXXXV. *Lighting of Rooms and General Astigmatism.*

General Astigmatism in Dioptres

Grades of Lighting	+ 3·00	+ 2·25	+ 1·50	+ 0·75	0·00	− 0·75	− 1·50	− 2·25	− 3·00	− 3·75	− 4·50	− 5·25	Totals
Very Good	—	—	—	2·5	30	4·5	1	2	—	—	—	—	40
Good	0·5	0·5	2·5	16	255	47	9·5	14·5	1·5	1	1	1	350
Fair	—	1	—	12·5	189	32·5	7	6	3	5	2	—	258
Poor and Very Poor	—	—	—	6	68	7	1	4	—	—	—	—	86
Totals	0·5	1·5	2·5	37	542	91	18·5	26·5	4·5	6	3	1	734

We first deal with the array-means:

Array-Means Astigmatism in Dioptres

Grades of Lighting	Disregarding Sign	Regarding Sign
Very Good	·2813 ± ·0783	− ·1875 ± ·0790
Good	·3386 ± ·0265	− ·2336 ± ·0267
Fair	·3750 ± ·0308	− ·2849 ± ·0311
Poor and Very Poor	·2355 ± ·0534	− ·1308 ± ·0539
General Population*	·3362 ± ·0183	− ·2371 ± ·0185

None of these means is significant and the only approach to significance occurs in the case of the boys from the worst lighted homes who are the least astigmatic! Applying the biserial process to the data disregarding sign we find:

$$r_b = + \cdot 0030 \pm \cdot 0392.$$

Clearly General Astigmatism is not in any way associated with the bad lighting of the home.

(*f*) *Lighting of Rooms and Corneal Astigmatism.* As usual we have endeavoured to ascertain whether the results for Corneal confirm those for General Astigmatism. We have dealt with the observations of A, B and C, and again A and B alone. We have not thought it needful to work the tables paying attention to sign, but have obtained the correlations on the assumption that we may class the astigmatisms with and against the rule together.

Table CCLXXXVI. *Lighting of Rooms and Corneal Astigmatism.*

Corneal Astigmatism in Dioptres

Grades of Lighting	*A*, *B* and *C*'s Observations													*A* and *B*'s Observations										
	− 2·25	− 1·50	− 0·75	0·00	+ 0·75	+ 1·50	+ 2·25	+ 3·00	+ 3·75	+ 4·50	+ 5·25	+ 6·00	Totals	− 1·50	− 0·75	0·00	+ 0·75	+ 1·50	+ 2·25	+ 3·00	+ 3·75	+ 4·50	+ 5·25	Totals
Very Good	—	—	1	19	17	4	3	—	—	—	—	—	44	—	1	12	15	3	3	—	—	—	—	34
Good	—	4	8·5	168	135·5	27	25	6	4	—	3	1	382	3	8	32	62	9	7	1	3	—	3	128
Fair	1	3	2	125	108	23	13	5	2	3	1	—	286	2	2	11	32	2	6	1	2	2	—	60
Poor and Very Poor	—	—	2	50	35	6	—	2	1	—	—	—	96	—	2	10	16	5	—	1	—	—	—	34
Totals	1	7	13·5	362	295·5	60	41	13	7	3	4	1	808	5	13	65	125	19	16	3	5	2	3	256

* Standard Deviation = ·7343 D. disregarding sign; = ·7410 D. regarding sign.

We now turn to the means of the arrays:

Corneal Astigmatism

Grades of Lighting	*A*, *B* and *C*'s Observations	*A* and *B*'s Observations
Very Good	·5966 ± ·0881	·6838 ± ·1097
Good	·6950 ± ·0299	·9226 ± ·0570
Fair	·6792 ± ·0346	1·0750 ± ·0826
Poor and Very Poor	·5000 ± ·0597	·7059 ± ·1097
General Population*	·6627 ± ·0206	·8906 ± ·0400

None of these means having regard to their probable errors can be considered to diverge significantly from the means of the General Population. The nearest approach to significance occurs in the *A*, *B* and *C* observations where the boys from the badly lighted homes show a minimum of Corneal Astigmatism, but even these only differ by one-sixth of a dioptre from the general population of Jewish boys.

To obtain a general measure of the association we apply as before the biserial method with the dichotomy between Good and Fair. We find:

For *A*, *B* and *C*'s observations: $r_b = \cdot 0278 \pm \cdot 0297$,
For *A* and *B*'s observations only: $r_b = \cdot 0523 \pm \cdot 0688$.

We conclude therefore that the results for Corneal Astigmatism confirm those for General Astigmatism and indicate that the lighting of the home is not a factor which is productive of astigmatism.

Summary for Lighting of Rooms. We have not succeeded in finding any relation between the lighting conditions of the home and ocular characters of the children. The rooms may look out on to a close blank wall, face in a narrow court another house, or look across a broad street; there appears to be no influence of such conditions on the boys' eyesight, and yet many of these boys appear to have long hours of homework, and others read much at home.

(v) *Ventilation of Rooms and Ocular Characters.*

(*a*) *Ventilation and Acuity of Vision.* It has been assumed frequently that fresh air is as important for general physical health as light, and it is therefore of interest to investigate whether its absence has any effect on the sensory organs, in particular on the eyes and sight. We consider first Acuity of Vision and Ventilation. The following table provides our data on this point:

Table CCLXXXVII. *Ventilation of Home and Acuity of Vision* (*Binocular*).

Acuity of Vision

Grades of Ventilation	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	Totals
Very Good	—	—	—	—	5	2	—	2	1	—	—	—	10
Good	1	1	24	36	23	16	10	4	4	3	1	1	124
Fair	1	2	23	43	38	14	14	13	2	6	2	2	160
Poor and Very Poor	1	—	9	39	14	6	8	7	2	1	—	1	88
Totals	3	3	56	118	80	38	32	26	9	10	3	4	382

Examining first the array-means we have:

Grades of Ventilation	Array-Means Vision	
Very Good	·7040 ± ·0703	·9150 ± ·0192
Good	·9675 ± ·0200	
Fair	·8831 ± ·0176	
Poor and Very Poor	·9267 ± ·0237	
General Population†:	·9043 ± ·0114	

* Standard Deviation: for *A*, *B* and *C*'s records = ·8667 D.; for *A* and *B*'s records = ·9480 D.

† Standard Deviation = ·3298.

Only the first two of these show significant differences from the mean; if combined there is no significance. If we keep them apart, it would indicate that homes with very good ventilation produced boys with the lowest mean acuity of vision!

Applying the biserial method with division between Good and Fair we find:

$$r_b = + \cdot 0306 \pm \cdot 0441.$$

This is quite non-significant, and as the array-means show no orderly system, we may safely conclude that acuity of vision is not seriously affected by poor ventilation.

(*b*) *Ventilation of Rooms and Refraction Class.* The following table provides the requisite data:

Table CCLXXXVIII. *Ventilation of Home and Refraction Class.*

Refraction Class

Grades of Ventilation	Emmetropia	Hypermetropia	Hypermetropic Astigmatism	Mixed Astigmatism	Myopic Astigmatism	Myopia	Totals
Very Good	11	4	—	1	1	7	24
Good	172	12	19	2	11	40	256
Fair	189	32	23	2	19	45	310
Poor and Very Poor	101	4	16	4	2	29	156
Totals	473	52	58	9	33	121	746

This table was first discussed by the method of mean square contingency with the result that:

$$\phi'^2 = \cdot 045{,}902, \qquad \bar{\phi}^2 = \cdot 030{,}831 \pm \cdot 006{,}580.$$

Accordingly ϕ'^2 differs from $\bar{\phi}^2$, the mean value for no association, by about 2·3 times its probable error. It cannot therefore definitely be asserted that any association exists. In the homes with Very Good ventilation there is some redundancy of boys with hypermetropia and myopia, but the total number of such boys is too small to give any secure footing for a general statement. In the boys with "fairly" ventilated homes there is a redundancy of hypermetropia, while the boys from badly ventilated homes have a deficiency of hypermetropia, a redundancy of all forms of astigmatism but no excess of myopia. The results are somewhat similar to those for Cleanliness of Home, but the indications are too slender to stress, for the probable errors indicate that these small variations may be merely the results of random sampling. Making a fourfold table:

Refraction

Ventilation	Normal	Abnormal	Totals
Very Good and Good	183	97	280
Fair, Poor and Very Poor	290	176	466
Totals	473	273	746

we found for the tetrachoric coefficient of correlation:

$$r_t = \cdot 0515 \pm \cdot 0403,$$

a completely non-significant result.

The following percentage results indicate how little significance Ventilation has for Refraction:

	Emmetropia	Hypermetropia	Astigmatism*	Myopia
Well Ventilated Homes	65·4	5·7	12·1	16·8
All Homes	63·4	7·0	13·4	16·2
Badly Ventilated Homes	62·3	7·7	14·2	15·8

* All types of astigmatism.

And again, arranging in a different manner, we have:

	Hypermetropia and Hypermetropic Astigmatism	Emmetropia	Myopia and Myopic Astigmatism
Well Ventilated Homes	13·0	65·4	21·6
All Homes	15·3	63·4	21·3
Badly Ventilated Homes	16·7	62·3	21·0

The percentages for well and ill-ventilated homes in no case differ significantly from those for all homes. We note the slight redundancy of hypermetropia in the ill-ventilated homes and the slighter defect of myopia in the badly ventilated homes. Even if these deviations were significant, we should not attribute them directly to the ventilation.

(*c*) *Ventilation of Rooms and General Refraction.* We have the following table:

Table CCLXXXIX. *Ventilation of Rooms and General Refraction.*

General Refraction in Dioptres

Grades of Ventilation	+ 6·75	+ 6·00	+ 5·25	+ 4·50	+ 3·75	+ 3·00	+ 2·25	+ 1·50	+ 0·75	0·00	− 0·75	− 1·50	− 2·25	− 3·00	− 3·75	− 4·50	− 5·25	− 6·00	− 6·75	..	− 12·75	..	− 15·75	Totals
Very Good	—	—	—	—	1	1	—	—	9	7	4	2	—	—	—	—	—	—	—	..	—	..	—	24
Good	—	2	—	1	4·5	3·5	6·5	6	46	138	24·5	9·5	5·5	—	3	—	2	—	2	..	1	..	1	256
Fair	—	1	2	1	3	1	16	10	68	146·5	27	11·5	12	3	3	—	3	—	2	..	—	..	—	310
Poor and V. Poor	1	—	2	2	2	—	7	3	22	87	16·5	6·5	5	2	—	—	—	—	—	..	—	..	—	156
Totals	1	3	4	4	10·5	5·5	29·5	19	145	378·5	72	29·5	22·5	5	6	—	5	—	4	..	1	..	1	746

Dividing between Good and Fair Ventilation a biserial coefficient of correlation was found:

$$r_b = -\cdot 0447 \pm \cdot 0401,$$

a result non-significant.

Investigating the means of the arrays we found:

Grades of Ventilation	Array-Means in Dioptres
Very Good	+ ·3125 ± ·2172
Good	− ·0264 ± ·0665
Fair	+ ·0750 ± ·0604
Poor and Very Poor	+ ·1995 ± ·0852
General Population*:	+ ·0739 ± ·0390

We see again that not a single array-mean differs significantly from that of the General Population.

We will now confirm these results from *A* and *B*'s observations on Corneal Refraction.

(*d*) *Ventilation of Rooms and Corneal Refraction.* The material is contained in the following table:

Table CCXC. *Ventilation of Rooms and Corneal Refraction* (*A and B only*).

Corneal Refraction in Dioptres

Grades of Ventilation	38·125	.....	40·125	40·625	41·125	41·625	42·125	42·625	43·125	43·625	44·125	44·625	45·125	45·625	46·125	46·625	47·125	Totals
Very Good	—	..	1	—	—	1	—	—	1	2	2	3	3	2	3	—	—	18
Good	—	..	1	1	2	2	4	13	12	20	18	12	9·5	5	5·5	1	—	106
Fair	1	..	5	—	2	3	4	9	12	12	16	9	11	7	7	2	—	100
Poor and Very Poor	—	..	1	1	2	3	4	3	2	3	5	3	4	2	5	1	1	40
Totals	1	..	8	2	6	9	12	25	27	37	41	27	27·5	16	20·5	4	1	264

* Standard Deviation = 1·5779 D.

Proceeding by the biserial method, dichotomy between Good and Fair, we find:

$$r_b = + \cdot 0507 \pm \cdot 0651,$$

another non-significant result.

Calculating the array-means we have:

Grades of Ventilation	Array-Means in Dioptres
Very Good	$44 \cdot 4028 \pm \cdot 2396$
Good	$43 \cdot 8278 \pm \cdot 0987$
Fair	$43 \cdot 7850 \pm \cdot 1016$
Poor and Very Poor	$43 \cdot 8000 \pm \cdot 1607$
General Population*:	$43 \cdot 8466 \pm \cdot 0626$

None of these is really significant, the greatest difference being that of the Very Good and the General Population, which $= \cdot 5562 \pm \cdot 2476$, or the difference is about 2·2 times its probable error. If this had any significance it would indicate that as far as Corneal Refraction is concerned, boys from the well-ventilated homes tended to be slightly myopic, which agrees with the negative correlation found for General Refraction.

(*e*) *Ventilation of Rooms and General Astigmatism.* The following table contains our data:

Table CCXCI. *Ventilation of Rooms and General Astigmatism.*

General Astigmatism in Dioptres

Grades of Ventilation	+ 3·00	+ 2·25	+ 1·50	+ 0·75	0·00	− 0·75	− 1·50	− 2·25	− 3·00	− 3·75	− 4·50	− 5·25	Totals
Very Good	—	—	—	3	16	3	—	1	1	—	—	—	24
Good	0·5	0·5	2	14·5	185	33·5	5	9·5	0·5	3	1	1	256
Fair	—	—	1·5	15	226	44	10·5	10	—	3	—	—	310
Poor and Very Poor	—	1	—	5·5	123	11·5	4	6	3	—	2	—	156
Totals	0·5	1·5	3·5	38	550	92	19·5	26·5	4·5	6	3	1	746

Considering only the amount of astigmatism without regard to sign, we find by the biserial method, dichotomy between Good and Fair,

$$r_b = - \cdot 0408 \pm \cdot 0401,$$

a value once more entirely non-significant. Dealing with array-means we have:

Grades of Ventilation	Array-Means in Dioptres
Very Good	$\cdot 4063 \pm \cdot 1008$
Good	$\cdot 3633 \pm \cdot 0309$
Fair	$\cdot 3097 \pm \cdot 0280$
Poor and Very Poor	$\cdot 3365 \pm \cdot 0395$
General Population†:	$\cdot 3368 \pm \cdot 0181$

None of the means here differs significantly from that of the General Population, but if they did we should have to associate the highest grade of astigmatism with the boys from the best ventilated houses.

Lack of ventilation is clearly not associated with General Astigmatism.

We now inquire whether we can confirm this result from our data for Corneal Astigmatism. The records are tabulated below.

(*f*) *Ventilation of Rooms and Corneal Astigmatism.* The table was dealt with by the biserial method, no attention being paid to sign and the dichotomy being between Good and Fair. We found:

$$r_b = + \cdot 0630 \pm \cdot 0300.$$

This result is hardly significant, but it suggests that the matter ought to be pushed further.

* Standard Deviation = 1·5070 D. † Standard Deviation = ·7319 D.

Table CCXCII. *Ventilation of Home and Corneal Astigmatism* (*A*, *B* and *C*).

Corneal Astigmatism in Dioptres

Grades of Ventilation	− 2·25	− 1·50	− 0·75	0·00	+ 0·75	+ 1·50	+ 2·25	+ 3·00	+ 3·75	+ 4·50	+ 5·25	+ 6·00	Totals
Very Good	—	—	—	7	12	3	2	—	2	—	—	—	26
Good	—	3	5·5	124	94·5	18	19	4	2	1	3	—	274
Fair	1	2	3	142	142	26	18	3	—	—	1	—	338
Poor and Very Poor	—	2	5	96	51	14	4	6	3	2	—	1	184
Totals	1	7	13·5	369	299·5	61	43	13	7	3	4	1	822

The array-means are as follows:

Grades of Ventilation	Array-Means in Dioptres
Very Good	·9808 ± ·1147
Good	·6898 ± ·0353
Fair	·6146 ± ·0318
Poor and Very Poor	·6481 ± ·0431
General Population*:	·6588 ± ·0204

Only one array-mean differs significantly from the General Population mean, that for boys coming from homes with Very Good ventilation, and this is nearly three times the probable error of the difference. If we can trust a mean based on 26 individuals, this again indicates that boys from the best ventilated houses are the more astigmatic.

As our whole object in this section is to pursue any trace of a suggestion that environment influences sight, and being somewhat uncertain of *C*'s corneal measurements, we proceed to work out again the material dealing with *A* and *B*'s records only.

Table CCXCII *bis*. *Ventilation of Rooms and Corneal Astigmatism* (*A and B only*).

Corneal Astigmatism in Dioptres

Grades of Ventilation	− 1·50	− 0·75	0·00	+ 0·75	+ 1·50	+ 2·25	+ 3·00	+ 3·75	+ 4·50	+ 5·25	Totals
Very Good	—	—	4	12	—	—	—	2	—	—	18
Good	2	5	24	51	7	9	1	3	1	3	106
Fair	1	3	26	54	8	8	—	—	—	—	100
Poor and Very Poor	2	5	13	13	4	—	1	1	1	—	40
Totals	5	13	67	130	19	17	2	6	2	3	264

This table was worked out (i) paying attention to sign, and (ii) not regarding sign. The systems of means are as follows:

	Array-Means in Dioptres	
Grades of Ventilation	Regarding Sign	Disregarding Sign
Very Good	·9167 ± ·1561	·9167 ± ·1507
Good	·9764 ± ·0643	1·0401 ± ·0621
Fair	·7050 ± ·0662	·7425 ± ·0639
Poor and Very Poor	·6750 ± ·1047	·8438 ± ·1011
General Population†:	·8239 ± ·0408	·8892 ± ·0394

Now although none of these array-means could be considered significantly different from the General Population mean, there is a distinct tendency for higher values of the astigmatism to be associated with the boys from the better ventilated houses, and the badly ventilated houses to provide boys with lower values of astigmatism. We next proceeded to find the biserial coefficient

* Standard Deviation = ·8667 D.

† Standard Deviation: regarding sign = ·9818 D.; disregarding sign = ·9481 D.

of correlation for the two cases and reached the following values, the dichotomy being between Good and Fair*.

Regarding the sign of the astigmatism: $r_b = \cdot 1730 \pm \cdot 0623$,
Disregarding the sign of the astigmatism: $r_b = \cdot 1656 \pm \cdot 0625$.

The first value is 2·8 and the second 2·6 times its probable error. Thus r_b is hardly likely to be due to random sampling from a population in which the true value of the association is zero. The correlation is not of great importance, but it is practically the only one we have found wherein the ventilation of the home may seem to affect the sight. And strange as it may appear, it is not the worse type of home which is associated with the greater intensity of the ocular defect; the boys from that type of home have the more normal sight, and it is the better type of home which has the most astigmatism to show.

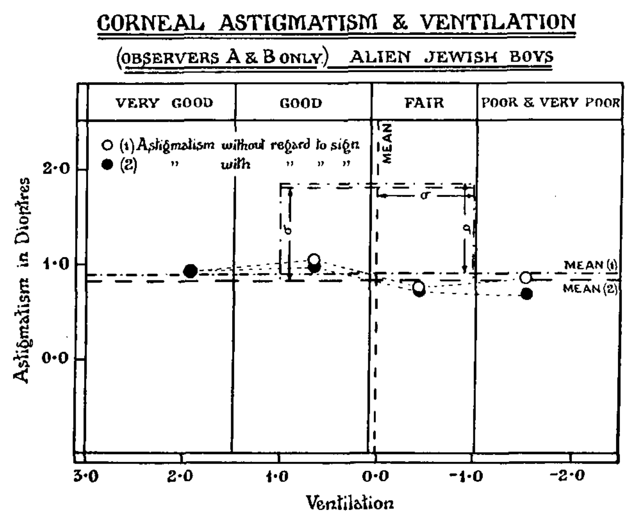

Diagram 131.

Summary. For none of our ocular characters can we assert that bad ventilation is really a source of inferior sight.

(vi) *Crowding and Ocular Characters.*

We pass now to another condition of poverty which is supposed largely to influence the health and possibly the sight of the denizens of small homes, i.e. the state of overcrowding. Our measure of crowding is the number of persons per room calculated in a special manner: see *Annals of Eugenics*, Vol. I, p. 106.

(*a*) *Crowding and Acuity of Vision* (*Binocular*). The following table sums up our data:

Table CCXCIII. *Crowding and Acuity of Vision* (*Binocular*).

Acuity of Vision

"Adults" per room	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	Totals
·45– ·95	—	—	—	1	2	—	2	—	—	—	—	—	5
·95–1·45	1	—	3	15	7	4	5	1	3	—	—	—	39
1·45–1·95	2	—	20	24	26	15	4	7	4	3	1	—	106
1·95–2·45	—	2	16	35	20	9	9	10	—	3	1	1	106
2·45–2·95	—	1	8	21	12	6	9	2	1	1	1	2	64
2·95–3·45	—	—	3	5	5	2	1	1	1	2	1	1	22
3·45–3·95	—	—	1	5	1	1	1	2	—	—	—	—	11
3·95–4·45	—	—	—	2	1	—	—	—	—	—	—	—	3
4·45–4·95	—	—	2	2	—	—	—	—	—	—	—	—	4
4·95–5·45	—	—	—	—	3	—	—	—	—	—	—	—	3
5·45–5·95	—	—	—	—	—	—	—	1	—	—	—	—	1
Totals	3	3	53	110	77	37	31	24	9	9	4	4	364

The constants of this table are as follows:

Mean: "Adults" per Room: 2·1986; Acuity of Vision: ·9007;
Standard Deviation: " " ·7562; " " ·3321;
Product Moment Coefficient of Correlation: $r = -\cdot 0159 \pm \cdot 0353$;
Correlation Ratio, Vision on "Adults" per Room:

$$\eta'^2_{V.p} = \cdot 027{,}762, \qquad \bar{\eta}^2_{V.p} = \cdot 027{,}473 \pm \cdot 008{,}520.$$

* The reader is reminded that "Fair" covers the doubtful ground between "Good" and "Poor" in our classifications, and carries something of the atmosphere, which we appreciate when a person is described as "fairly" clean, or "fairly" honest.

Accordingly we see that $\eta'^2_{V.p}$ is not significant in comparison with $\bar{\eta}^2_{V.p}$, while the correlation coefficient is also non-significant.

Turning to the array-means we have:

Grade of Crowding	Array-Means Vision	
·45–1·45	·8977 ± ·0338	
1·45–1·95	·9128 ± ·0218	
1·95–2·45	·9123 ± ·0218	
2·45–2·95	·8900 ± ·0280	
2·95–3·45	·7759 ± ·0478	·8618 ± ·0338
3·45–5·95	·9477 ± ·0478	
General Population:	·9007 ± ·0117	

It is clear that all the array-means are non-significant as compared with the General Population mean. We cannot trace accordingly any influence of Overcrowding on Acuity of Vision.

(*b*) *Crowding and Refraction Class.* Our data are contained in the following table:

Table CCXCIV. *Crowding and Refraction Class.*

Refraction Class

"Adults" per Room	Emmetropia	Hypermetropia	Hypermetropia Astigmatism	Mixed Astigmatism	Myopic Astigmatism	Myopia	Totals
·45– ·95	10	—	2	—	—	—	12
·95–1·45	60	11	4	2	3	12	92
1·45–1·95	124	18	16	—	7	41	206
1·95–2·45	117	13	15	4	9	38	196
2·45–2·95	88	8	9	2	7	14	128
2·95–3·45	23	1	1	—	3	10	38
3·45–3·95	16	—	7	—	3	2	28
3·95–4·45	6	2	—	—	—	—	8
4·45–4·95	1	—	—	1	—	—	2
4·95–5·45	6	—	—	—	—	—	6
Totals	451	53	54	9	32	117	716

We have tested this table in various ways. First a correlation ratio of "Adults" per Room on Refraction Class was found and gave:

$$\eta'^2_{p.R} = \cdot009{,}504, \qquad \bar{\eta}^2_{p.R} = \cdot006{,}983 \pm \cdot002{,}966.$$

Clearly $\eta'^2_{p.R}$ is not significant having regard to $\bar{\eta}^2_{p.R}$ and its probable error.

We next examined the array-means of the various refraction classes, but none of these array-means shows any really significant divergence from the General Population mean. In fact, the hypermetropic and myopic boys come from houses with less than the average number of "adults" per room. But there is a point worth bearing in mind, the astigmatics of all types come from homes, on the average, more crowded than usual.

Refraction Class	Mean No. of Persons per Room
Emmetropia	2·170 ± ·023
Hypermetropia	1·992 ± ·068
Hypermetropic Astigmatism	2·219 ± ·067
Mixed Astigmatism	2·367 ± ·165
Myopic Astigmatism	2·341 ± ·088
Myopia	2·093 ± ·046
General Population*:	2·158 ± ·0185

Clearly we cannot determine the correlation ratio of Refraction Class on Crowding, as the refraction classes are purely qualitative and arbitrary. But we have determined the mean square contingency. This gave:

$$\phi'^2 = \cdot023{,}697, \qquad \bar{\phi}^2 = \cdot033{,}520,$$

* Standard Deviation = ·7341 persons per room.

or ϕ'^2 is less than the mean square contingency $\bar{\phi}^2$ for no association. There are really no outstanding contributions to ϕ'^2, and we therefore conclude that it is not possible to trace any definite association of Refraction Class with Crowding in the home.

(*c*) *Crowding and General Refraction.* The following table gives our data for General Refraction and Persons per Room:

Table CCXCV. *Crowding and General Refraction.*

General Refraction in Dioptres

"Adults" per Room	+ 6·75	+ 6·00	+ 5·25	+ 4·50	+ 3·75	+ 3·00	+ 2·25	+ 1·50	+ 0·75	0·00	− 0·75	− 1·50	− 2·25	− 3·00	− 3·75	− 4·50	− 5·25	− 6·00	− 6·75	..	− 12·75	..	− 15·75	Totals
·45– ·95	—	—	—	—	—	—	2	—	1	9	—	—	—	—	—	—	—	—	—	..	—	..	—	12
·95–1·45	—	—	2	—	1	1	1	5	28	40	6	4	2	—	2	—	—	—	—	..	—	..	—	92
1·45–1·95	—	—	—	3	4	1	9	7	35	103	26	10	4	2	—	—	1	—	1	..	—	..	—	206
1·95–2·45	1	2	1	—	2	1	10	5	37	91·5	24·5	6	7	2	2	—	1	—	3	..	—	..	—	196
2·45–2·95	—	—	—	—	2·5	0·5	0·5	1	31·5	71	6	5·5	3·5	—	2	—	2	—	—	..	1	..	1	128
2·95–3·45	—	—	—	—	—	—	—	1	7	17	4	2	4	2	1	—	—	—	—	..	—	..	—	38
3·45–3·95	—	—	1	—	1	—	5	—	—	16	3	—	1	—	1	—	—	—	—	..	—	..	—	28
3·95–4·45	—	—	—	—	—	—	1	1	—	6	—	—	—	—	—	—	—	—	—	..	—	..	—	8
4·45–4·95	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	..	—	..	—	2
4·95–5·45	—	—	—	—	—	—	—	—	3	3	—	—	—	—	—	—	—	—	—	..	—	..	—	6
Totals	1	2	4	3	10·5	3·5	28·5	20	144·5	356·5	69·5	27·5	21·5	6	8	—	4	—	4	..	1	..	1	716

Worked out by the product moment method we find:

$$r = -\cdot 0509 \pm \cdot 0251,$$

which would mean that the higher negative refraction would come from the less crowded homes. Actually it is non-significant.

Turning to the array-means for different grades of crowding we find the following results:

Grade of Crowding	Mean Refraction in Dioptres
0·7	+ ·437 ± ·303
1·2	+ ·277 ± ·110
1·7	+ ·131 ± ·073
2·2	+ ·052 ± ·075
2·7	− ·234 ± ·093
3·2	− ·474 ± ·170
3·7	+ ·429 ± ·199
4·6	+ ·469 ± ·263
General Population*:	+ ·055 ± ·039

The two negative array-means differ significantly from the general mean.

We have a continuous fall in refraction from the 0·7 "adults" per room to 3·2 "adults" per room. But then for the small frequencies at the overcrowded homes we come upon large positive values upsetting the general orderliness. Does this high positive refraction for the least and the most crowded homes indicate anything of real importance?

The correlation ratio of Refraction on "Adults" per Room was found, and yielded:

$$\eta'^2_{R.p} = \cdot 019{,}909,$$

while

$$\bar{\eta}^2_{R.p} = \cdot 009{,}776 \pm \cdot 003{,}504.$$

Thus η'^2 differs from $\bar{\eta}^2$ by about 2·9 times the probable error of the latter, and it seems likely that there exists some association between General Refraction and Crowding. It is, however, very difficult to interpret how few "adults" and many "adults" per room should both lead

* Standard Deviation = 1·5776 D. (For persons per room the mean = 2·158 and the Standard Deviation = ·7340.)

to the same type of abnormal refraction. To test whether any light would be thrown on the matter if we regarded all deviations from zero refraction whether positive or negative as defects, we neglected the sign of the refraction and obtained the following results:

Grade of Crowding	Array-Means of Refraction Disregarding Sign
0·7	·437 ± ·268
1·2	·766 ± ·097
1·7	·728 ± ·065
2·2	·890 ± ·066
2·7	·814 ± ·082
3·2	·829 ± ·151
3·7 } 4·04	1·018 ± ·176 } ·818 ± ·134
4·64 }	·469 ± ·232 }

Looked at from this standpoint, i.e. without regard to sign, we see an increasing refraction from 0·7 persons per room upwards with deviations quite reasonable owing to the small frequency of some of the terminal arrays. The correlation coefficient is, however, only

$$r = + \cdot 0561 \pm \cdot 0250,$$

hardly significant, and if so, of no importance. It is possibly better to account for this anomaly by reference to the Refraction Class Contingency Table, where we find two of the chief contributions to ϕ'^2 are made by a redundancy of myopes in the homes of ·45–1·45 persons and in those of 2·45–2·95 persons per room. The better homes and the worse homes may have different causes producing myopia.

(*d*) *Crowding and Corneal Refraction.* We have here limited our data to the observations of *A* and *B*.

Table CCXCVI. *Crowding and Corneal Refraction* (*A and B only*).

Corneal Refraction in Dioptres

"Adults" per Room	38·125	..	40·125	40·625	41·125	41·625	42·125	42·625	43·125	43·625	44·125	44·625	45·125	45·625	46·125	46·625	47·125	47·625	Totals
·45– ·95	—	..	—	—	—	—	—	—	1	1	—	2	—	—	—	—	—	—	4
·95–1·45	1	..	1	—	3	2	2	3	4	14	8	2	1	3	—	—	—	—	44
1·45–1·95	—	..	3	2	—	2	3	10	10	10	14	13	11	8	11	2	—	1	100
1·95–2·45	—	..	1	—	2	—	3	10	8	4	13	7	6	2	4	2	1	1	64
2·45–2·95	—	..	—	—	—	2	1	2	4	6	4	5	2	1	2	—	1	—	30
2·95–3·45	—	..	3	—	—	—	2	1	1	1	3	1	4	—	—	—	—	—	16
3·45–3·95	—	..	—	—	1	2	1	—	—	—	—	—	—	—	—	—	—	—	4
3·95–4·45	—	..	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	2
4·45–4·95	—	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4·95–5·45	—	..	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	2
5·45–5·95	—	..	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	2
Totals	1	..	8	2	6	8	12	26	29	37	42	30	27	15	17	4	2	2	268

Worked by the product moment method the correlation coefficient

$$r = + \cdot 0302 \pm \cdot 0412,$$

and is non-significant.

We may now examine the mean Corneal Refraction for each grade of Crowding.

Grade of Crowding	Array-Means in Dioptres
1·16	43·344 ± ·148
1·7	44·085 ± ·102
2·2	43·984 ± ·128
2·7	43·992 ± ·187
3·2	43·219 ± ·256
4·5	43·425 ± ·323
General Population*:	43·856 ± ·062

* Standard Deviation = 1·5161 D. (Mean No. of "adults" per room = 2·0284; Standard Deviation for "adults" per room = ·6032.)

It will be noted that it is in the least and in the most crowded homes that the lesser Corneal Refraction is found, and here the differences begin to make an approach to significance. This corresponds with what we have seen of General Refraction, where the least and the most crowded homes had the highest positive refraction. At the same time we found that the correlation ratio of Refraction on Crowding was just significant. If we apply the same test here we find:

$$\eta'^2_{CR.p} = \cdot 043{,}496, \qquad \bar{\eta}^2_{CR.p} = \cdot 018{,}656 \pm \cdot 007{,}930,$$

which suggests that $\eta'^2_{CR.p}$ is definitely significant. We have then

$$\eta'_{CR.p} = \cdot 2086.$$

Diagram 132 gives the result graphically for both General and Corneal Refraction, which here as elsewhere have tended to show similar results. We must conclude that there is some slight association between Refraction and Crowding, probably arising from more than one cause and indirectly.

(*e*) *Crowding and General Astigmatism.* The data required are provided in the following table:

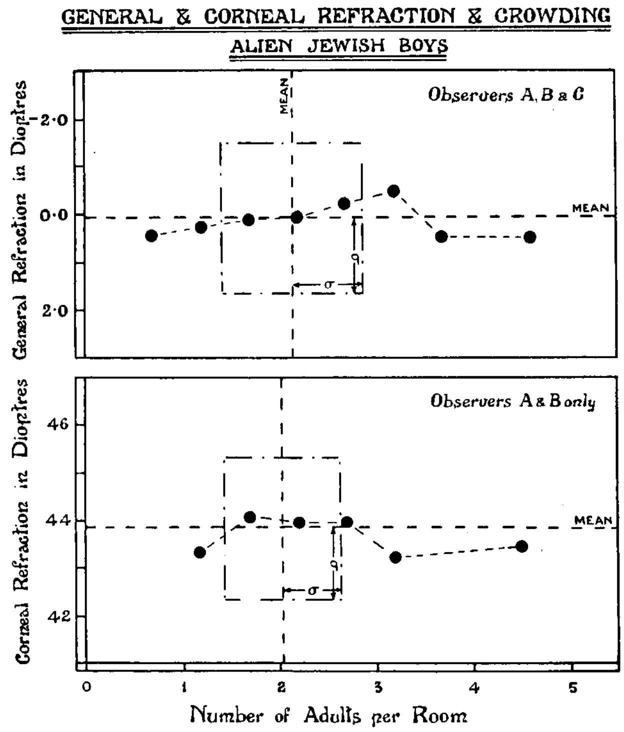

Diagram 132.

Table CCXCVII. *Crowding and General Astigmatism.*

General Astigmatism in Dioptres

"Adults" per Room	+ 3·00	+ 2·25	+ 1·50	+ 0·75	0·00	− 0·75	− 1·50	− 2·25	− 3·00	− 3·75	− 4·50	− 5·25	Totals
·45– ·95	—	—	—	—	8	2	—	2	—	—	—	—	12
·95–1·45	—	—	—	2·5	76	6·5	3	2	1	1	—	—	92
1·45–1·95	—	1	2·5	16	151	24	4·5	6	—	1	—	—	206
1·95–2·45	—	—	—	9	140	28	4	9	—	2	3	1	196
2·45–2·95	0·5	0·5	—	2·5	100	14·5	3	2·5	2·5	2	—	—	128
2·95–3·45	—	—	—	4	27	4	3	—	—	—	—	—	38
3·45–3·95	—	—	—	2	16	3	3	3	1	—	—	—	28
3·95–4·45	—	—	—	—	6	2	—	—	—	—	—	—	8
4·45–4·95	—	—	—	—	—	2	—	—	—	—	—	—	2
4·95–5·45	—	—	—	1	3	2	—	—	—	—	—	—	6
Totals	0·5	1·5	2·5	37	527	88	20·5	24·5	4·5	6	3	1	716

From this we deduce the following system of array-means:

Grade of Crowding	Array-Means of Astigmatism: Regarding Sign	Disregarding Sign
0·7	− ·5000 ± ·1450	·5000 ± ·1435
1·2	− ·2038 ± ·0524	·2446 ± ·0518
1·7	− ·1165 ± ·0350	·2913 ± ·0346
2·2	− ·3406 ± ·0359	·4094 ± ·0355
2·7	− ·2461 ± ·0444	·3164 ± ·0439
3·2	− ·1184 ± ·0815	·2763 ± ·0806
3·7	− ·5357 ± ·0950	·6429 ± ·0939
4·6	− ·2344 ± ·1256	·3281 ± ·1243
General Population*:	− ·2378 ± ·0188	·3394 ± ·0186

* Standard Deviation: regarding sign, ·7449 D.; disregarding sign, ·7370 D.

Several of these array-means* are significant or approach significance, but the two series have no orderly sequence, and skew regression, if it exists, could show, even approximately, no smooth regression line. The coefficient of correlation by the product moment method is

$$r = + \cdot 0514 \pm \cdot 0251, \text{ paying no attention to sign,}$$

and is

$$r = - \cdot 0489 \pm \cdot 0251, \text{ if we pay attention to sign.}$$

These results cannot be said to be significant, and, if they were, would be of no practical importance.

Disregarding sign we have:

$$\eta'^2_{A.p} = \cdot 013{,}821, \qquad \bar{\eta}^2_{A.p} = \cdot 009{,}777 \pm \cdot 003{,}488,$$

which shows that $\eta'_{A.p}$ is non-significant.

Regarding sign we have:

$$\eta'^2_{A.p} = \cdot 022{,}821, \qquad \bar{\eta}^2_{A.p} = \cdot 009{,}777 \pm \cdot 003{,}488,$$

which seems to be significant.

Thus while the non-significance of the correlation coefficients is convincing as to Astigmatism not being simply associated with Crowding, one correlation ratio, that for the first series, shows significance and thus corresponds with the great significance shown by the array-means of this series. It is very difficult to interpret this correlation ratio for the Astigmatism on "Adults" per Room when we regard sign. Putting every two grades of crowding together we find:

Persons per Room	Mean Astigmatism
1·13	− ·2380 ± ·0493
1·94	− ·2258 ± ·0251
2·81	− ·2169 ± ·0390
4·03	− ·4261 ± ·0757
General Population:	− ·2378 ± ·0188

The regression line thus simplified is seen to be now somewhat parabolic in character, but only the last array-mean is just possibly significant, being about 2·4 times the probable error in its deviation from the general mean. This skew regression, if it could be considered significant, would mean that the least and most crowded houses had the boys with the greater astigmatism. When we remember, however, that we are here dealing with differences not exceeding $\frac{1}{4}$D., we see how trivial is really any association of Astigmatism with Crowding that may exist.

(*f*) *Crowding and Corneal Astigmatism.* Some light on the results of the previous section may be obtained if we discuss the relation of Crowding to Corneal Astigmatism, dealing only with *A* and *B*'s records. The data are given in the table below.

Table CCXCVIII. *Crowding and Corneal Astigmatism.*

Corneal Astigmatism in Dioptres

"Adults" per Room	− 1·50	− 0·75	0·00	+ 0·75	+ 1·50	+ 2·25	+ 3·00	+ 3·75	+ 4·50	+ 5·25	Totals
·45– ·95	—	—	—	4	—	—	—	—	—	—	4
·95–1·45	—	1	8	25	2	5	—	3	—	—	44
1·45–1·95	4	4	29	43	10	8	1	—	—	1	100
1·95–2·45	1	3	12	33	6	3	—	2	2	2	64
2·45–2·95	—	2	7	18	1	1	1	—	—	—	30
2·95–3·45	—	3	6	6	—	—	1	—	—	—	16
3·45–3·95	—	—	4	—	—	—	—	—	—	—	4
3·95–4·45	—	—	1	1	—	—	—	—	—	—	2
4·45–4·95	—	—	—	—	—	—	—	—	—	—	—
4·95–5·45	—	—	—	2	—	—	—	—	—	—	2
5·45–5·95	—	—	—	2	—	—	—	—	—	—	2
Totals	5	13	67	134	19	17	3	5	2	3	268

* Three in the first series, those at 1·7, 2·2 and 3·7, are all more than three times the probable error, and one in the second series, that at 3·7, also exceeds that value, in deviation from the general mean.

The constants of this table are:

Mean:	"Adults" per Room: 2·0284;	Corneal Astigmatism: ·8843 D.
Standard Deviation:	,, ,, ·6032;	,, ,, ·9337 D.

Product Moment Coefficient of Correlation:

$$r = - \cdot 1205 \pm \cdot 0406.$$

The constants have been deduced by disregarding the sign of the astigmatism.

It will be seen that the association of Crowding with Corneal Astigmatism is definite, if it be of no practical intensity. Diagram 133 shows the association graphically and we place below the array-means:

Grade of Crowding	Corneal Astigmatism (without regard to Sign)
1·16 persons per room	1·0000 D. ± ·0909
1·7 ,, ,,	·8250 D. ± ·0630
2·2 ,, ,,	1·1133 D. ± ·0787
2·7 ,, ,,	·7250 D. ± ·1150
3·2 ,, ,,	·6094 D. ± ·1574
4·5 ,, ,,	·3750 D. ± ·1991
General Population:	·8843 D. ± ·0385

While in the individual array-means there is little that differs significantly from the General Population mean the tendency to a falling astigmatism with increased crowding is very visible.

CORNEAL ASTIGMATISM & NUMBER OF ADULTS PER ROOM

(OBSERVERS A & B ONLY) ALIEN JEWISH BOYS

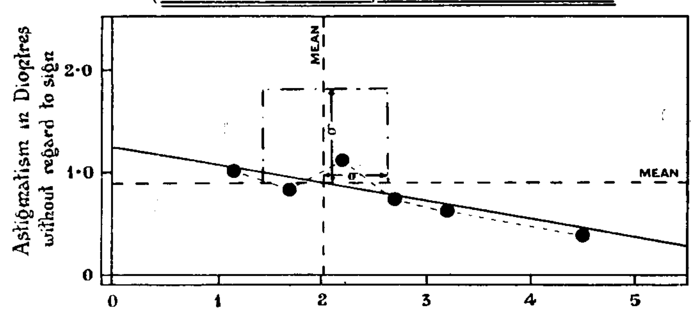

Diagram 133.

It is less easy to say how it arises that the most crowded homes produce boys with the least astigmatism. But we would make the following suggestion. Corneal Astigmatism is a strongly inherited character, and probably is entirely uninfluenced by environmental conditions. But crowding in the home is usually the result (i) of a large family and (ii) of a low infant death-rate. These are marks of a superior physique. Failure to reach a normal structure, whether in the eye or any other organ, is a sign of poor physique and delicacy of stock. The student of pathological heredity is very familiar with this aspect of the poor and weak stocks, i.e. failure to reach normality in more than one organ. We would suggest therefore that this may be the real explanation of why in one or two cases we have come across a more favourable value of an ocular character associated with worse environment.

Summary. The results of this section seem to indicate that few of the ocular characters dealt with by us have any relation whatever to crowding, and even in those cases where overcrowding does seem associated with sight, the association is of little practical importance. Even where it exists, it may be described as the "wrong way round," and if we supposed the overcrowding to be causal, it would produce good rather than bad sight!

(vii) *Rent and Ocular Characters.*

While treating of the possible influence of environment on the condition of the eye, it is not without value to consider whether the economic factors are of any importance.

Poverty itself is a very important environmental condition, and "Rent" is in our experience a fairly reasonable measure of it.

(*a*) *Rent and Binocular Visual Acuity.* As before, we measure "Rent" by "Rent per Adult" and not by absolute rent. The following is the correlation table of "Rent" and "Visual Acuity."

Table CCXCIX. *Rent and Binocular Visual Acuity.*

Rent "per Adult" in Shillings per Week

Visual Acuity	·55–·75	·75–·95	·95–1·15	1·15–1·35	1·35–1·55	1·55–1·75	1·75–1·95	1·95–2·15	2·15–2·35	2·35–2·55	2·55–2·75	2·75–2·95	2·95–3·15	3·15–3·35	3·35–3·55	3·55–3·75	3·75–3·95	3·95–4·15	4·15–4·35	Totals
1·50	—	—	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	3
1·40	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
1·29	1	3	2	17	5	7	4	1	2	1	1	—	—	1	—	—	—	—	—	45
1·11	2	9	10	25	17	14	3	4	—	3	—	1	—	—	—	—	—	1	—	89
·91	—	6	16	16	13	7	4	1	—	3	—	—	—	—	—	—	1	—	1	68
·75	—	4	5	8	4	5	—	1	—	1	—	—	—	—	1	—	—	—	—	29
·58	1	3	5	2	7	3	4	—	—	—	—	—	—	1	—	—	—	—	—	26
·37	—	1	7	8	7	2	1	—	—	—	—	—	—	—	—	—	—	—	—	26
·25	—	—	—	4	—	1	1	—	—	—	—	1	—	—	—	—	—	—	—	7
·14	—	2	—	4	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7
·08	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
·04	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
Totals	4	28	46	89	57	40	18	7	2	8	1	2	—	2	1	—	1	1	1	308

The constants of this table are:

Mean: Rent: 1·4182; Visual Acuity: ·8947.

Standard Deviation: „ ·4925; „ ·3332.

Correlation Ratio, Vision on Rent:

$\eta'^2_{V.R} = \cdot 029{,}176$, $\bar{\eta}^2_{V.R} = \cdot 019{,}481 \pm \cdot 007{,}501$.

Product Moment Coefficient of Correlation:

$r = + \cdot 1168 \pm \cdot 0379.$

Turning to the array-means we find:

Grade of "Rent"	Visual Acuity
0·825*s*. per week	·9000 ± ·0397
1·05 „	·8165 ± ·0331
1·25 „	·8863 ± ·0238
1·45 „	·8519 ± ·0298
1·65 „	·9730 ± ·0355
1·85 „	·9206 ± ·0530
2·65 „	1·0104 ± ·0441
General Population:	·8947 ± ·0128

It is not possible to lay much stress on the mean of the first array, and indeed none of the differences can be said to be definitely significant, still there is a general tendency to show improved vision with higher rent, and although we cannot demonstrate it on $\eta^{2\prime}_{V.R}$, which is non-significant as compared with $\bar{\eta}^2_{V.R}$, it is shown in the small but probably significant correlation coefficient. Diagram 134 illustrates the amount of relationship graphically. The existence of this lower visual acuity in the homes with smaller rentals might possibly be connected with definite eye diseases

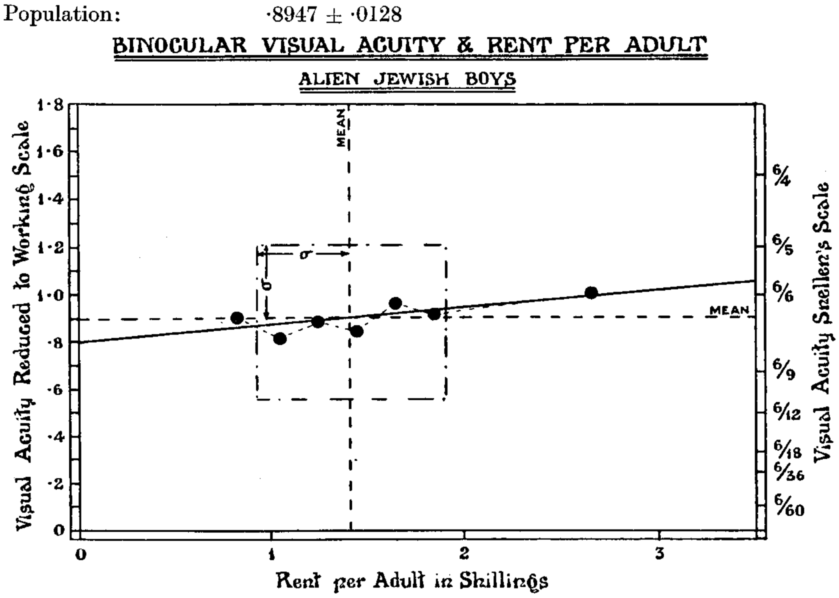

Diagram 134.

(largely associated with dirt, rather than with defects of refraction) had we not failed to find correlation between visual acuity and cleanliness of home.

(*b*) *Rent and Refraction Class.* Table CCC provides the requisite data.

Table CCC. *Rent and Refraction Class.*

Rent "per Adult" in Shillings per Week

Refraction Class	·55–·75	·75–·95	·95–1·15	1·15–1·35	1·35–1·55	1·55–1·75	1·75–1·95	1·95–2·15	2·15–2·35	2·35–2·55	2·55–2·75	2·75–2·95	2·95–3·15	3·15–3·35	3·35–3·55	3·55–3·75	3·75–3·95	3·95–4·15	4·15–4·35	Totals
Emmetropia	6	40	54	97	63	48	20	12	—	14	2	2	—	2	2	—	2	—	—	364
Hypermetropia	—	1	8	12	5	6	3	—	—	—	—	—	—	—	—	—	—	—	—	35
Hypermetropic Astigmatism	—	2	10	12	15	3	1	—	—	—	—	—	—	—	—	—	—	—	—	43
Mixed Astigmatism	—	—	1	4	—	2	—	—	—	—	1	—	—	—	—	—	—	—	—	8
Myopic Astigmatism	1	2	7	4	4	1	4	—	—	1	1	—	—	—	—	—	—	—	—	25
Myopia	1	1	14	37	21	10	8	8	—	1	—	—	—	—	—	—	—	—	2	103
Totals	8	46	94	166	108	70	36	20	—	16	4	2	—	2	2	—	2	—	2	578

Looking first at the arrays of Rent for a given Refraction Class we have:

Emmetropia...	$1·413 \pm ·016$
Hypermetropia	$1·341 \pm ·053$
Hypermetropic Astigmatism	$1·297 \pm ·048$
Mixed Astigmatism	$1·500 \pm ·110$
Myopic Astigmatism	$1·386 \pm ·062$
Myopia	$1·471 \pm ·031$
General Population*	$1·411 \pm ·013$

None of these means is significantly different from that of the General Population, but they indicate, if anything, that myopic boys come from the higher rented homes. Finding the correlation ratio of Rent on Refraction Class, we have:

$$\eta'^2_{R.RC} = ·009{,}615, \qquad \bar{\eta}^2 = ·008{,}651 \pm ·003{,}672,$$

showing that $\eta'^2_{R.RC}$ is non-significant.

Looking at the matter from the standpoint of Refraction Class percentages we find for the two divisions we have used before:

Rent	Hypermetropia†	Emmetropia	Myopia‡
Less than 1·35*s*. per Person	14·3 %	62·8 %	22·9 %
More than 1·35*s*. per Person	12·5	63·3	24·2
General Population	13·5	63·0	23·5

There is nothing in these percentages to indicate any relation of importance between Refraction Class and Rental. We doubt whether it is safe to make smaller rent classes. But if we take extreme classes, we find:

Rent more than 1·75*s*.	4·7 %	65·1 %	30·2 %
Rent less than 1·15*s*.	14·2 %	67·6 %	18·2 %

* Standard Deviation: ·4625.

† Including Hypermetropic Astigmatism.

‡ Including Myopic Astigmatism and the eight cases of Mixed Astigmatism.

Or, we should have to conclude that the higher rentals showed a greater percentage of myopic boys than the lower rentals—corresponding to a fact noted before of the better homes.

On the whole we should prefer to draw the safe conclusion that the low-rented homes do not indicate anomalies of refraction.

(*c*) *Rent per Adult and General Refraction.* The following table—by no means pleasing to the eye of the statistical investigator—provides the requisite data:

Table CCCI. *Rent and General Refraction.*

Rent "per Adult" in Shillings

Refraction in Dioptres: Central Values	·55–·75	·75–·95	·95–1·15	1·15–1·35	1·35–1·55	1·55–1·75	1·75–1·95	1·95–2·15	2·15–2·35	2·35–2·55	2·55–2·75	2·75–2·95	2·95–3·15	3·15–3·35	3·35–3·55	3·55–3·75	3·75–3·95	3·95–4·15	4·15–4·35	Totals
+ 6·75	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
+ 6·00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
+ 5·25	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
+ 4·50	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
+ 3·75	—	—	—	5	2·5	1	—	—	—	—	—	—	—	—	—	—	—	—	—	8·5
+ 3·00	—	—	—	1	0·5	1	—	—	—	—	—	—	—	—	—	—	—	—	—	2·5
+ 2·25	—	2	10	5	4·5	1	—	—	—	—	—	—	—	—	—	—	—	—	—	22·5
+ 1·50	—	—	4	5	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	12
+ 0·75	—	8	30	32·5	17·5	15	9	5	—	2	3	—	—	—	—	—	1	—	—	123
0·00	6	32	29	75·5	55	41·5	16	9	—	13	1	2	—	2	2	—	1	—	—	285
− 0·75	1	2	9	15	13	7	9	6	—	1	—	—	—	—	—	—	—	—	2	65
− 1·50	·5	1	3	8	3	1·5	2	—	—	—	—	—	—	—	—	—	—	—	—	19
− 2·25	·5	1	5	10	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19·5
− 3·00	—	—	—	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4
− 3·75	—	—	3	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6
− 4·50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
− 5·25	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
− 6·00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
− 6·75	—	—	1	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
− 12·75	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
− 15·75	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Totals	8	46	94	166	108	70	36	20	—	16	4	2	—	2	2	—	2	—	2	578

The constants of this table are here given:

Mean: Rent: 1·4106*s.*; Refraction: ·0292 D.

Standard Deviation: „ ·4625*s.*; „ 1·5223 D.

Product Moment Coefficient of Correlation:

$$r = \cdot 0078 \pm \cdot 0281.$$

Correlation Ratio of Refraction on Rent:

$$\eta'^2_{Rf.Re} = \cdot 009{,}151; \qquad \bar{\eta}^2_{Rf.Re} = \cdot 013{,}841.$$

Thus η'^2 is less than $\bar{\eta}^2$ and we conclude from this and the value of r that, as for Refraction Class, there is no association of Rent and General Refraction.

(*d*) *Rent and Corneal Refraction.* If we confine our attention to A and B only we have but sparse material for these characters. It is exhibited in the accompanying table.

Table CCCII. *Rent per Adult and Corneal Refraction.*

Corneal Refraction in Dioptres (Central Values)

Rent "per Adult" in Shillings	40·125	40·625	41·125	41·625	42·125	42·625	43·125	43·625	44·125	44·625	45·125	45·625	46·125	46·625	47·125	47·625	Totals
·55– ·75	—	—	—	—	—	—	—	—	—	—	0·5	1	0·5	—	—	—	2
·75– ·95	—	—	—	—	—	—	5	—	1	—	2	—	1	1	—	—	10
·95–1·15	2	—	1	3	2	3	5	7	7	7	5	3	1	—	—	—	46
1·15–1·35	2	—	1	1	3	7	5	3	12	11	6	2	1	—	—	2	56
1·35–1·55	2	—	1	—	3	4	3	4	5	4	3	6	6	1	—	—	42
1·55–1·75	—	1	—	1	—	3	3	5	5	1	3	—	3	2	1	—	28
1·75–1·95	—	—	—	1	3	4	2	1	3	—	4	—	1	—	1	—	20
1·95–2·15	—	—	—	—	1	—	—	1	—	—	2	2	—	—	—	—	6
2·15–2·35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2·35–2·55	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2·55–2·75	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	2
Totals	7	1	3	7	12	21	23	21	33	23	25·5	14	13·5	4	2	2	212

The constants of this table are:

Mean: Rent per Adult: 1·3670*s.*; Corneal Refraction: 43·9412 D.

Standard Deviation: ,, ,, ·3259*s.*; ,, ,, 1·5221 D.

Product Moment Coefficient of Correlation:

$$r = \cdot 0522 \pm \cdot 0462.$$

Correlation Ratio of Refraction on Rent:

$$\eta'^2_{CR.Re} = \cdot 025{,}710, \qquad \bar{\eta}^2_{CR.Re} = \cdot 023{,}585 \pm \cdot 009{,}919.$$

Clearly neither r nor η'^2 is significant and we cannot assert that Rent has any effect on Corneal Refraction.

Nor do the array-means provide any better evidence; they run:

Rental Grade	Corneal Refraction in Dioptres
·82*s.*	44·500 ± ·296
1·05*s.*	43·679 ± ·151
1·25*s.*	43·893 ± ·137
1·45*s.*	44·137 ± ·158
1·65*s.*	44·232 ± ·194
1·95*s.*	43·268 ± ·194
General Population:	43·941 ± ·071

The only two of these which appear to have significance are the first and the last, namely, the refraction for boys from a rental grade of 1·95*s.*, where the difference from the mean of the General Population is some three times the probable error, and the refraction of boys in the lowest class of rents which is also more than three times the probable error. The latter would mean, as far as Corneal Refraction is concerned, more myopic boys from the lowest rentals, and the former more hypermetropic boys from the highest rentals. But the General Refraction (when the array-means are considered) gives no trace of such a relation to rental, and considering the paucity of data in the above table, we lay no stress on it.

(*e*) *Rent per Adult and General Astigmatism.* Table CCCIII comprises our data for these variates.

The constants of this distribution are (sign regarded):

Mean: General Astigmatism: – ·2297 D.; Rent per Adult: 1·4106*s.*

Standard Deviation: ,, ,, ·7077 D.; ,, ,, ·4625*s.*

Product Moment Correlation Coefficient:

$$r = \cdot 0192 \pm \cdot 0280.$$

Correlation Ratio of Astigmatism on Rental:

$$\eta'^2_{A.R} = \cdot 012{,}272, \qquad \bar{\eta}^2_{A.Re} = \cdot 013{,}841.$$

Clearly both $\eta'^2_{A.Re}$ and r are non-significant.

Table CCCIII. *Rent per Adult and General Astigmatism.*

Rent "per Adult" in Shillings

Astigmatism in Dioptres (Central Values)	·55–·75	·75–·95	·95–1·15	1·15–1·35	1·35–1·55	1·55–1·75	1·75–1·95	1·95–2·15	2·15–2·35	2·35–2·55	2·55–2·75	2·75–2·95	2·95–3·15	3·15–3·35	3·35–3·55	3·55–3·75	3·75–3·95	3·95–4·15	4·15–4·35	Totals
+ 3·00	—	—	—	—	0·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0·5
+ 2·25	—	—	—	—	1·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1·5
+ 1·50	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	2
+ 0·75	0·5	1	10	9	6	3	2	—	—	—	—	—	—	—	—	—	—	—	—	31·5
0·00	6	34	58	125	74	54	28	17	—	14	2	2	—	2	—	—	—	—	2	418
− 0·75	1·5	8	13	18	15	10	4	3	—	2	—	—	—	—	2	—	2	—	—	78·5
− 1·50	—	—	7	4	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	14
− 2·25	—	3	6	5	5·5	—	2	—	—	—	1	—	—	—	—	—	—	—	—	22·5
− 3·00	—	—	—	3	0·5	—	—	—	—	—	1	—	—	—	—	—	—	—	—	4·5
− 3·75	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
− 4·50	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Totals	8	46	94	166	108	70	36	20	—	16	4	2	—	2	2	—	2	—	2	578

None of the array-means is significant, and all of them differ by less than one-fifth of a dioptre from the population mean.

We also found the array-means disregarding the sign of the Astigmatism and the same remark applies to them as to the array-means regarding the sign. The correlation coefficient was increased and its sign changed, i.e.

$$r = -\cdot 0427 \pm \cdot 0280.$$

It was thus still non-significant, and we were accordingly unable to trace any association of General Astigmatism with poverty as measured by "Rent per Adult."

(*f*) *Rent per Adult and Corneal Astigmatism.* We again only dealt with *A* and *B*'s records so that our data as given in the table below are sparse.

Table CCCIV. *Rent per Adult and Corneal Astigmatism.*

Rent "per Adult" in Shillings

	·55–·75	·75–·95	·95–1·15	1·15–1·35	1·35–1·55	1·55–1·75	1·75–1·95	1·95–2·15	2·15–2·35	2·35–2·55	2·55–2·75	Totals
− 1·50	—	—	1	—	2	2	—	—	—	—	—	5
− 0·75	—	—	4	4	—	4	1	—	—	—	—	13
0·00	1	2	12	12	16	5	10	—	—	—	—	58
+ 0·75	1	6	21	32	18	12	6	5	—	—	—	101
+ 1·50	—	1	5	4	1	3	1	—	—	—	—	15
+ 2·25	—	1	3	1	2	1	2	1	—	—	—	11
+ 3·00	—	—	—	1	1	1	—	—	—	—	—	3
+ 3·75	—	—	—	1	1	—	—	—	—	—	2	4
+ 4·50	—	—	—	1	1	—	—	—	—	—	—	2
Totals	2	10	46	56	42	28	20	6	—	—	2	212

The constants of this distribution are as follows:

Mean: Rent per adult: 1·3670*s.*; Corneal Astigmatism: ·8172 D.

Standard Deviation: ,, ,, ·3259*s.*; ,, ,, ·8326 D.

Product Moment Correlation Coefficient: $r = \cdot 0505 \pm \cdot 0462$.

Correlation Ratio, Corneal Refraction on Rent:

$$\eta'^2_{CA.Re} = \cdot 003{,}596, \qquad \bar{\eta}^2_{CA.Re} = \cdot 023{,}585 \pm \cdot 009{,}919.$$

Hence neither r nor η'^2 is significant and we are unable to find any association between Corneal Astigmatism and poverty as measured by rent per adult.

Summary. We have failed entirely in this section to detect any association between poverty as measured by rent and any ocular character. The apparent exception to this rule, which occurs in the case of Visual Acuity, might be attributed to diseases of the eye which are connected with dirt and poverty, and not to ocular defects such as refraction and astigmatism. But this interpretation is rendered very doubtful because we have not found any significant association between dirt of person (p. 6) or cleanliness of home (p. 12) with visual acuity (see also p. 17).

(viii) *Familial Income and Ocular Characters.*

It seemed worth while considering another economic factor in relation to ocular characters. We have several such measures of poverty and relative prosperity, but beyond the considerable labour of working them all out, there lies further the great expense of printing the tables and their textual discussion. Having failed to find any association of ocular characters with rent per adult, we were fairly confident that economic conditions are not a source of eye defect. But we considered that it might be worth while confirming this on a second economic factor. We accordingly selected "Income per adult." The method by which "Income per adult" as well as "Rent per adult" have been reached, has been fully described in an earlier section of this memoir, and need not be rediscussed here*. It seemed to us as a quantitative measure of economic status, on the whole better than the field-worker's general appreciation of the character of the home†. At the same time it suffers from the defects already noted that information was entirely refused in about 13 % of cases and in about 8 % the house-mother would not go further than saying that her economic conditions were "Comfortable." We are forced, as we were earlier when considering Intelligence, to make a separate group of the "Comfortable" incomes. This difficulty is got over reasonably by the use of either the correlation ratio or the mean square contingency methods, and fairly satisfactorily in the case of the tetrachoric method‡. But when we come to apply the product moment method we have to omit this group, and our conclusions will be less satisfactory.

(*a*) *Familial Income and Visual Acuity.* The accompanying table exhibits our data.

Table CCCV. *Familial Income and Visual Acuity* (*Binocular*).

Income "per Adult" in Shillings per Week

Visual Acuity	0·95–1·95	1·95–2·95	2·95–3·95	3·95–4·95	4·95–5·95	5·95–6·95	6·95–7·95	7·95–8·95	8·95–9·95	9·95–10·95	10·95–11·95	11·95–12·95	12·95–13·95	13·95–14·95	14·95–15·95	15·95–16·95	16·95–17·95	..	22·95–23·95	..	27·95–28·95	..	"Comfortable"	Totals
1·50	—	—	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	3
1·40	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	2
1·29	—	2	17	10	9	3	1	2	1	—	—	—	—	—	1	—	—	..	—	..	—	..	6	52
1·11	1	7	14	24	25	6	7	5	1	1	—	—	1	—	1	—	—	..	—	..	—	..	14	107
·91	1	3	16	10	15	9	4	2	1	—	1	—	—	—	1	—	1	..	—	..	1	..	6	71
·75	—	5	8	3	5	2	—	1	—	2	—	—	—	—	—	—	—	..	—	..	—	..	6	32
·58	1	1	7	6	5	3	2	1	—	—	—	—	1	—	—	—	—	..	—	..	—	..	4	31
·37	—	1	5	5	7	2	2	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	1	23
·25	—	2	—	3	1	—	—	1	—	—	1	—	—	—	—	—	—	..	1	..	—	..	—	9
·14	—	2	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	1	7
·08	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	1	4
·04	—	—	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	1	4
Totals	3	23	71	64	70	28	18	12	3	3	2	—	2	—	3	—	1	..	1	..	1	..	40	345

* See *Annals of Eugenics*, Vol. I, pp. 106, 110.

† *Ibid.* Vol. I, p. 104.

‡ *Ibid.* Vol. I, p. 110. We do not think it probable that the cases where information was refused were a selected group of either low or high-incomed families.

The constants of this table are as follows, omitting "Comfortable":

Mean:	Visual Acuity: ·9042;	Income: 4·6107*s*.
Standard Deviations:	,, ·3325:	,, 2·8038*s*.

Product Moment Correlation: $r = -0100 \pm \cdot 0386$.

Including "Comfortable," we have for the Correlation Ratio of Vision on Familial Income:

$$\eta'^2_{V.I} = \cdot 008{,}367, \qquad \bar{\eta}^2_{V.I} = \cdot 017{,}391.$$

Thus not only r is insignificant but $\eta'^2_{V.I}$ less than the mean value for no association. These results are confirmed if we examine the array-means:

Grade of Income "per Adult"	Visual Acuity
2·33*s*. per week	·8139 ± ·0439
3·45 ,,	·9059 ± ·0266
4·45 ,,	·9361 ± ·0280
5·45 ,,	·9169 ± ·0268
6·84 ,,	·8809 ± ·0330
11·66 ,,	·9171 ± ·0423
"Comfortable"	·9047 ± ·0354
General Population:	·9042 ± ·0121

The only difference here which even approaches slight significance is that of the lowest grade of income and the General Population which is just *under* twice the probable error. We should anticipate that some diseases of the eye which may affect visual acuity would arise from dirt of person or home and this would be more probably the case in the poorer homes. The significance is, however, too slight for us to assert with any degree of certainty that the boys with the less visual acuity come to any appreciable extent from poorer homes.

(*b*) *Familial Income and Refraction Class.* Our data are comprised in the following table:

Table CCCVI. *Familial Income and Refraction Class.*

Income "per Adult" in Shillings per Week

Refraction Class	0·95–1·95	1·95–2·95	2·95–3·95	3·95–4·95	4·95–5·95	5·95–6·95	6·95–7·95	7·95–8·95	8·95–9·95	9·95–10·95	10·95–11·95	11·95–12·95	12·95–13·95	13·95–14·95	14·95–15·95	15·95–16·95	16·95–17·95	..	22·95–23·95	..	27·95–28·95	"Comfortable"	Totals
Emmetropia	2	26	94	70	84	35	20	16	3	4	—	—	4	—	6	—	3	..	—	..	2	54	423
Hypermetropia	—	2	6	4	13	8	4	2	—	2	—	—	—	—	—	—	1	..	—	..	—	4	46
Hypermetropic Astigmatism	—	—	9	11	13	1	5	1	—	—	2	—	—	2	—	—	—	..	—	..	—	5	49
Mixed Astigmatism	—	—	1	—	3	—	1	—	—	—	—	—	—	—	—	1	—	..	—	..	—	1	7
Myopic Astigmatism	—	3	11	7	2	—	3	—	—	2	—	—	—	—	—	1	—	..	—	..	—	3	32
Myopia	2	5	21	16	23	14	5	5	3	—	2	—	—	—	—	—	—	..	2	..	—	9	107
Totals	4	36	142	108	138	58	38	24	6	8	4	—	4	2	6	2	4	..	2	..	2	76	664

Omitting "Comfortable" economic conditions we have for the array-means for each refraction class:

Refraction Class	Rent "per Adult" in Shillings	
Emmetropia	5·409 ± ·107	
Hypermetropia	5·974 ± ·316	
Hypermetropic Astigmatism	5·791 ± ·309	
Mixed Astigmatism	7·283 ± ·836	5·450 ± ·339
Myopic Astigmatism	5·071 ± ·380	
Myopia	5·634 ± ·207	
General Population*:	5·518 ± ·085	

* Standard Deviation = 3·0361*s*.

The only array which on the basis of its probable error would show significance is that for Mixed Astigmatism, but there are only six individuals in this array and the theory of probable errors is meaningless for a sample of this size. If we combine Mixed with Myopic Astigmatism there is nothing significant in the combined array.

We next made a contingency table with the six refraction classes and the following seven rent classes:

0·95–2·95, 2·95–3·95, 3·95–4·95, 4·95–5·95, 5·95–7·95, 7·95 and over, "Comfortable."

It is not needful to reproduce this table, which can be formed at once from Table CCCVI above. It gave the following values of the Mean Square Contingency:

$$\phi'^2 = \cdot 046{,}468, \qquad \bar{\phi}^2 = \cdot 061{,}747.$$

Thus ϕ'^2 is less than $\bar{\phi}^2$ the mean value for no contingency. Myopia in no rental class contributes anything of note to ϕ'^2, nor does Emmetropia.

It is the Hypermetropic and Myopic Astigmatism classes which make up the value of ϕ'^2 such as it is. The rentals over 5·95*s.* per adult contribute nothing of any size to ϕ'^2. But the lowest rental group contributes 2·95 to 664 ϕ'^2 under Hypermetropic Astigmatism; the 2·95–3·95 rental group has 2·53 and the 4·95–5·95 rental group has 3·25 under Myopic Astigmatism. These results, although on the whole there is no significance, seem to indicate, as we have seen in other parts of this investigation, that there is possibly some slight association—we do not assert that it is causal—between astigmatism and poverty as measured by income. We can test the matter again by the precarious method of percentages. We have:

Income per Adult	Hypermetropia and Hypermetropic Astigmatism	Emmetropia	Myopia, Mixed and Myopic Astigmatism
0·95–3·95	9·34 %	67·03 %	23·63 %
3·95–5·95	16·67	62·60	20·73
5·95 and over*	15·68	62·29	22·03
General Population	14·31	63·70	21·99

It would be unsafe to make any statement here except that there appears to be less Hypermetropia in the homes where the income is lowest. Tabling so as to bring out the amounts of Astigmatism we find:

Income per Adult	Hypermetropia	Emmetropia	Astigmatism	Myopia
0·95–3·95	4·39 %	67·03 %	13·19 %	15·39 %
3·95–5·95	6·91	62·60	14·63	15·86
5·95 and over*	8·90	62·29	11·86	16·95
General Population	6·93	63·70	13·25	16·12

The lower percentage of Hypermetropia in the smaller income homes is again noticeable, but it is difficult to lay stress on the higher Astigmatism percentages for lower incomes. The Myopia continually increases with higher income, but there is nothing really beyond the limits of random sampling in the Myopia or Astigmatism results. If there be any relation between Refraction Class and Income it is too slender to be ascertainable definitely on our data.

(*c*) *Familial Income and General Refraction.* This is the type of table which is most depressing to the statistician; the observational units are not suitable for statistical treatment, the bulk of frequency being to the extent of 50 % in a central class. We may say this without in the least

* Including the "Comfortable" Group.

disregarding the grave difficulty of determining General Refraction to $\frac{1}{4}$ D. accuracy, or indeed, overlooking the point that $\frac{1}{4}$ D. one way or the other has little practical importance. Table CCCVII gives our data. The following are the mean General Refractions for each grade of Familial Income:

Grade of Income "per Adult"	General Refraction in Dioptres
2·35*s*. per week	$-\cdot 2625 \pm \cdot 1701$
3·45 "	$+\cdot 0000 \pm \cdot 0903$
4·45 "	$+\cdot 1910 \pm \cdot 1035$
5·45 "	$+\cdot 1250 \pm \cdot 0916$
6·45 "	$-\cdot 0194 \pm \cdot 1413$
7·45 "	$-\cdot 1086 \pm \cdot 1745$
9·03 "	$+\cdot 1974 \pm \cdot 1745$
16·45 "	$+\cdot 1154 \pm \cdot 2110$
"Comfortable"	$+\cdot 0395 \pm \cdot 1234$
General Population*:	$+\cdot 0537 \pm \cdot 0418$

Working out the Correlation Ratio for General Refraction on Familial Income we have:

$$\eta'^2_{GR.I} = \cdot 005{,}768, \qquad \bar{\eta}^2_{GR.I} = \cdot 012{,}048,$$

or η'^2 is less than $\bar{\eta}^2$, and is not significant.

This is in accordance with the array-means; none of these is significantly different from the mean of the General Population. The nearest approach to significance (under twice the probable error) is that of the lowest grade income, where the boys are on the average about $\frac{1}{4}$ D. below normal. No stress can be laid on this statistically, or, were it certain, practically. Excluding "Comfortable" the product moment coefficient of correlation is:

$$r = \cdot 0212 \pm \cdot 0278,$$

again a non-significant association. General Refraction shows no sign of a definite association with poverty.

Table CCCVII. *General Refraction and Familial Income.*

Income "per Adult" in Shillings

General Refraction (Central Values)	0·95–1·95	1·95–2·95	2·95–3·95	3·95–4·95	4·95–5·95	5·95–6·95	6·95–7·95	7·95–8·95	8·95–9·95	9·95–10·95	10·95–11·95	11·95–12·95	12·95–13·95	13·95–14·95	14·95–15·95	15·95–16·95	16·95–17·95	..	22·95–23·95	..	27·95–28·95	..	"Comfortable"	Totals
+ 6·75	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	1
+ 6·00	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	3
+ 5·25	—	—	—	1	—	—	2	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	3
+ 4·50	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	1	2
+ 3·75	—	—	2	3	1	—	1·5	—	—	1	—	—	—	—	—	—	—	..	—	..	—	..	2	10·5
+ 3·00	—	—	1	—	—	—	0·5	—	—	1	—	—	—	—	—	—	—	..	—	..	—	..	3	5·5
+ 2·25	—	2	3	4	9	—	1·5	1	—	—	2	—	—	1	—	—	—	..	—	..	—	..	2	25·5
+ 1·50	—	—	3	—	4	2	1	1	—	—	—	—	—	1	—	—	—	..	—	..	—	..	2	14
+ 0·75	—	—	36	17·5	28	20	9·5	7	—	—	—	—	—	—	2	1	4	..	—	..	—	..	7	132
0·00	4	26	63·5	59	69	24	14	12	4	4	—	—	4	—	4	1	—	..	—	..	2	..	47	337·5
− 0·75	—	3	13·5	13	14	5·5	5	1	2	1	—	—	—	—	—	—	—	..	—	..	—	..	2	60
− 1·50	—	—	5·5	3·5	8	1·5	1	1	—	1	—	—	—	—	—	—	—	..	2	..	—	..	3	26·5
− 2·25	—	4	6·5	4	—	3	—	1	—	—	—	—	—	—	—	—	—	..	—	..	—	..	4	22·5
− 3·00	—	—	1	—	1	2	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	4
− 3·75	—	1	3	—	2	—	—	—	—	—	2	—	—	—	—	—	—	..	—	..	—	..	—	8
− 4·50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	—
− 5·25	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	3	4
− 6·00	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	—
− 6·75	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	3
......	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
− 12·75	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	1
......	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
− 15·75	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	1
Totals	4	36	142	108	138	58	38	24	6	8	4	—	4	2	6	2	4	..	2	..	2	..	76	664

* Standard Deviation = 1·5950 D.

(*d*) *Corneal Refraction and Familial Income.* Here again we are troubled with paucity of data, especially as we consider *A* and *B*'s records more reliable than *C*'s. Further, for the product moment method the "Comfortable" incomes (here, however, only few in number) must be disregarded. We have the following table:

Table CCCVIII. *Corneal Refraction and Familial Income* (*A and B only*).

Income "per Adult" in Shillings

Corneal Refraction in Dioptres	0·95–1·95	1·95–2·95	2·95–3·95	3·95–4·95	4·95–5·95	5·95–6·95	6·95–7·95	7·95–8·95	8·95–9·95	9·95–10·95	10·95–11·95	11·95–12·95	12·95–13·95	13·95–14·95	14·95–15·95	15·95–16·95	16·95–17·95	..	22·95–23·95	..	27·95–28·95	..	"Comfortable"	Totals
38·125	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	1	..	—	..	—	1
......	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
......	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
40·125	—	2	3	1	—	—	—	—	—	—	1	—	—	—	—	1	—	..	—	..	—	..	—	8
40·625	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	..	—	..	—	..	—	2
41·125	—	—	1	1	—	1	2	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	5
41·625	—	—	—	2	2	1	—	—	—	—	1	—	—	—	—	1	1	..	—	..	—	..	—	8
42·125	—	—	3	—	3	3	—	—	—	—	1	—	—	—	—	—	1	..	—	..	—	..	—	11
42·625	—	—	6	4	6	1	—	2	—	—	—	—	—	—	2	—	—	..	—	..	—	..	—	21
43·125	—	—	9	4	7	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	1	..	—	21
43·625	—	—	1	7	9	4	—	—	—	1	—	—	—	—	—	—	1	..	—	..	1	..	2	26
44·125	—	2	5	10	5	8	3	1	—	2	2	—	—	—	—	—	1	..	1	..	—	..	1	41
44·625	—	2	6	3	2	8	—	1	—	1	—	—	—	—	—	—	—	..	—	..	—	..	3	26
45·125	—	3	6	—	4	3	4	3	—	2	—	—	—	—	—	—	—	..	—	..	—	..	—	25
45·625	—	1	2	2	2	3	1	1	1	—	—	—	—	—	—	—	—	..	—	..	—	..	—	13
46·125	—	—	—	—	3	4	2	4	1	—	—	—	—	—	—	—	—	..	—	..	—	..	—	14
46·625	—	—	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	3
47·125	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	1
47·625	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	2
Totals	—	10	42	34	48	38	12	12	2	6	6	—	—	—	2	2	4	..	2	..	2	..	6	228

Neglecting "Comfortable" and proceeding by the product moment method we find*:

$$r = -\cdot 1113 \pm \cdot 0447.$$

The correlation coefficient is not quite 2·5 times its probable error; this suggests that there is some small association of Familial Income and Corneal Refraction, the higher income corresponding to the smaller corneal refraction. This corresponds to what we found for rental and corneal refraction. We may pursue the matter further by considering the array-means:

Grade of Income	Corneal Refraction in Dioptres
2·45*s*. "per adult"	43·875 ± ·331
3·45 ,,	43·470 ± ·161
4·45 ,,	43·507 ± ·179
5·45 ,,	43·938 ± ·151
6·45 ,,	44·388 ± ·170
7·95 ,,	44·687 ± ·214
10·74 ,,	43·661 ± ·261
19·78 ,,	42·292 ± ·302
General Population:	43·842 ± ·069
"Comfortable":	44·208 ± ·427

Several of these array-means, judged by their probable errors, give significant differences, and what is more the plotted graph shows change, of a fairly uniform although rather complicated kind, indicating mixed factors at work: see Diagram 135. The array-means for Familial Income

* Mean Corneal Refraction: 43·8322 D.; Standard Deviation = 1·5687 D.
Mean Income: 6·3329*s*.; Standard Deviation = 3·9229*s*.

on Corneal Refraction are given in the diagram, and confirm the conclusion of a small but definite association. Proceeding to the correlation ratio of Corneal Refraction on Income we find:

$$\eta'^2_{CR.I} = \cdot 125{,}235, \qquad \bar{\eta}^2_{CR.I} = \cdot 035{,}088 \pm \cdot 011{,}597.$$

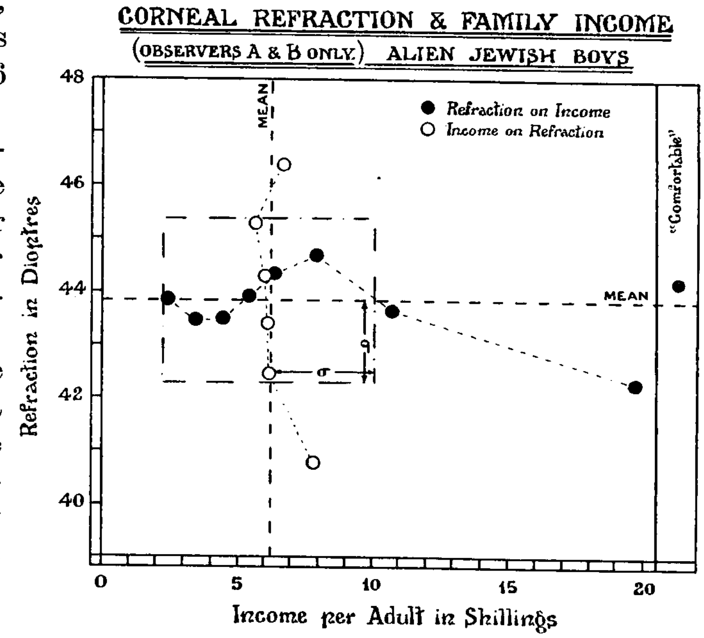

Diagram 135.

Clearly η'^2 is significant as compared with $\bar{\eta}^2$, and we shall have a correlation ratio as high as $\eta'_{CR.I} = \cdot 3539$ before correction, and about ·36 after correction for class-index.

Now it is noteworthy that while we were unable to find any definite trace of the influence of familial income on General Refraction or Refraction Class, it should nevertheless appear in one of its component factors Corneal Refraction.

What is clear, however, is that familial income as a measure of poverty or prosperity is not a causal factor of Corneal Refraction. If it were we should anticipate a continual change of refraction in one sense as income changed. Low incomes "per adult" as a rule indicate a large family of young children not old enough yet to earn, and high incomes "per adult" either few children or older children able to earn. Corneal Refraction changes to some extent with age. Are we only up against a result of our method of approaching the subject?

We will now consider some of these relationships. In the first place we sought to ascertain whether the "kinks" would disappear from our regression curve, if we investigated the relation between Total Familial Income and Corneal Refraction instead of income per adult. The following Table provides the data:

Table CCCIX. *Corneal Refraction and Total Family Income.*

Total Family Income in Shillings (Central Values)

Refraction in Dioptres (Central Values)	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	"Comfortable"	Totals
38·125	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
.....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
40·125	—	—	3	2	1	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	8
40·625	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	2
41·125	—	1	—	—	1	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6
41·625	—	1	1	2	—	—	3	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—	9
42·125	1	—	1	—	4	2	2	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	11
42·625	2	2	3	3	4	1	1	1	—	—	2	2	—	—	1	—	—	—	—	—	—	—	—	—	22
43·125	1	1	6·5	2·5	2·5	3·5	1	1	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	21
43·625	—	1	2·5	3	3·5	4	6	1	—	1	—	—	1	—	—	—	—	—	1	—	—	—	—	2	26
44·125	—	—	8	6	4·5	5·5	7	3	—	2·5	0·5	—	1	—	—	—	—	—	3	—	—	—	—	1	42
44·625	—	2	4	2·5	4·5	2	5	—	1	1·5	0·5	—	—	—	—	—	—	—	—	—	—	—	—	3	26
45·125	—	1	6	3	3	4	6	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	25
45·625	—	3	2	1	—	2	1	2	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	13
46·125	—	—	—	2	2	1	3	2	1	1	—	—	—	2	—	—	—	—	—	—	—	—	—	—	14
46·625	—	—	—	—	1	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3
47·125	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
47·625	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Totals	4	12	38	28	31	28	39	12	3	6	5	2	2	4	2	2	—	—	6	—	—	—	2	6	232

The constants of this distribution are as follows:

Income (without "Comfortable")—Mean: 36·327*s.*; Standard Deviation: 19·556*s.*
Corneal Refraction— Mean: 43·817 D.; Standard Deviation: 1·556 D.

Without "Comfortable," if we use the product moment method, we have:

$$r = -\cdot 0382 \pm \cdot 0442,$$

or the correlation coefficient is non-significant.

The array-means are shown in Diagram 136 and their values are given below:

Grade of Total Income	Corneal Refraction in Dioptres
13·75*s.* per week	43·531 ± ·262
20 ,,	43·566 ± ·170
25 ,,	43·813 ± ·198
30 ,,	43·689 ± ·189
35 ,,	44·232 ± ·198
40 ,,	43·933 ± ·168
50·77 ,,	44·356 ± ·206
87 ,,	43·100 ± ·235
General Population:	43·817 ± ·069
"Comfortable":	44·208 ± ·429

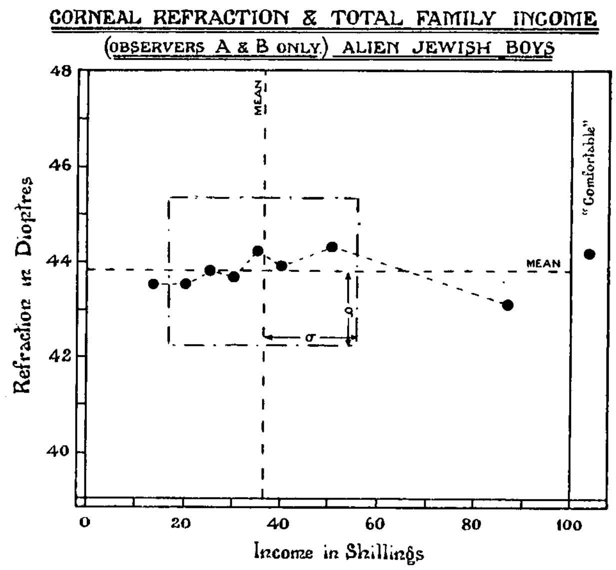

Diagram 136.

It is only the last two array-means, those for high familial income, which have real significance, but unfortunately they are in opposite senses; the array-mean at 50·77*s.* has the maximum value of the Corneal Refraction and that at 87*s.* the minimum value of the series! Thus there is no general tendency of higher income to correspond to an influence in one direction on Corneal Refraction. If we appeal to the Correlation Ratio of Corneal Refraction on Total Income we have:

$$\eta'^2_{CR.TI} = \cdot 050{,}374, \qquad \bar{\eta}^2_{CR.TI} = \cdot 034{,}483 \pm \cdot 011{,}405,$$

or η'^2 is not significant compared with $\bar{\eta}^2$.

Dealing with total familial income we smooth out the "kinks" of the regression curve on income "per adult," but we fail to find evidence that corneal refraction is correlated with economic conditions.

Since we are dealing with Corneal Refraction and Income "per adult" and the latter is largely determined by the size of family, it appeared worth while, as we have correlated Corneal Refraction with Total Income, to test whether it could possibly have any relation to Size of Family. We determined the product moment correlation coefficient as

$$r = -\cdot 0125 \pm \cdot 0404,$$

and this is non-significant. The correlation ratio as given by $\eta'^2_{CR.SF}$ differed from $\bar{\eta}^2_{CR.SF}$ by less than 2·5 times the probable error of $\bar{\eta}^2$. We conclude that there is no direct relation between Corneal Refraction and the Size of the Family to which the child belongs.

(*e*) *Familial Income and General Astigmatism.* Table CCCX (p. 44) contains our data.

The constants of this table are as follows:

Without regard to sign of the astigmatism and including "Comfortable":

$$\eta'^2_{A.I} = \cdot 021{,}033, \qquad \bar{\eta}^2_{A.I} = \cdot 012{,}048 \pm \cdot 004{,}040.$$

Table CCCX. *Familial Income and General Astigmatism.*

Income "per adult" in Shillings

Central Values

General Astigmatism in Dioptres	0·95–1·95	1·95–2·95	2·95–3·95	3·95–4·95	4·95–5·95	5·95–6·95	6·95–7·95	7·95–8·95	8·95–9·95	9·95–10·95	10·95–11·95	11·95–12·95	12·95–13·95	13·95–14·95	14·95–15·95	15·95–16·95	16·95–17·95	..	22·95–23·95	..	27·95–28·95	..	"Comfortable"	Totals
+ 3·00	—	—	—	—	—	—	0·5	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	0·5
+ 2·25	—	—	—	—	—	—	0·5	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	0·5
+ 1·50	—	—	1	2·5	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	3·5
+ 0·75	—	1	9·5	5	5	5·5	5	1	—	2	0·5	—	—	—	—	—	—	..	—	..	—	..	1	35·5
0·00	4	31	98	79	104	46	25	19	6	5	1	—	4	—	6	—	4	..	2	..	2	..	55	491
− 0·75	—	2	23·5	11	16	6·5	2	4	—	1	2·5	—	—	—	—	—	—	..	—	..	—	..	12	80·5
− 1·50	—	1	2	1·5	7	—	2	—	—	—	—	—	—	2	—	—	—	..	—	..	—	..	1	16·5
− 2·25	—	1	4	5	6	—	1·5	—	—	—	—	—	—	—	—	1	—	..	—	..	—	..	4	22·5
− 3·00	—	—	—	2	—	—	0·5	—	—	—	—	—	—	—	—	1	—	..	—	..	—	..	—	3·5
− 3·75	—	—	2	—	—	—	1	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	3	6
− 4·50	—	—	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	3
− 5·25	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	..	—	1
Totals	4	36	142	108	138	58	38	24	6	8	4	—	4	2	6	2	4	..	2	..	2	..	76	664

Thus η'^2 only differs from $\bar{\eta}^2$ by about twice the probable error, and can hardly be considered as significant. We will next consider the array-means:

Grade of Income	General Astigmatism in Dioptres
2·35*s*. "per adult"	·1500 ± ·0787
3·45 ,,	·3908 ± ·0417
4·45 ,,	·4097 ± ·0479
5·45 ,,	·2880 ± ·0423
6·45 ,,	·1552 ± ·0653
7·45 ,,	·5132 ± ·0807
9·03 ,,	·1579 ± ·0807
16·45 ,,	·4038 ± ·0976
General Population*:	·3343 ± ·0193
"Comfortable":	·4145 ± ·0571

Here the only array-mean which differs by at least 2·5 times the probable error from that of the general population is that for the 6·45*s*. income. There appears no reason for this result for the series of array-means forms no orderly sequence. The least General Astigmatism is found in the boys with the families of least income per adult. If we exclude the "Comfortable" we can find the product moment correlation coefficient, which is:

$$r = - \cdot 0014 \pm \cdot 0278,$$

clearly non-significant.

We have already drawn attention to the difficulty attending sign in astigmatism, where both positive and negative astigmatism may be considered undesirable. If, however, we pay attention to sign we have the following system of array-means:

Grade of Income	General Astigmatism in Dioptres
2·35*s*. "per adult"	− ·1313 ± ·0776
3·45 ,,	− ·3301 ± ·0412
4·45 ,,	− ·3403 ± ·0472
5·45 ,,	− ·2609 ± ·0418
6·45 ,,	− ·0841 ± ·0644
7·45 ,,	− ·3454 ± ·0796
9·03 ,,	− ·0987 ± ·0796
16·45 ,,	− ·3898 ± ·0962
General Population*:	− ·2824 ± ·0191
"Comfortable":	− ·4046 ± ·0563

* Omitting "Comfortable" Means: Income: 5·5180*s*.; Astigmatism (without regard to sign): ·3240 D.
Standard Deviations: Income: 3·0361*s*.; Astigmatism (,, ,, ,,): ·7163 D.

Here again the only array-mean to which we can attribute significant divergence is that at 6·45*s*., but there appears no reason why this array, slightly above the mean income, should be one of minimum astigmatism; the array-means suggest no orderly sequence. Turning to the general measure of association we have for the correlation ratio of astigmatism on income:

$$\eta'^2_{GA.I} = \cdot 019{,}386, \qquad \bar{\eta}^2_{GA.I} = \cdot 012{,}048 \pm \cdot 004{,}040.$$

Having regard to the probable error of $\bar{\eta}^2$ it is not possible to assert significance. Deviations in General Astigmatism of about a quarter of a dioptre, even if η' were significant, would be of no practical importance. It does not appear that General Astigmatism is influenced by Familial Income.

(*f*) *Familial Income and Corneal Astigmatism.* Here again we regret the small amount of our data. The accompanying table is based upon *A* and *B*'s observations only:

Table CCCXI. *Familial Income and Corneal Astigmatism.*

Income "per Adult" in Shillings

Corneal Astigmatism in Dioptres (Central Values)	1·95–2·95	2·95–3·95	3·95–4·95	4·95–5·95	5·95–6·95	6·95–7·95	7·95–8·95	8·95–9·95	9·95–10·95	10·95–11·95	. .	14·95–15·95	15·95–16·95	16·95–17·95	. .	22·95–23·95	. .	27·95–28·95	"Comfortable"	Totals
− 1·50	—	—	2	—	3	—	—	—	—	—	. .	—	—	—	. .	—	. .	—	—	5
− 0·75	2	2	—	1	4	2	—	—	—	—	. .	—	—	—	. .	—	. .	—	—	11
0·00	4	8	6	10	16	5	1	—	2	2	. .	—	—	1	. .	—	. .	—	1	56
+ 0·75	3	24	15	30	15	4	11	2	2	1	. .	2	—	3	. .	2	. .	2	3	119
+ 1·50	1	1	5	4	—	1	—	—	1	1	. .	—	—	—	. .	—	. .	—	—	14
+ 2·25	—	1	4	3	—	—	—	—	—	2	. .	—	—	—	. .	—	. .	—	1	11
+ 3·00	—	2	—	—	—	—	—	—	1	—	. .	—	—	—	. .	—	. .	—	—	3
+ 3·75	—	1	1	—	—	—	—	—	—	—	. .	—	2	—	. .	—	. .	—	1	5
+ 4·50	—	1	1	—	—	—	—	—	—	—	. .	—	—	—	. .	—	. .	—	—	2
+ 5·25	—	2	—	—	—	—	—	—	—	—	. .	—	—	—	. .	—	. .	—	—	2
Totals	10	42	34	48	38	12	12	2	6	6	. .	2	2	4	. .	2	. .	2	6	228

We will consider first the array-means:

Grade of Income "per Adult"	Corneal Astigmatism in Dioptres: Sign Disregarded	Sign Regarded
2·45*s*.	·5250 ± ·1960	·2250 ± ·2153
3·45*s*.	1·1429 ± ·0956	1·0714 ± ·1050
4·45*s*.	1·1471 ± ·1063	·9706 ± ·1167
5·45*s*.	·7500 ± ·0895	·7187 ± ·0982
6·45*s*.	·4934 ± ·1006	·0987 ± ·1104
7·95*s*.	·5938 ± ·1265	·4688 ± ·1389
10·74*s*.	1·0179 ± ·1657	1·0179 ± ·1819
19·78*s*.	1·1875 ± ·1789	1·1875 ± ·1965
General Population*:	·8684 ± ·0411	·7303 ± ·0451
"Comfortable":	1·3750 ± ·2531	1·3750 ± ·2779

Several of these array-means are significant and others approach significance. Further, the series have some approach to regularity, though not one in which a continuous rise in familial income denotes a continuous fall in astigmatism. Diagram 137 shows the nature of the curve; it indicates that homes with low familial income and with an income slightly over the mean have boys with low corneal astigmatism, while homes with income below the mean but not in quite the lowest grade and homes with the highest familial income produce boys with the higher corneal

* Standard Deviation: sign disregarded: ·9190 D.; sign regarded: 1·0092 D.

astigmatism. The significance of this curious relationship is confirmed on examination of the correlation ratio of Corneal Astigmatism on Income. We have:

Disregarding sign:

$$\eta'^2_{CA.I} = \cdot 092{,}877, \qquad \bar{\eta}^2_{CA.I} = \cdot 035{,}088 \pm \cdot 011{,}597.$$

Regarding sign:

$$\eta'^2_{CA.I} = \cdot 139{,}397, \qquad \bar{\eta}^2_{CA.I} = \cdot 035{,}088 \pm \cdot 011{,}597.$$

Having regard to the probable errors η'^2 is in both cases significant, and the indication is that of a corrected correlation ratio of the order ·31 to ·30. It is true that the range of Corneal Astigmatism associated with Familial Income is not great, about $\frac{1}{3}$ D. on either side the mean, but it is none the less important to interpret it.

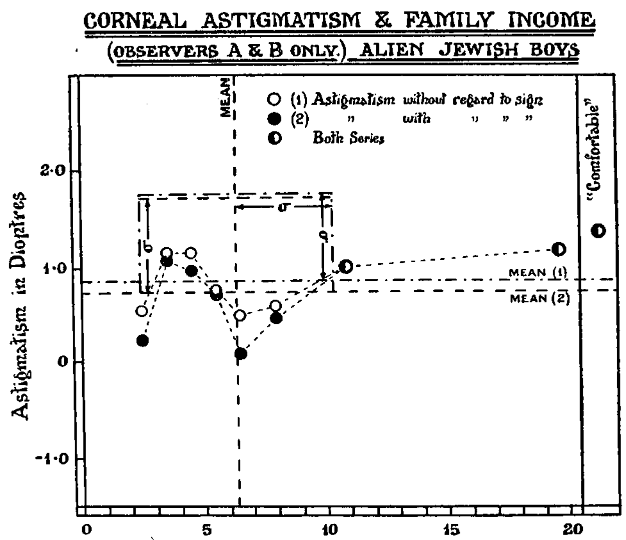

Diagram 137.

To investigate the matter further we correlated Corneal Astigmatism with the numerator (Total Family Income) and with the denominator (meaning roughly Size of Family*) of the index, Familial Income "per adult." Table CCCXII contains the data for Corneal Astigmatism and Total Family Income.

Table CCCXII. *Corneal Astigmatism and Total Family Income* (*A and B only*).

Total Family Income in Shillings

Corneal Astigmatism: Dioptres	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	..	100	..	120	Comfortable	Totals
− 1·50	—	—	2	1	1	—	1	—	—	—	—	—	—	—	—	—	..	—	..	—	—	5
− 0·75	—	1	2	2	2	1	2	—	—	—	—	—	—	1	—	—	..	—	..	—	—	11
0·00	2	4	10	7	9	6	10	4	1	—	1	—	—	1	—	—	..	1	..	—	1	57
+ 0·75	2	4	18·5	11	16·5	15	24	5	2	3	4	2	2	2	—	—	..	5	..	—	3	119
+ 1·50	—	1	1	4·5	0·5	4	1	1	—	2	—	—	—	—	1	—	..	—	..	—	—	16
+ 2·25	—	—	4·5	2·5	—	—	1	2	—	—	—	—	—	—	1	2	..	—	..	—	1	14
+ 3·00	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	..	—	..	—	—	1
+ 3·75	—	—	—	—	1	2	—	—	—	—	—	—	—	—	—	—	..	—	..	2	1	6
+ 4·50	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	—	1
+ 5·25	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	—	—	2
Totals	4	12	38	28	31	28	39	12	3	6	5	2	2	4	2	2	..	6	..	2	6	232

Turning to the means of the arrays, we have:

Income Grade	Corneal Astigmatism in Dioptres: Without regard to Sign	With regard to Sign
13·75*s*.	1·078 ± ·151	·984 ± ·166
20*s*.	·790 ± ·098	·553 ± ·108
25*s*.	·844 ± ·114	·629 ± ·126
30*s*.	·786 ± ·108	·593 ± ·119
35*s*.	·911 ± ·114	·857 ± ·126
40*s*.	·635 ± ·097	·481 ± ·106
50·77*s*.	·865 ± ·118	·865 ± ·130
87*s*.	1·237 ± ·135	1·116 ± ·149
General Population†:	·866 ± ·040	·731 ± ·044
"Comfortable":	1·375 ± ·246	1·375 ± ·271

* Usually the family consists of two adults and the children, occasionally only there is an additional relative. The children are reduced to adults. The existence of the two adults is immaterial for correlation.

† Standard Deviation: without regard to sign = ·8951 D.; with regard to sign = ·9854 D.

The differences of the array-means from the general population means hardly show significance except in the case of total incomes of 40*s*. and 87*s*. Diagram 138 suggests, however, a more or less continuous curve of a parabolic nature, i.e. the maxima of Corneal Astigmatism with low and high total incomes. If we find the correlation ratio we have:

Without regard to sign:

$\eta'^2_{CA.TI} = \cdot 040{,}958$, $\quad \bar{\eta}^2_{CA.TI} = \cdot 034{,}483 \pm \cdot 011{,}405$.

With regard to sign:

$\eta'^2_{CA.TI} = \cdot 056{,}314$, $\quad \bar{\eta}^2_{CA.TI} = \cdot 034{,}483 \pm \cdot 011{,}405$.

It is clear that we cannot definitely assert that η'^2 differs from $\bar{\eta}^2$ significantly. There may be a slender association between Corneal Astigmatism and Total Income, but we are not able definitely to assert its existence. It does not suffice to account for the more substantial association between Corneal Astigmatism and Income "per adult."

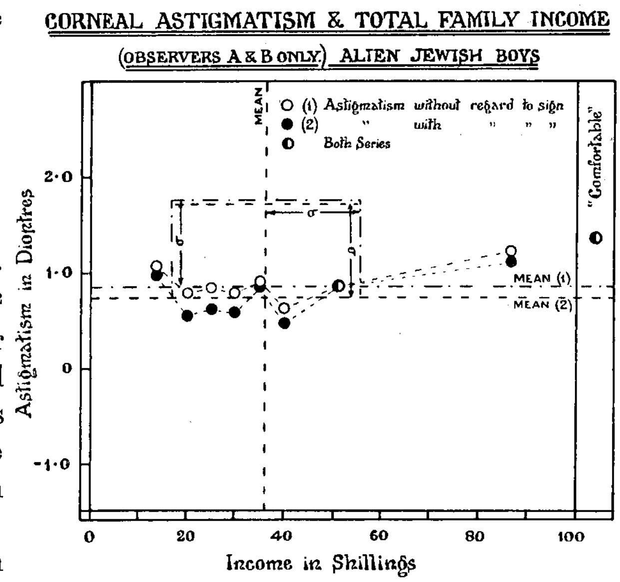

Diagram 138.

We next proceeded to determine the association between Corneal Astigmatism and Size of Family. This may appear absurd; it seems impossible to imagine how the size of the family into which a child is born can influence his astigmatism. But this is not the right way to approach the matter. Size of Family may be highly correlated with some factor, such as age, which does influence Corneal Astigmatism. Our data are provided in Table CCCXIII.

Table CCCXIII. *Corneal Astigmatism and Size of Family* (*A and B only*).

Size of Family

Dioptres	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Totals
− 1·50	—	—	—	2	1	—	2	—	—	—	—	—	—	—	—	5
− 0·75	—	—	—	—	2	2	1	5	1	1	1	—	—	—	—	13
0·00	—	1	4	4	9	12	9	9	8	6	7	—	—	—	—	69
+ 0·75	—	5	10	11	12	27	12	16	15	15	7	5	5	—	2	142
+ 1·50	—	—	—	1	1	4	3	1	2	5	1	—	1	—	—	19
+ 2·25	—	—	—	2	1	3	—	3	1	3	—	1	—	3	—	17
+ 3·00	—	—	—	—	2	—	1	—	—	—	—	—	—	—	—	3
+ 3·75	—	—	—	—	—	—	—	2	1	—	2	—	—	—	—	5
+ 4·50	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	2
+ 5·25	—	—	—	—	—	—	2	—	—	—	—	—	—	1	—	3
Totals	—	6	14	20	28	48	30	38	28	30	18	6	6	4	2	278

The constants of this distribution are as follows:

Size of Family: Mean: 7·4173; Standard Deviation: 2·7092.

Corneal Astigmatism: Mean: Without regard to sign: ·8741 D.; With regard: ·7500 D.

Corneal Astigmatism, Standard Deviation: Without regard to sign: ·9201 D.; With regard: 1·0006 D.

The correlation ratios are given by:

Without regard to sign:

$$\eta'^2_{CA.SF} = \cdot 044{,}295, \qquad \bar{\eta}^2_{CA.SF} = \cdot 032{,}374 \pm \cdot 010{,}107.$$

With regard to sign:

$$\eta'^2_{CA.SF} = \cdot 038{,}242, \qquad \bar{\eta}^2_{CA.SF} = \cdot 032{,}374 \pm \cdot 010{,}107.$$

Having regard to the probable error of $\bar{\eta}^2$ we cannot certainly assert significance on the basis of the numbers dealt with; the deviation of η'^2 from $\bar{\eta}^2$ is of the order of the probable error of the latter.

Nevertheless, if we plot the array-means we see a definite trend to increased Corneal Astigmatism with increased Size of Family (Diagram 139). Proceeding then by the product moment method, we find:

Disregarding Sign:

$$r = + \cdot 1427 \pm \cdot 0396.$$

Regarding Sign:

$$r = + \cdot 1662 \pm \cdot 0393.$$

These are both significant having regard to their probable errors*.

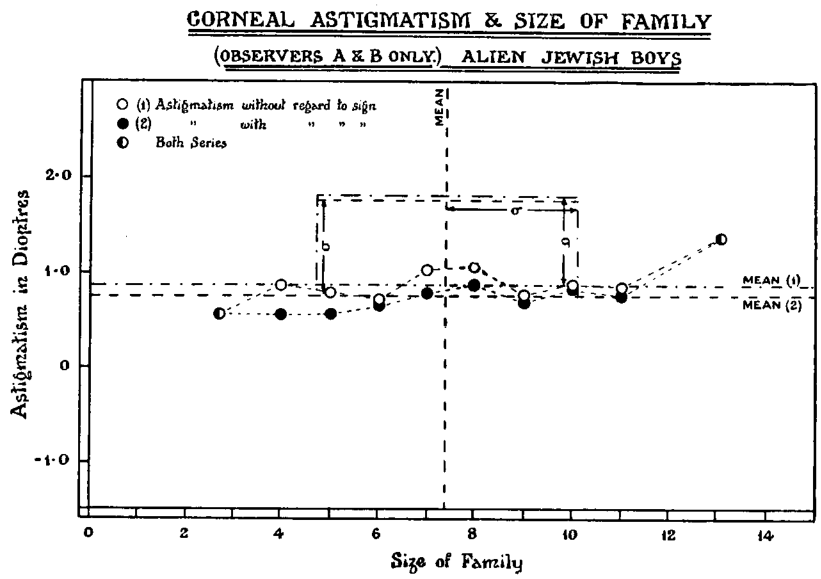

Diagram 139.

Hence it seems to us that the essential factor in the correlation of Corneal Astigmatism and Income "per adult" is Size of Family. This seems to shift the association from the economic ground to some physiological ground. Corneal Astigmatism changes, if but slightly, with age (see *Annals of Eugenics*, Vol. II, p. 133); could it be that Size of Family was a measure of the boy's age? We proceeded to correlate Age and Size of Family.

Table CCCXIV. *Age of Boy and Size of Family.*

Size of Family

Central Ages	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Totals
6·4583	—	—	2	1	—	—	—	—	—	—	—	—	—	—	—	3
7·4583	—	2	6	6	8	7	7	6	9	1	1	1	—	—	—	54
8·4583	1	6	7	8	18	19	15	12	13	10	6	1	2	—	—	118
9·4583	—	2	5	11	13	12	14	13	4	11	2	2	2	—	—	91
10·4583	1	4	3	5	12	16	15	19	14	7	5	3	—	—	—	104
11·4583	2	—	2	8	18	18	12	12	23	5	5	2	1	—	—	108
12·4583	1	7	13	22	38	46	51	55	42	33	18	10	2	1	2	341
13·4583	1	5	5	7	13	29	27	21	21	14	14	9	1	1	1	169
14·4583	—	1	1	5	4	7	5	6	2	5	1	2	1	—	—	40
15·4583	—	—	—	1	—	1	—	—	—	—	—	—	—	—	—	2
Totals	6	27	44	74	124	155	146	144	128	86	52	30	9	2	3	1030

The mean size of family for each age of boy was then ascertained with the following results:

Age in Years	Mean Size of Family
7·406	6·123 ± ·223
8·458	6·712 ± ·155
9·458	6·813 ± ·177
10·458	7·096 ± ·165
11·458	7·241 ± ·162
12·458	7·334 ± ·091
13·458	7·592 ± ·130
14·546	7·048 ± ·260
General Population†:	7·1320 ± ·0525

* The reader must bear in mind that if the correlation be roughly linear r will often give a significant result, while η' fails to indicate significance with certainty.

† Standard Deviation: 2·4994. The mean and standard deviation of age are 11·3962 and 1·9168 years respectively.

This shows a continual increase of size of family with age of boy. The drop in the last age group is probably due to those boys of 14, who belong to large families, leaving rather earlier to earn their living, than other boys of the same age. At first sight it may seem odd that a boy's age should be associated with the number of his brothers and sisters, but the explanation is fairly simple. The boys go at a fairly early age to school, and are then the elder or eldest boys of the family, their brothers and sisters increase during their school years, and so they become at older ages members of larger families. Of course their younger brothers and sisters might and do go on to school, but it was rather rare to find brothers and sisters in this school, either because there was a tendency to send only the elder-born to the school, or because many of the younger-born were not yet ripe to come. We have thus, so to speak, opposing factors and they appear in this case to leave the balance with the elder-born. Diagram 140 indicates the relationship. The correlation, as found by the product moment method, is:

$$r = +\cdot1340 \pm \cdot0206.$$

This is quite significant and obvious on the diagram; the regression line is:

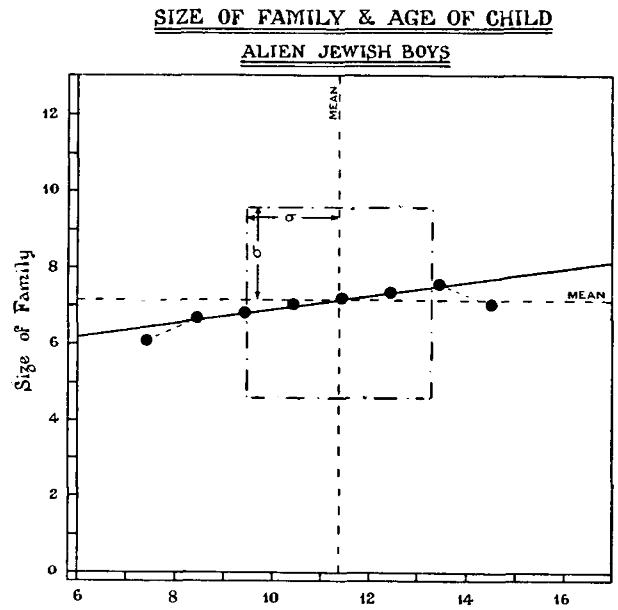

Diagram 140.

$$\text{Size of Family} = \cdot1747 \text{ Age in Years} + 5\cdot1408.$$

But the relationship, if quite significant, is far too small for us to suppose that size of family is a real measure of a boy's age, and so of the age factor introduced into the association of Corneal Astigmatism and Size of Family. Again, we have shown in Section C, *Annals*, Vol. II, p. 133, that the Correlation of Corneal Astigmatism and Age is itself small, and *two* small correlations will not suffice to give the requisite association of Corneal Astigmatism and Size of Family.

Possible explanations are: (i) that the larger families are the product of weaker stocks, or stocks more liable to defects of growth, or (ii) that large families involve later born children and that these are liable to such defects. We may test these suggestions by considering (*a*) the health of

Table CCCXV. *Size of Family and Place of Boy therein.*

Place in Family \ Size of Family	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Totals
1	6	15	17	25	29	20	17	9	2	1	—	—	—	—	—	141
2	—	12	16	24	30	31	22	10	5	2	—	1	—	—	—	153
3	—	—	11	14	27	34	14	23	10	3	1	—	—	—	—	137
4	—	—	—	11	20	25	25	26	16	4	3	1	—	—	—	131
5	—	—	—	—	18	23	30	22	18	13	4	2	1	—	—	131
6	—	—	—	—	—	22	16	18	19	12	8	3	1	—	—	99
7	—	—	—	—	—	—	23	18	21	11	6	3	1	—	—	83
8	—	—	—	—	—	—	—	16	12	12	9	4	—	—	—	53
9	—	—	—	—	—	—	—	—	23	18	6	2	1	—	—	50
10	—	—	—	—	—	—	—	—	—	11	6	5	—	1	—	23
11	—	—	—	—	—	—	—	—	—	—	8	2	2	1	—	13
12	—	—	—	—	—	—	—	—	—	—	—	7	3	—	3	13
Totals	6	27	44	74	124	155	147	142	126	87	51	30	9	2	3	1027

parents and size of family, (*b*) the Place of Boy in Family and his liability to Corneal Astigmatism. If the latter gave any significant correlation the Place in Family is so associated with Size of Family that we should have an explanation of the association found between Corneal Astigmatism and Income per Adult. We can at once show that a boy's Place in Family is so highly correlated with its size that if Place in Family be even moderately associated with defects then Size of Family will also be correlated with those defects. The requisite table will be found on p. 49.

The constants of this table are:

Means: Size of Family: 7·1256;
Place in Family: 4·4937.

Standard Deviations: Size of Family: 2·5167;
Place in Family: 2·6909.

Product Moment Correlation Coefficient:

$$r = \cdot 7260 \pm \cdot 0100.$$

The boy's Place in Family is thus closely correlated with Size of Family in the actual data; indeed, more closely correlated than if the boys were picked at random from each family*. Diagram 141 shows the actual regression straight line and the corresponding "theoretical" line based on random sampling from families of each size.

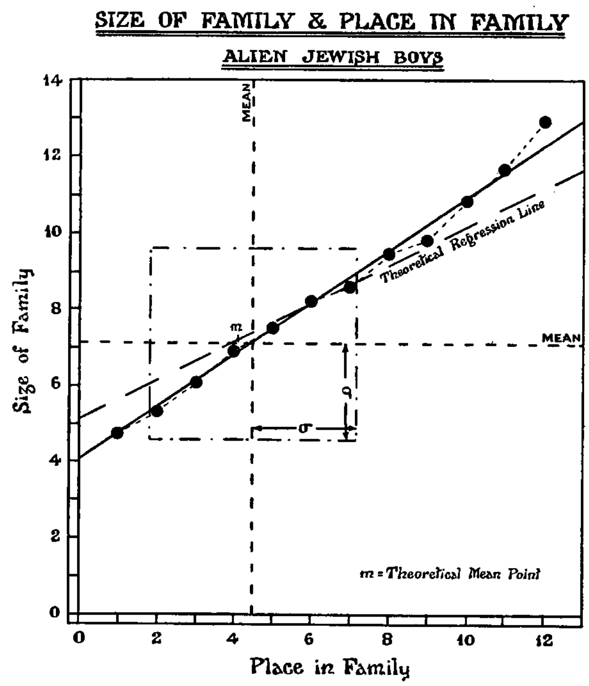

Diagram 141.

It now remains for us to consider Corneal Astigmatism and Place in Family of the boy.

* A close distribution of places to a frequency of families like this with the boys drawn at random would be as follows:

Table CCCXVI. *Size of Family and Place in Family, if Boy drawn at random.*

Size of Family

Place in Family	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Totals
1	8	12	16	19	25	26	21	18	14	9	5	3	1	·5	·2	177·7
2	—	12	16	19	25	26	21	18	14	9	5	3	1	·5	·2	169·7
3	—	—	16	19	25	26	21	18	14	9	5	3	1	·5	·2	157·7
4	—	—	—	19	25	26	21	18	14	9	5	3	1	·5	·2	141·7
5	—	—	—	—	25	26	21	18	14	9	5	3	1	·5	·2	122·7
6	—	—	—	—	—	26	21	18	14	9	5	3	1	·5	·2	97·7
7	—	—	—	—	—	—	21	18	14	9	5	3	1	·5	·2	71·7
8	—	—	—	—	—	—	—	18	14	9	5	3	1	·5	·2	50·7
9	—	—	—	—	—	—	—	—	14	9	5	3	1	·5	·2	32·7
10	—	—	—	—	—	—	—	—	—	9	5	3	1	·5	·2	18·7
11	—	—	—	—	—	—	—	—	—	—	5	3	1	·5	·2	9·7
12	—	—	—	—	—	—	—	—	—	—	—	3	1	·5	·2	4·7
13	—	—	—	—	—	—	—	—	—	—	—	—	1	·5	·2	1·7
14	—	—	—	—	—	—	—	—	—	—	—	—	—	·5	·2	0·7
15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	·2	0·2
Totals	8	24	48	76	125	156	147	144	126	90	55	36	13	7	3	1058

Here: Mean Size of Family: 7·2108; Mean Place in Family: . 4·1054.
Standard Deviation: Size of Family: 2·6069; Standard Deviation: Place in Family: 2·5524.

The correlation is ·5107 and the regression of Place in Family upon Size of Family of course $\frac{1}{2}$. Actually in the small families there is an excess of boys with low places, and in the large families an excess of boys with high places.

We will deal only with the more reliable observations of the observers A and B. Our data are given in Table CCCXVII below.

Table CCCXVII. *Corneal Astigmatism and Place in Family.*

Corneal Astigmatism in Dioptres / Place in Family	1	2	3	4	5	6	7	8	9	10	11	12	Totals
− 1·50	—	—	2	1	—	2	—	—	—	—	—	—	5
− 0·75	3	—	1	3	—	1	2	2	—	—	1	—	13
0·00	19	5	7	11	6	2	6	6	3	1	2	—	68
+ 0·75	17	19	20	23	22	9	10	4	7	1	5	4	141
+ 1·50	2	5	1	3	3	2	2	—	—	1	—	—	19
+ 2·25	2	2	—	1	3	—	3	2	—	3	1	—	17
+ 3·00	1	1	1	—	—	—	—	—	—	—	—	—	3
+ 3·75	—	—	1	—	1	2	1	—	—	—	—	—	5
+ 4·50	—	—	1	—	1	—	—	—	—	—	—	—	2
+ 5·25	2	—	—	—	—	—	—	—	—	—	1	—	3
Totals	46	32	34	42	36	18	24	14	10	6	10	4	276

The constants of this table are as follows:

Mean Place: 4·5507; Standard Deviation of Place: 2·8567.

Corneal Astigmatism: Mean: Disregarding Sign, ·8777 D.; Regarding Sign, ·7527 D.

Corneal Astigmatism: Standard Deviation: Disregarding Sign, ·9219 D.; Regarding Sign, 1·0034 D.

Product Moment Correlation Coefficient:

Disregarding Sign: $r = \cdot 0527 \pm \cdot 0405$;
Regarding Sign: $r = \cdot 0402 \pm \cdot 0405$.

Thus r in either case does not differ significantly from zero.

Correlation Ratio of Corneal Astigmatism on Place in Family:

Disregarding Sign:

$$\eta'^2_{CA.PF} = \cdot 025{,}198, \qquad \bar{\eta}^2_{CA.PF} = \cdot 032{,}609 \pm \cdot 010{,}181.$$

Regarding Sign:

$$\eta'^2_{CA.PF} = \cdot 031{,}971, \qquad \bar{\eta}^2_{CA.PF} = \cdot 032{,}609 \pm \cdot 010{,}181.$$

Thus η'^2 in both ways of approaching Corneal Astigmatism is less than $\bar{\eta}^2$, or does not differ significantly from the value when there is no association. Accordingly we cannot assert that Corneal Astigmatism is related to Size of Family because either late or early born are more liable to suffer from it. Our second possible explanation thus falls to the ground.

If we turn now to the Parents' Health and the Size of Family we find small but significant correlation ratios of Size of Family on Health. These are very difficult to interpret as the array-means give no clue. The "Robust" parents in the case of both Father and Mother have the fewest children, and their differences from the General Population are significant, but in the case of both Father and Mother the "Very Robust" parents have the largest families, yet here the differences are not significant. It is, however, clear that we cannot assert that a large family is associated with bad health, or that the relation of Corneal Astigmatism to Size of Family is due to large families coming from generally degenerate stock.

Table CCCXVIII. *Parents' Health and Size of Family**.

	Father's Health							Mother's Health						
	VR.	*R.*	*N.*	*RD.*	*D.*	*VD.*	Totals	*VR.*	*R.*	*N.*	*RD.*	*D.*	*VD.*	Totals
1	—	2	—	1	—	—	3	—	1	1	1	—	—	3
2	1	13	4	5	—	—	23	1	11	9	1	1	—	23
3	—	18	8	2	2	2	32	—	12	13	4	3	—	32
4	3	29	15	8	5	—	60	—	22	24	9	4	1	60
5	1	45	24	18	13	3	104	1	41	36	16	7	2	103
6	2	51	46	16	15	3	133	4	29	56	20	18	6	133
7	—	41	48	25	12	2	128	1	34	54	23	13	3	128
8	2	48	38	20	15	9	132	2	38	60	17	11	3	131
9	3	37	39	21	10	2	112	2	29	50	18	13	—	112
10	2	19	28	14	11	1	75	2	13	46	7	6	1	75
11	3	14	16	7	6	2	48	2	9	24	6	6	1	48
12	—	10	9	6	—	2	27	—	8	15	2	2	—	27
13	1	4	—	3	—	—	8	1	1	4	1	1	—	8
14	—	1	1	—	—	—	2	—	1	1	—	—	—	2
15	—	1	1	1	—	—	3	—	1	1	1	—	—	3
Totals	18	333	277	147	89	26	890	16	250	394	126	85	17	888

We have the following mean Sizes of Family for given Health Grades in Father and Mother:

Health Grades	Mean Size of Family: Father	Mean Size of Family: Mother
Very Robust	$7{\cdot}778 \pm {\cdot}396$	$7{\cdot}938 \pm {\cdot}420$
Robust	$6{\cdot}841 \pm {\cdot}092$	$6{\cdot}784 \pm {\cdot}106$
Normal	$7{\cdot}480 \pm {\cdot}101$	$7{\cdot}520 \pm {\cdot}085$
Rather Delicate	$7{\cdot}497 \pm {\cdot}138$	$7{\cdot}127 \pm {\cdot}150$
Delicate	$7{\cdot}315 \pm {\cdot}178$	$7{\cdot}400 \pm {\cdot}182$
Very Delicate	$7{\cdot}654 \pm {\cdot}329$	$6{\cdot}824 \pm {\cdot}407$
General Population:	$7{\cdot}238 \pm {\cdot}056$	$7{\cdot}240 \pm {\cdot}056$

From these means we find:

$$\eta'^2_{SF.FH} = {\cdot}016{,}127, \qquad \bar{\eta}^2_{SF.FH} = {\cdot}005{,}618 \pm {\cdot}002{,}389,$$
$$\eta'^2_{SF.MH} = {\cdot}017{,}707, \qquad \bar{\eta}^2_{SF.MH} = {\cdot}005{,}631 \pm {\cdot}002{,}386.$$

Both η'^2's are in all probability therefore significant, and we have:

$$\eta'_{SF.FH} = {\cdot}1270, \qquad \eta'_{SF.MH} = {\cdot}1331.$$

It is difficult to find a reason for the sequence of array-means given above, and in the case of small associations such as these any unriddling seems improbable without much more material than we have at our disposal.

A somewhat more reasonable result is obtained if we inquire what is the Mother's Health for a given Size of Family. Here we find:

$$\eta'^2_{MH.SF} = {\cdot}020{,}544, \qquad \bar{\eta}^2_{MH.SF} = {\cdot}009{,}009 \pm {\cdot}003{,}002.$$

Thus η'^2 appears to be significant in relation to $\bar{\eta}^2$, and we have:

$$\eta'_{MH.SF} = {\cdot}1433,$$

a small but sensible association.

* Mother's Health not given in two cases where Father's Health was given. As usual *VR.* = Very Robust, *R.* = Robust, *N.* = Normal, *RD.* = Rather Delicate, *D.* = Delicate, *VD.* = Very Delicate. No family is included for which both parents were not alive at time of record, and thus the families are incomplete.

The means of arrays are given in Diagram 142 and notwithstanding their irregularity we see a distinct tendency for the Mother's Health to be worse when she has a larger family. This is a point which has been remarked on before in publications of the Galton Laboratory, but it has also been pointed out therein that there is a decadence of Health with Age and that the Mothers with larger families are older. On the whole we do not think there is enough evidence to show that the boys from large families come of markedly pathological stocks and so are more liable to corneal astigmatism. Any-one who has dealt with these small correlations (·1 to ·15) knows how elusive they are and how difficult it is to trace their sources. It is almost adequate to say that, although significant, they are of no importance for unriddling the causes of observed relations of their own or even somewhat higher numerical order.

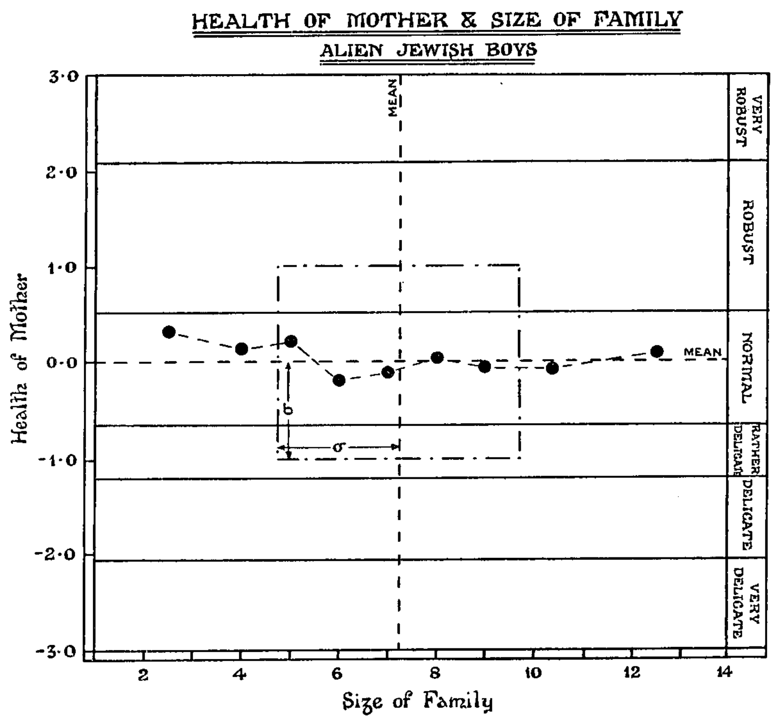

Diagram 142.

Summary. In general we have not succeeded in finding a relation between economic conditions and ocular characters, but there does appear to be an association of a somewhat complicated kind, which we have not succeeded in unriddling, between Corneal Astigmatism and Economic Conditions. This is the more noteworthy in that there is small doubt that Corneal Astigmatism is largely determined by heredity.

(ix) *Miscellaneous Factors and Ocular Characters.*

While working out various environmental factors in their relation to our ocular characters, we tried certain other factors, with a view to testing whether they would lead us to associations, which would not only be significant, but of an intensity useful for practical purposes. The reader must remember that our questionnaire covered a very wide field and to work out all possible correlations would not only involve an immense amount of labour, but an impossible cost in printing*. All this section attempts is to give some of these exploratory researches which may throw a little light on topics already referred to in earlier portions of this part of our memoir.

(*a*) *Familial Income and Parental "Sight."* We have already drawn attention to the vague observations which were all we were able to make on parental "sight." We have, however, attempted to see whether such "sight" affects economic conditions.

If we deal with an individual parent we are only able to classify into "good" and "bad" sight, and must use the biserial method. If we combine the two parents we can form three classes, i.e. both parents good sight; one good, one bad; and both with bad sight. We have then the table on p. 54.

* We very strongly condemn the practice—if it can possibly be avoided—of publishing correlation coefficients unaccompanied by data. There is no check on the work, and no means of determining whether the correlation coefficient is justifiably used.

Table CCCXIX. *Parental Sight and Familial Income.*

Income "per Adult" in Shillings

Sight Classes	0·95–1·95	1·95–2·95	2·95–3·95	3·95–4·95	4·95–5·95	5·95–6·95	6·95–7·95	7·95–8·95	8·95–9·95	9·95–10·95	10·95–11·95	11·95–12·95	12·95–13·95	13·95–14·95	14·95–15·95	15·95–16·95	16·95–17·95	..	22·95–23·95	..	27·95–28·95	"Comfortable"	Totals
Both Parents																							
Both Good	2	11	36	42	40	23	14	10	2	4	3	—	1	—	3	—	1	..	1	..	1	38	232
One Good, one Bad	—	8	26	16	21	4	6	3	1	—	—	—	1	1	—	—	1	..	—	..	—	4	92
Both Bad	1	4	12	6	13	2	1	1	1	—	—	—	—	—	—	1	—	..	—	..	—	2	44
Totals	3	23	74	64	74	29	21	14	4	4	3	—	2	1	3	1	2	..	1	..	1	44	368
Father																							
Good	2	15	46	52	52	24	18	12	2	4	3	—	2	—	3	—	1	..	1	..	1	40	278
Bad	1	8	30	15	23	6	3	3	2	—	—	—	—	1	—	1	1	..	—	..	—	4	98
Totals	3	23	76	67	75	30	21	15	4	4	3	—	2	1	3	1	2	..	1	..	1	44	376
Mother																							
Good	2	15	53	51	49	27	16	11	2	4	3	—	1	1	3	—	2	..	1	..	1	40	282
Bad	1	8	21	14	25	2	5	3	2	—	—	—	1	—	—	1	—	..	—	..	—	4	87
Totals	3	23	74	65	74	29	21	14	4	4	3	—	2	1	3	1	2	..	1	..	1	44	369

Omitting the "Comfortable" we have the following results:

Mean Income "per Adult"

Sight	Both Parents	Sight	Father	Mother
Both Good	5·775*s*. ± ·144	Good	5·635*s*. ± ·129	5·615*s*. ± ·129
One Good	5·064*s*. ± ·214	—	—	—
Both Bad	4·879*s*. ± ·310	Bad	5·003*s*. ± ·205	5·016*s*. ± ·220
General Population*	5·465*s*. ± ·112	—	5·456*s*. ± ·109	5·462*s*. ± ·111

It will be seen from this that, although these results are not significantly different having regard to their probable errors, there is still a fair amount of evidence that bad sight in one or other parent, still more in both parents, is accompanied by a reduced family income. If the lower income directly flows from the bad sight, i.e. less earning power of the parents, there is a reason why the income when *both* parents have bad sight should be smaller. But if the bad sight is the result of a bad environment and not the lesser income the result of bad sight, it is not so easily explicable why a lessened income should follow both parents having bad sight. Of course the correlations are small and of little use for prognosis. We have by triserial and biserial methods:

Both Parents' "Sight" and Familial Income: $r_{tri} = \cdot 1055 \pm [\cdot 0592]\dagger$.
Father's "Sight" and Familial Income: $r_{bi} = \cdot 1312 \pm \cdot 0630$.
Mother's "Sight" and Familial Income: $r_{bi} = \cdot 1193 \pm \cdot 0675$.

These seem probably significant taken as a whole, although none of them is individually significant and the coefficients are small. Yet it may be inferred that bad sight in the wage-earners is accompanied by lesser familial income.

(*b*) *Parental "Sight" and Rental "per Adult."* We controlled the results given in the last sub-

* Standard Deviations: Parents, 2·9762*s*.; Father, 2·9506*s*.; Mother, 2·9721*s*.
† Calculated as for a biserial coefficient; it will be slightly in excess of true value.

section by making a similar investigation on "Sight" of the wage-earners and Rental "per adult." The following table gives the data:

Table CCCXX. *Parental "Sight" and Rental "per Adult."*

Rent "per Adult" in Shillings per Week

Sight Classes	·55–·75	·75–·95	·95–1·15	1·15–1·35	1·35–1·55	1·55–1·75	1·75–1·95	1·95–2·15	2·15–2·35	2·35–2·55	2·55–2·75	2·75–2·95	2·95–3·15	3·15–3·35	3·35–3·55	3·55–3·75	3·75–3·95	3·95–4·15	4·15–4·35	Totals
Both Parents																				
Both Good	4	14	22	56	36	24	14	5	—	7	—	2	—	2	1	—	1	1	1	190
One Good	—	6	17	26	17	11	3	4	1	—	—	—	—	—	—	—	—	—	—	85
Both Bad	—	8	7	11	6	7	2	1	1	—	2	—	—	—	—	—	—	—	—	45
Totals	4	28	46	93	59	42	19	10	2	7	2	2	—	2	1	—	1	1	1	320
Father																				
Good	4	18	35	67	44	28	17	7	—	7	—	2	—	2	1	—	1	1	1	235
Bad	—	11	15	27	17	14	3	3	2	—	2	—	—	—	—	—	—	—	—	94
Totals	4	29	50	94	61	42	20	10	2	7	2	2	—	2	1	—	1	1	1	329
Mother																				
Good	4	16	29	71	47	31	15	7	1	8	—	2	—	2	1	—	1	1	1	237
Bad	—	12	17	22	13	11	4	3	1	—	2	—	—	—	—	—	—	—	—	85
Totals	4	28	46	93	60	42	19	10	2	8	2	2	—	2	1	—	1	1	1	322

Proceeding as with Familial Income we have:

Mean Rental "per Adult" per week.

Sight	Both Parents	Sight	Father	Mother
Both Good	1·476*s*. ± ·024	Good	1·443*s*. ± ·021	1·462*s*. ± ·022
One Good	1·344*s*. ± ·036	—	—	—
Both Bad	1·366*s*. ± ·049	Bad	1·363*s*. ± ·034	1·336*s*. ± ·036
General Population*	1·426*s*. ± ·018	—	1·420*s*. ± ·018	1·429*s*. ± ·019

These point in the same direction as in the previous subsection, i.e. where there is bad "sight" there is a slightly worse economic condition.

Turning to the correlation coefficients we see that they are about the same order as in the case of Familial Income:

Both Parents' "Sight" and Rental per adult: $r_{tri} = \cdot 0950 \pm [\cdot 0606]\dagger$.
Father's "Sight" and Rental per adult: $r_{bi} = \cdot 0993 \pm \cdot 0647$.
Mother's "Sight" and Rental per adult: $r_{bi} = \cdot 1509 \pm \cdot 0661$.

Again we cannot assert significance in the individual values, but taken in conjunction with the previous series there does seem a small positive correlation of about the order ·1, between bad economic conditions and poor sight in the parents.

Is the result, however, due to the manner in which we form these indices "Income per adult" and "Rental per adult"? In order to throw more light on this we correlated the former of these

* Standard Deviations: Parents, ·4896*s*.; Father, ·4862*s*.; Mother, ·4914*s*.
† Calculated as for a biserial coefficient; it will be slightly in excess of true value.

indices first with the size of family. The data are given in Table CCCXXI. The two regression lines are shown in Diagram 143. The results are striking, although they have been already indicated in other publications of the Galton Laboratory*.

The "Income per adult" falls rapidly as the family increases from 2 to 5 children; it falls less rapidly from 5 to 8, because doubtless some of the older children are beginning to earn; it remains stationary or slightly increases as the family increases from 8 to 14. It is, however, quite clear that the smaller the family the better is the economic position. As the family increases and the parents grow older the income does not increase in like proportion. Children are not arrows in the economic quiver. Again, looking at our diagram the other way about we see that for incomes from 18*s.* to 8*s.* there is no increase in the size of family; the average remains 6 children. But with incomes from 8*s.* to 2*s.* per adult there is a fairly rapid increase in the number of children, those with least to spend having the greatest number of children.

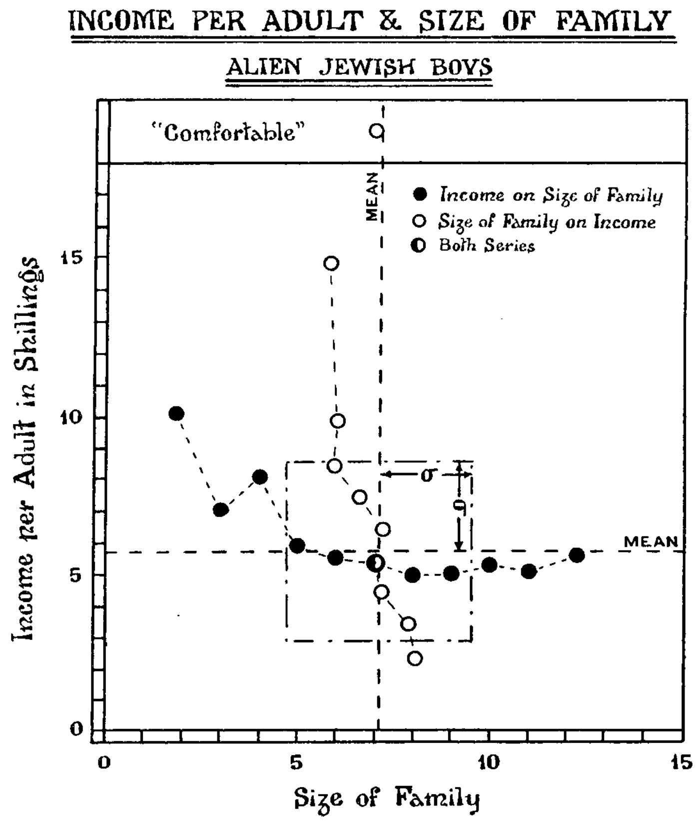

Diagram 143.

Table CCCXXI. *Income "per Adult" and Size of Family.*

Income "per Adult" in Shillings per Week

Size of Family	0·95–1·95	1·95–2·95	2·95–3·95	3·95–4·95	4·95–5·95	5·95–6·95	6·95–7·95	7·95–8·95	8·95–9·95	9·95–10·95	10·95–11·95	11·95–12·95	12·95–13·95	13·95–14·95	14·95–15·95	15·95–16·95	16·95–17·95	17·95–18·95	18·95–19·95	...	22·95–23·95	..	25·95–26·95	.	27·95–28·95	"Comfortable"	Totals
1	—	—	—	1	—	—	—	1	1	1	—	—	—	—	—	—	—	—	—	...	—	..	—	.	—	—	4
2	—	—	2	1	1	—	2	3	—	2	1	—	—	—	1	—	1	1	—	...	—	..	—	.	1	5	21
3	—	1	3	3	2	7	3	5	2	2	1	1	—	—	—	—	—	—	—	...	—	..	—	.	—	6	36
4	—	1	3	11	12	4	5	7	4	2	3	—	—	—	4	—	—	—	1	...	1	..	1	.	—	6	65
5	1	1	18	22	30	9	9	2	2	5	2	—	2	—	—	1	1	—	—	...	—	..	—	.	—	9	114
6	2	6	17	22	28	15	18	6	2	1	2	—	—	—	—	—	—	—	—	...	—	..	—	.	—	10	129
7	—	4	23	33	29	11	12	6	1	—	2	—	1	—	1	—	—	—	—	...	—	..	—	.	—	12	135
8	1	8	38	24	26	8	7	5	2	—	—	—	2	—	—	—	1	—	—	...	—	..	—	.	—	7	129
9	—	14	25	17	23	8	7	4	5	—	—	—	1	—	1	—	—	—	—	...	—	..	—	.	—	6	111
10	—	4	13	17	12	8	4	2	2	2	1	—	—	—	—	—	—	—	—	...	—	..	—	.	—	11	76
11	1	2	12	8	4	7	—	1	1	1	—	—	—	—	—	1	—	—	—	...	—	..	—	.	—	6	44
12	—	1	6	2	4	3	2	1	1	—	1	—	—	1	—	—	—	—	—	...	—	..	—	.	—	1	23
13	—	1	3	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	...	—	..	—	.	—	1	8
14	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	...	—	..	—	.	—	—	1
15	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	...	—	..	—	.	—	—	1
Totals	5	43	164	162	172	81	69	43	23	16	14	1	6	1	7	2	3	1	1	...	1	..	1	.	1	80	897

The constants of this table are:

Mean Family: 7·1204; Standard Deviation, Family: 2·4184.

Mean Income "per Adult": 5·7511*s.*; Standard Deviation, Income: 2·8649*s.*

* See for example: *Eugenics Laboratory Memoirs*, XVIII, "Correlation of Fertility and Social Value," pp. 32–46

It is idle to give a correlation coefficient. The correlation ratio of Income on Size of Family is given by:

$$\eta'^2_{I.F} = \cdot 133{,}488, \qquad \bar{\eta}^2_{I.F} = \cdot 012{,}240 \pm \cdot 003{,}667,$$

η'^2 is accordingly definitely significant, and we have $\eta'_{I.F} = \cdot 3653$, a quite considerable value.

The array-means are as follows:

Size of Family	Mean Income per Adult	Grade of Income	Mean Size of Family
1·8	10·1000*s.* ± ·4320	2·35*s.*	8·1042 ± ·2354
3	7·0167*s.* ± ·3530	3·45*s.*	7·8963 ± ·1274
4	8·0263*s.* ± ·2515	4·45*s.*	7·2160 ± ·1282
5	5·9452*s.* ± ·1885	5·45*s.*	7·0756 ± ·1244
6	5·5508*s.* ± ·1770	6·45*s.*	7·2963 ± ·1812
7	5·4175*s.* ± ·1740	7·45*s.*	6·5652 ± ·1964
8	4·9992*s.* ± ·1750	8·45*s.*	5·9767 ± ·2488
9	5·0976*s.* ± ·1885	9·86*s.*	6·0769 ± ·2612
10	5·3115*s.* ± ·2395	14·81*s.*	5·8205 ± ·2612
11	5·1342*s.* ± ·3135	"Comfortable"	6·9000 ± ·1824
12·39	5·6758*s.* ± ·3470	—	—
General Population:	5·7511*s.* ± ·0675	General Population:	7·1204 ± ·0545

Most of the deviations from the population means are significant and the whole series having regard to their probable errors form fairly continuous curves.

The next point we turned our attention to was the relation of "Income 'per adult'" to the age of the child. The data are provided in Table CCCXXII.

Table CCCXXII. *Income "per adult" and Age of Child.*

Income "per Adult" in Shillings per Week

Central Ages	0·95–1·95	1·95–2·95	2·95–3·95	3·95–4·95	4·95–5·95	5·95–6·95	6·95–7·95	7·95–8·95	8·95–9·95	9·95–10·95	10·95–11·95	11·95–12·95	12·95–13·95	13·95–14·95	14·95–15·95	15·95–16·95	16·95–17·95	17·95–18·95	18·95–19·95	...	22·95–23·95	..	25·95–26·95	.	27·95–28·95	"Comfort-able"	Totals
6·4583	—	—	—	—	—	—	1	1	—	—	—	1	—	—	—	—	—	—	—	...	—	..	—	.	—	—	3
7·4583	—	2	12	9	3	2	4	4	—	1	2	—	1	—	—	—	—	1	—	...	—	..	—	.	—	9	50
8·4583	—	3	17	26	16	7	5	3	2	3	2	—	—	—	1	—	—	—	1	...	—	..	—	.	—	14	100
9·4583	1	7	12	17	12	7	7	5	4	—	1	—	—	—	—	—	—	—	—	...	—	..	—	.	—	11	84
10·4583	1	7	18	20	26	3	3	1	2	1	—	—	1	—	—	—	—	—	—	...	—	..	—	.	—	8	91
11·4583	1	11	33	15	17	3	4	2	2	2	1	—	—	—	1	—	—	—	—	...	—	..	—	.	—	7	99
12·4583	1	7	44	52	66	35	29	17	9	7	4	—	—	1	2	1	2	—	—	...	1	..	—	.	—	16	294
13·4583	1	6	26	18	27	21	14	9	3	2	3	—	2	—	—	1	1	—	—	...	—	..	—	.	1	13	148
14·4583	—	—	3	6	7	2	2	1	1	1	1	—	2	—	3	—	—	—	—	...	—	..	1	.	—	3	33
15·4583	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	...	—	..	—	.	—	—	1
Totals	5	43	165	163	174	81	69	43	23	17	14	1	6	1	7	2	3	1	1	...	1	..	1	.	1	81	903

The constants of this table are:

Mean Age (without "Comfortable"): 11·4291 yrs.; Standard Deviation, Age: 1·8810 yrs.
Mean Income („ „): 5·7517*s.* „ „ Income: 2·8623*s.*

The Mean Incomes "per adult" for given ages are:

Age in Years	Mean Income "per Adult"
7·3901	6·2000*s.* ± ·2910
8·4583	5·6360*s.* ± ·2082
9·4583	5·3404*s.* ± ·2259
10·4583	4·8717*s.* ± ·2119
11·4583	4·7217*s.* ± ·2013
12·4583	6·0112*s.* ± ·1158
13·4583	6·0870*s.* ± ·1662
14·4905	8·0306*s.* ± ·3467
General Population:	5·7517*s.* ± ·0673

These means are exhibited in Diagram 144.

Clearly we should gain little knowledge by determining the correlation coefficient. The Income "per adult" grows steadily smaller until the child is 11, then it begins to rise rapidly until the child leaves school at 14·5 yrs. This is probably owing to elder brothers and sisters beginning to earn or leaving the family home. For the correlation ratio of Income "per adult" on Age of Child we have:

$\eta'^2_{I.A} = \cdot056{,}292, \quad \bar{\eta}^2_{I.A} = \cdot008{,}516 \pm \cdot002{,}965,$

or $\eta'^2_{I.A}$ is significant compared to $\bar{\eta}^2_{I.A}$. Thus $\eta'_{I.A} = \cdot2373$, which with class-index correction on eight arrays might be raised to ·25. It is thus not so close as the association of Income "per adult" and Size of Family, which shows that it is the number of children rather than their age, which in the first place modifies our index.

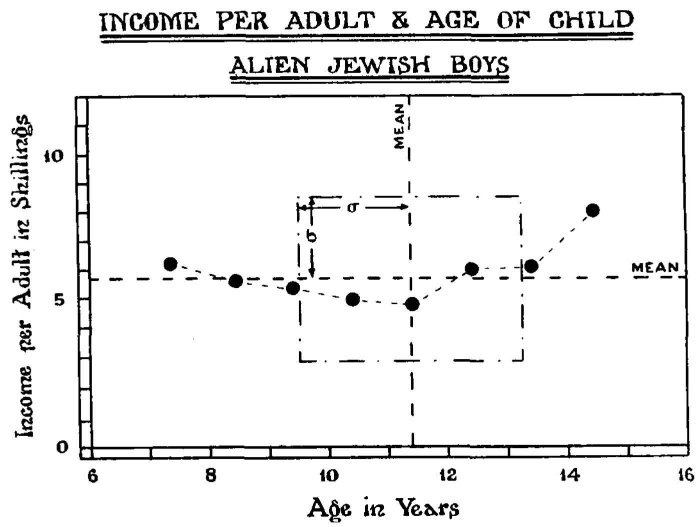

Diagram 144.

We next questioned how the Parents' Sight was separately related to the numerator (total income) and the denominator (roughly size of family*) of the variate Income "per adult." Table CCCXXIII gives our data. The distribution of incomes forms an irregular skew curve ranging from 5*s.* (when, of course, charity supplemented) to 120*s.* The average income is 31·276*s.* with a standard deviation of 14·635*s.*

Table CCCXXIII. *Total Income and Parents' Sight.*

Total Income in Shillings per Week

Sight	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	..	100	...	120	Totals
Parents																						
Both Good	2	5·5	12·5	25	49	32	19	34·5	2·5	5	2	3	1	2	1	—	1	..	3	...	—	200
One Good	—	2	6	22·5	13·5	18	4·5	12·5	2·5	3·5	—	—	1	1	—	—	—	..	—	...	1	88
Both Bad	—	2·5	2·5	11	5	3·5	4·5	7	3	—	0·5	0·5	—	—	1	1	—	..	—	...	1	43
Totals	2	10	21	58·5	67·5	53·5	28	54	8	8·5	2·5	3·5	2	3	2	1	1	..	3	...	2	331
Father																						
Good	2	7·5	15·5	33·5	54·5	43	22	41·5	4	6·5	2	3	2	2	1	—	1	..	3	...	—	244
Bad	—	2·5	6·5	26·5	14·5	12·5	7	14·5	4	2·5	1	0·5	—	1	1	1	—	..	—	...	2	97
Totals	2	10	22	60	69	55·5	29	56	8	9	3	3·5	2	3	2	1	1	..	3	...	2	341
Mother																						
Good	2	6·5	16·5	40·5	58·5	41	20·5	41	3·5	7	2	3	1	3	1	—	1	..	3	...	1	252
Bad	—	4·5	4·5	19	9	12·5	7·5	13	4·5	1·5	0·5	0·5	1	—	1	1	—	..	—	...	1	81
Totals	2	11	21	59·5	67·5	53·5	28	54	8	8·5	2·5	3·5	2	3	2	1	1	..	3	...	2	333

Contrary to our expectations the Total Income was rather greater when the Father's Sight was bad (31·65*s.*) than when it was good (31·13*s.*); the difference, however, being non-significant. The correlation coefficient found by the biserial formula was $r_b = -\cdot0214 \pm \cdot0646$, which is non-significant. In the case of the Mother's Sight the same result occurred, the total Income being

* Only roughly as there were occasionally other members of the family, e.g. grandparents, etc., sometimes had to be counted in, not to mention the reduction of children to "adults."

31·09*s*. for Good Sight and 31·48*s*. for Bad Sight, while the correlation was $r_b = -\cdot 0155 \pm \cdot 0694$; all again non-significant.

Finally, on the triserial table for both Parents' Sight we found the following series of means leading to the triserial correlation coefficient $r_{tri} = +\cdot 0831 \pm [\cdot 0591]$.

Parents' Sight	Mean Total Income
Both Good	31·500*s*. ± ·703
One Good	29·972*s*. ± 1·060
Both Bad	32·965*s*. ± 1·516
General Population:	31·284*s*. ± ·546

None of the differences is significant, and we conclude that Total Income is not associated with the Sight of the parents, indeed in all cases the parents with the worse Sight are associated with the higher income, if stress could be laid on such differences.

But Income "per adult" as we have seen does appear to be correlated with Sight of the Parents. Hence it seems to be necessary that Sight of Parents should be correlated with the denominator of the Income "per adult'," i.e. with its approximation, Size of Family. The data are given in Table CCCXXIV.

Table CCCXXIV. *Sight of Parents and Size of Family.*

Size of Family

Sight	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Totals
Father																
Good	1	5	14	30	38	55	39	49	29	27	9	9	6	2	—	313
Not Good	—	5	1	7	11	15	16	22	15	11	10	4	2	—	1	120
Totals	1	10	15	37	49	70	55	71	44	38	19	13	8	2	1	433
Mother																
Good	2	7	12	30	39	52	44	55	30	20	14	12	7	2	1	327
Not Good	—	3	3	7	8	15	11	15	12	17	5	1	1	—	—	98
Totals	2	10	15	37	47	67	55	70	42	37	19	13	8	2	1	425

From this table we deduce:

Parents' Sight	Mean Size of Family	
	Father	Mother
Good	7·035 ± ·096	7·122 ± ·095
Not Good	7·650 ± ·192	7·429 ± ·172
General Population:	7·206 ± ·082	7·193 ± ·083

The correlations found by the biserial method are:

Father: $r_b = -\cdot 1462 \pm \cdot 0560$; Mother: $r_b = -\cdot 0704 \pm \cdot 0623$.

It is probable accordingly that at least the Father's Sight, if not the Mother's, is associated with Size of Family.

What explanation can be found for this? We believe it to lie in the simple fact that Size of Family is correlated with Parents' Age and Age is highly correlated with Vision. When the family is larger, the parents are older, their sight is worse and their total income slightly larger. If this view be correct, and we think it is so, the slender correlations we have found between Income "per adult" and Rental "per adult" and Parental Sight cannot be taken as measuring a small association of Vision with economic environment, they are indirect effects of the age factor. We have hesitated to correct for age by partial correlation because the existing theory only applies in the case of linear regression, and age and other characters usually give markedly skew regressions.

To justify the remarks made in the last paragraph we have formed further correlation tables. We first investigated the relation of the Parents' Age to their Sight. We have the following table:

Table CCCXXV. *Parents' Sight and Parents' Age.*

Parents' Age

Sight	24–26	27–29	30–32	33–35	36–38	39–41	42–44	45–47	48–50	51–53	54–56	57–59	60–62	63–65	66–68	69–71	Totals
Father																	
Good	1	5	9	29	62	58	48	37	43	5	8	4	1	—	1	1	312
Bad	—	—	1	8	18	13	16	19	21	10	7	4	4	—	—	—	121
Totals	1	5	10	37	80	71	64	56	64	15	15	8	5	—	1	1	433
Mother																	
Good	—	4	26	44	82	58	41	33	23	12	3	1	—	—	—	—	327
Bad	—	—	4	12	13	17	16	14	15	2	2	—	—	—	—	—	95
Totals	—	4	30	56	95	75	57	47	38	14	5	1	—	—	—	—	422

We are limited here to the biserial method of finding the correlation. We have the following array-means:

Sight	Father's Age	Mother's Age
Good	$42{\cdot}317 \pm {\cdot}259$	$40{\cdot}326 \pm {\cdot}217$
Bad	$45{\cdot}632 \pm {\cdot}416$	$42{\cdot}332 \pm {\cdot}402$
General Population*:	$43{\cdot}073 \pm {\cdot}220$	$40{\cdot}777 \pm {\cdot}191$

The resulting biserial correlations are:

Father's Sight and Age: $r_b = -\,{\cdot}2923 \pm {\cdot}0506$.

Mother's Sight and Age: $r_b = -\,{\cdot}2005 \pm {\cdot}0600$.

It is clear therefore that the older the parents the worse is their sight†.

We next turned our attention to Parents' Age and Size of Family. The data are provided in Tables CCCXXVI *a* and *b*.

Table CCCXXVI *a*. *Parents' Age and Size of Family.*

Father

Ages	Size of Family															Totals
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
24–26	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1
27–29	—	1	2	1	—	2	—	—	—	—	—	—	—	—	—	6
30–32	—	1	2	5	2	4	2	—	—	—	—	—	—	—	—	16
33–35	1	5	5	7	11	16	12	7	1	2	—	—	—	—	—	67
36–38	1	3	7	14	39	25	20	32	10	3	—	—	—	—	—	154
39–41	1	4	12	14	21	34	34	15	12	2	1	3	1	—	—	154
42–44	—	—	2	11	7	17	17	19	26	19	9	4	2	—	—	133
45–47	—	3	—	2	8	10	14	20	25	22	7	6	—	—	—	117
48–50	—	—	—	4	10	13	16	28	22	15	13	4	4	2	—	131
51–53	—	—	1	—	2	5	8	6	7	4	8	3	—	—	1	45
54–56	—	1	1	—	2	3	2	3	5	5	7	3	—	—	1	33
57–59	—	2	2	—	2	2	1	—	1	2	—	1	—	—	—	13
60–62	—	—	—	1	1	1	—	2	1	—	1	1	1	—	—	9
63–65	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	2
66–68	—	—	—	—	—	—	—	—	2	—	—	—	—	—	1	3
69–71	—	—	—	—	—	1	—	—	—	1	1	—	—	—	—	3
72–74	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1
Totals	3	20	34	60	105	133	126	132	113	75	47	27	8	2	3	888

* Father's Standard Deviation: 6·7893 years; Mother's: 5·8164 years.

† For change in Acuity of Vision with Age see *Annals of Eugenics*, Vol. II, pp. 118–125, also *Biometrika*, Vol. XV, pp. 351–352.

Table CCCXXVI *b*. *Parents' Age and Size of Family* (*contd.*)

Mother

Ages	Size of Family															Totals
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
24–26	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	2
27–29	—	3	3	2	4	3	—	—	—	—	—	—	—	—	—	15
30–32	1	3	9	6	11	10	8	6	—	1	—	—	—	—	—	55
33–35	—	4	7	11	27	14	20	11	5	2	1	—	—	—	—	102
36–38	1	3	4	24	23	37	26	32	20	6	3	1	—	—	—	180
39–41	1	2	9	7	10	31	22	26	19	19	7	3	3	—	—	159
42–44	—	1	3	7	13	13	12	21	24	13	9	4	—	—	—	120
45–47	—	2	—	3	11	14	22	11	18	13	10	5	—	—	—	109
48–50	—	1	—	—	4	4	13	15	18	11	12	8	4	2	2	94
51–53	—	—	—	—	1	7	1	7	4	5	5	5	—	—	1	36
54–56	—	—	2	—	—	1	—	2	2	2	2	—	1	—	—	12
57–59	—	1	—	—	—	1	1	—	1	1	—	—	—	—	—	5
60–62	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1
63–65	—	—	—	—	—	—	—	—	2	—	—	1	—	—	—	3
66–68	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
69–71	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
72–74	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Totals	3	20	37	62	104	135	125	131	114	73	49	27	8	2	3	893

The constants of these tables are as follows:

	Father		Mother	
	Mean	Standard Deviation	Mean	Standard Deviation
Age	43·760 years	6·821 years	41·394 years	6·284 years
Size of Family	7·242 children	2·462 children	7·224 children	2·475 children

The product moment correlation coefficients are:

Father: $r = \cdot 4352 \pm \cdot 0183$; Mother: $r = \cdot 4598 \pm \cdot 0178$.

Correlation Ratio, Size of Family on Parents' Age:

Father: $\eta'^2_{S.A} = \cdot 234{,}735$; $\bar{\eta}^2_{S.A} = \cdot 010{,}135 \pm \cdot 003{,}203$.

Mother: $\eta'^2_{S.A} = \cdot 232{,}662$; $\bar{\eta}^2_{S.A} = \cdot 010{,}078 \pm \cdot 003{,}188$.

Thus $\eta'^2_{S\,A}$ is certainly significant and we have:

Father: $\eta'_{S.A} = \cdot 4845$; Mother: $\eta'_{S.A} = \cdot 4824$.

We conclude therefore that the regressions are not absolutely linear, and that the relationship between Age of Parents and Size of Family is quite considerable. The curves are of interest in themselves and are given in Diagrams 145 and 146. The family tends to increase with both parents' ages till 50* and then flattens out or even falls. This is due to the fact that parents with a child at school when they are 50 or over will, on the average, have married later and so must have smaller families on the average. The means of the arrays are:

Age of Father	Size of Family	Age of Mother	Size of Family
30·46 years	4·522	28·15 years	4·059
34·5 „	5·582	31·5 „	5·218
37·5 „	6·136	34·5 „	5·843
40·5 „	6·208	37·5 „	6·528
43·5 „	7·932	40·5 „	7·365
46·5 „	8·256	43·5 „	7·725
49·5 „	8·389	46·5 „	7·881
52·5 „	8·644	49·5 „	9·223
55·5 „	8·909	52·5 „	9·056
62·27 „	8·032	57·79 „	8·286
General Population (Mean: 43·760)	7·242	General Population (Mean: 41·394)	7·224

* It is worth noting that the average size of the mother's family goes on increasing until she is 50, and the father's until he is 55.

We have reached now, we think, the solution of the paradox of the sight of the parents being correlated with Income or Rental "per adult," but hardly at all with total Income or Rental. The sight of the parent is correlated negatively with the size of the family because as the family grows larger the parent gets older and the sight becomes worse. The size of the family is a factor of the denominator of "Income per adult" and accordingly the sight of the parent becomes worse as the "Income per adult" becomes smaller. In other words we have not discovered an environmental effect on sight, but merely an age influence depending upon the age factor being introduced into our measure of economic status. It is still another illustration of the dangers arising from spurious correlation.

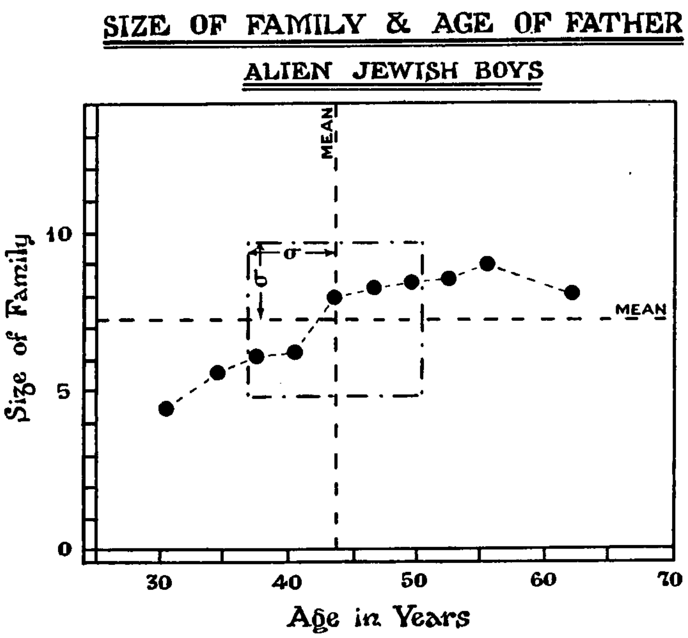

Diagram 145.

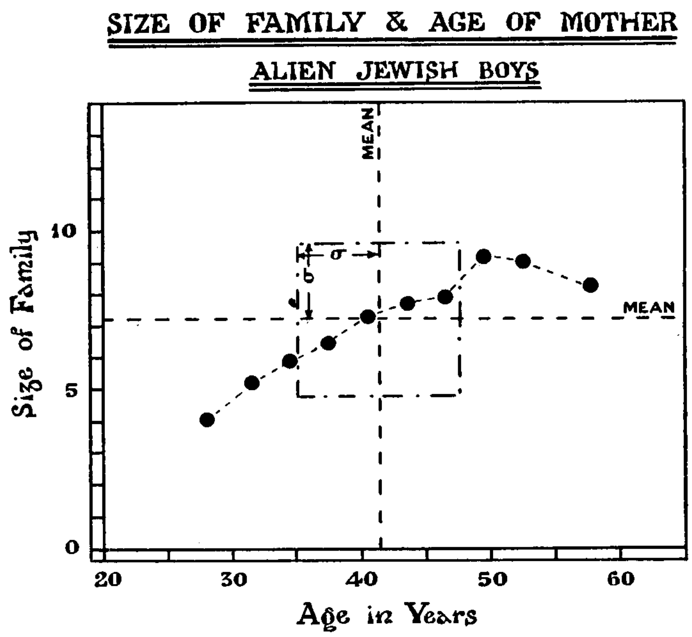

Diagram 146.

(*c*) *Eye Diseases and Rent "per adult."* We investigated whether economic conditions had any relation to the prevalence of eye diseases. Table CCCXXVII provides the data.

Table CCCXXVII. *Eye Diseases and Rent "per Adult"* (*Boys*).

Rent "per Adult" in Shillings per Week

Disease Categories	·55–·75	·75–·95	·95–1·15	1·15–1·35	1·35–1·55	1·55–1·75	1·75–1·95	1·95–2·15	2·15–2·35	2·35–2·55	2·55–2·75	2·75–2·95	2·95–3·15	3·15–3·35	3·35–3·55	3·55–3·75	3·75–3·95	3·95–4·15	4·15–4·35	Totals
Absent	6	46	104	157	120	73	55	24	10	11	5	2	—	3	—	3	1	—	3	623
Present	2	1	11	15	8	10	4	—	1	—	—	—	—	1	—	—	—	—	—	53
Strabismus	1	—	1	4	4	2	3	—	1	—	—	—	—	—	—	—	—	—	—	16
Totals	9	47	116	176	132	85	62	24	12	11	5	2	—	4	—	3	1	—	3	692

Condition as to Disease	Mean Rent
Absent	1·4810*s*. ± ·0149
Present	1·3858*s*. ± ·0467
Strabismus	1·4750*s*. ± ·0850
General Population*:	1·4402*s*. ± ·0121

* Standard Deviation: ·5043*s*

As we might anticipate Strabismus shows no sign of being influenced by economic conditions, and it would be more reasonable to class it with the normal than with the diseased eyes. None of the array-means shows a significant difference. Working biserial coefficients of correlation:

$$r_b = \cdot 0612 \pm \cdot 0472, \text{ if Strabismus be included with the normal.}$$
$$r_b = \cdot 0405 \pm \cdot 0439, \text{ if Strabismus be included with disease.}$$

In neither case can r_b be considered definitely significant, and if it were so, its value is too small to be of any importance.

Turning from the directly economic to a factor largely determined by the economic status we ask: Does the general poverty of the home, its size and state of crowding, etc., have any association with Eye Disease?

Table CCCXXVIII. *Character of Home and Eye Disease.*

Condition of Eye

Character of Home*	No Disease	Strabismus	Disease Present	Totals
Very Good	14	1	—	15
Good	257	5	17	279
Fair	417	11	38	466
Poor and Very Poor	117	2	12	131
Totals	805	19	67	891

Bearing in mind that our correlations are higher when Strabismus is included with the "No Disease" category, we formed a fourfold table:

	No Disease	Disease	Totals
Very Good and Good	277	17	294
Fair, Poor and Very Poor	547	50	597
Totals	824	67	891

and found for the tetrachoric correlation coefficient:

$$r_t = \cdot 1161 \pm \cdot 0538,$$

i.e. the boys with eye disease come from the poorer type of home in the larger numbers. But the correlation which is of the same order as that of rental is of doubtful significance. Clearly the economic conditions and the crowding of the home are not the chief factors in the production of eye disease.

It may be argued that a more important factor of home environment than the economic is the cleanliness of the home. We accordingly formed a table for this.

Table CCCXXIX. *Eye Disease and Cleanliness of Home.*

Condition of Eye

Cleanliness of Home	No Disease	Strabismus	Disease Present	Totals
Very Good	51	3	3	57
Good	331	6	30	367
Fair	307	6	23	336
Poor and Very Poor	129	4	12	145
Totals	818	19	68	905

* For a description of our categories see *Annals of Eugenics*, Vol. I, p. 104.

Forming again a tetrachoric table with dichotomic planes between "Strabismus" and "Disease Present," and between "Good" and "Fair" Cleanliness, we find:

$$r_t = -\cdot 0221 \pm \cdot 0524.$$

Or, strange as it may seem, the Cleanliness of the Home is a non-significant factor in the production of eye disease.

A rather more hopeful inquiry seemed to be that of personal cleanliness*.

Table CCCXXX. *Eye Disease and Personal Cleanliness.*

Condition of Eye

Cleanliness Grade	No Disease	Strabismus	Disease Present	Totals
A	274	8	15	297
B	347	7	22	376
C	163	3	19	185
D	71	1	14	86
Totals	855	19	70	944

Proceeding as before to form a fourfold table, throwing Strabismus in with the No Disease, we find:

$$r_t = \cdot 2602 \pm \cdot 0519.$$

	No Disease	Disease Present	Totals
A + B	636	37	673
C + D	238	33	271
Totals	874	70	944

Clearly we have here a quite significant association between uncleanliness of person and the presence of eye disease. We thus obtain a distinct positive result: Home environment, whether that of poverty or of dirt, is not significantly associated with eye disease, but uncleanliness of person undoubtedly is so associated. Thus we again reach the important conclusion that habits rather than environment form the fundamental factor in disease.

While we are dealing with eye disease, it is worth while measuring what association there is between acuity of vision and eye disease.

In order to get a satisfactory estimate of the effect on Visual Acuity of Disease we have to remember that the medical cards give only the type of disease, but do not state whether it is in right or left eye or in both eyes. We have accordingly tabled for "Better Eye" and "Worse Eye" in order to measure the effect of those cases in which the disease was unilateral. Table CCCXXXI contains our data.

Table CCCXXXI. *Visual Acuity and Eye Disease.*

Disease	Visual Acuity Worse Eye								Totals	Visual Acuity Better Eye								Totals
	6/6	6/9	6/12	6/18	6/24	6/36	6/60	<6/60		6/6	6/9	6/12	6/18	6/24	6/36	6/60	<6/60	
No disease	205	203	157	103	57	50	24	1	800	264	244	148	79	27	28	10	—	800
Strabismus	1	1	2	2	4	2	3	—	15†	3	1	8	3	1	—	—	—	16
Disease	7	15	9	9	8	7	5	—	60	11	17	14	7	6	3	2	—	60
Totals	213	219	168	114	69	59	32	1	875	278	262	170	89	34	31	12	—	876

We have again the alternative of throwing Strabismus in with no disease or with diseased eyes. Both have been done, and here the latter seems the more reasonable as like disease it reduces the acuity. The following array-means result from the above tables:

* For categories of personal cleanliness see *Annals of Eugenics*, Vol. I, pp. 96–97, also p. 5 ftn. of this Section E.

† One case of unilateral squint in which affected eye was not or could not be tested.

	Vision of Worse Eye	Vision of Better Eye
Disease Absent	·7020 ± ·0083	·7970 ± ·0076
Disease Present	·5490 ± ·0303	·6642 ± ·0277
Strabismus	·3693 ± ·0606	·6400 ± ·0537
General Population*:	·6858 ± ·0079	·7858 ± ·0073

The differences from the General Population are in the main significant and form an orderly sequence. The reduction of visual acuity is most marked in the case of Strabismus, and forms a strong argument for its remedy, whether by exercises or operation. It is also clear that while the effect of Strabismus is more serious than that of disease†, yet as the former occurs in only 1·83 % of cases, while the latter occurs in 6·85 % of cases, it may have on the whole a more serious influence. The aptest method of deducing correlation in this case seems to be the biserial, when we must class Strabismus with Disease Present or Disease Absent.

	Strabismus with Disease Present	Strabismus with Disease Absent
Disease and Worse Eye	$r_b = \cdot 2717 \pm \cdot 0636$	$r_b = \cdot 2040 \pm \cdot 0796$
Disease and Better Eye	$r_b = \cdot 2187 \pm \cdot 0683$	$r_b = \cdot 1983 \pm \cdot 0798$

A tetrachoric table putting Strabismus with Disease Present and taking the dichotomic plane between visual acuities 6/9 and 6/12 gave:

$$\text{For Better Eye: } r_t = \cdot 2688 \pm \cdot 0491,$$
$$\text{For Worse Eye: } r_t = \cdot 2413 \pm \cdot 0490.$$

The corresponding tables for Girls are:

Table CCCXXXII. *Eye Diseases and Visual Acuity* (*Girls*).

	Worse Eye								Totals	Better Eye								Totals
	6/6	6/9	6/12	6/18	6/24	6/36	6/60	<6/60		6/6	6/9	6/12	6/18	6/24	6/36	6/60	<6/60	
Disease Absent	136	197	212	105	71	52	23	5	801	174	253	195	97	40	34	5	3	801
Disease Present	9	11	12	13	4	1	4	2	56	13	15	14	10	2	1	1	—	56
Strabismus	1	—	5	5	3	1	—	—	15*	2	3	8	3	1	—	—	—	17
Totals	146	208	229	123	78	54	27	7	872	189	271	217	110	43	35	6	3	874

* It was impossible to determine vision for the worse eye in two cases of Strabismus.

The array-means give the following results:

	Worse Eye	Better Eye
Disease Absent	·6400	·7218
Disease Present	·5898	·7168
Strabismus	·4527	·6329
General Population:	·6336	·7198

The series of means are very similar to those for the Boys, except that in the case of Disease Absent or in the General Population the Visual Acuity of the Girls is markedly less than that of the Boys. When the Boys have disease, however, their Visual Acuity is less than that of the Girls in the worse eye—probably that chiefly affected. This suggests that the diseases (including squint) are more severe in Boys, possibly more neglected.

We have found the correlation between Disease and Vision by two methods, working out only

* Standard Deviation: Worse Eye: ·3480; Better Eye: ·3182.

† The chief eye diseases it must be remembered were Blepharitis, Conjunctivitis and Corneal Opacities.

the values when Strabismus is included with the Disease present group, the biserial method, and the tetrachoric where the dichotomic plane was taken between 6/9 and 6/12. The results are:

	Worse Eye	Better Eye
Tetrachoric Method	$r_t = \cdot 1583 \pm \cdot 0514$	$r_t = \cdot 1012 \pm \cdot 0512$
Biserial Method	$r_b = \cdot 1214 \pm \cdot 0740$	$r_b = \cdot 0393 \pm \cdot 0739$

The correlations are lower than in the case of boys, and the methods not in such close agreement. The fact that the Girls' Vision does not seem to be affected as much by disease as the Boys' will account for the lowering of the correlation.

These correlations are, while not really very large, still some of the most important we have reached, and it is satisfactory to find the biserial and tetrachoric methods in the case of the Boys confirming each other as closely as we could anticipate such different manners of approaching the subject would be likely to do.

If eye disease to this extent does affect acuity of vision, may it not be that we have passed over a factor of sight which does, after all, affect Intelligence? To answer this question we directly correlated Intelligence with Eye Disease.

Table CCCXXXIII. *Intelligence and Eye Disease.*

	Girls							*Boys*						
Category	Very Able	Capable	Intelligent	Slow	Dull	Very Dull and M.D.*	Totals	Very Able	Capable	Intelligent	Slow	Dull	Very Dull and M.D.*	Totals
Disease Absent	5	32	141	196	98	60	532	18	71	213	207	66	12	587
Disease Present	2	4	5	14	7	2	34	2	11	17	16	3	2	51
Strabismus	—	—	1	8	—	3	12	—	1	6	7	2	—	16
Totals	7	36	147	218	105	65	578	20	83	236	230	71	14	654

Making fourfold tables with dichotomic planes between Intelligent and Slow, and with Disease Absent and Present, i.e. including Strabismus with the latter, we find for the tetrachoric coefficient:

$$\textit{Boys: } r_t = - \cdot 0499 \pm \cdot 0561.$$
$$\textit{Girls: } r_t = + \cdot 1044 \pm \cdot 0661.$$

Neither correlation coefficient is significant having regard to its probable error; and neither, if significant, would have any practical value. We endeavoured to confirm these results by investigating the relation of Eye Disease to Place in Class for Boys.

Table CCCXXXIV. *Eye Disease and Place in Class.*

	Place in Class																									
Disease	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16	17, 18	19, 20	21, 22	23, 24	25, 26	27, 28	29, 30	31, 32	33, 34	35, 36	37, 38	39, 40	41, 42	43, 44	45, 46	47, 48	49, 50	Totals
Absent	19	15	15	12	23	24	16	15	18	21	19	17	18	17	11	20	22	23	19	9	16	15	11	9	8	412
Present	1	1	1	3	2	—	5	—	3	2	3	1	1	1	2	4	1	1	—	—	2	—	—	—	1	35
Strabismus	—	—	—	—	1	—	2	2	1	1	2	—	—	—	1	—	—	—	—	—	1	—	—	—	—	11
Totals	20	16	16	15	26	24	23	17	22	24	24	18	19	18	14	24	23	24	19	9	19	15	11	9	9	458

* The five mentally defective (M.D.) Girls all fell into the Disease Absent category; of the two mentally defective Boys, one fell into Disease Absent and the other into Disease Present categories.

Finding the array-means we have:

	Mean Place in Class
Disease Absent	23·961 ± ·443
Disease Present	21·100 ± 1·518
Strabismus	19·864 ± 2·709
General Population*:	23·644 ± ·420

Adding Strabismus to Disease Present we find for the value of the Biserial Correlation Coefficient:

$$r_b = -\cdot 1216 \pm \cdot 0903.$$

r_b is non-significant and this is in accordance with the probable errors of the array-means; but if it were significant it would need us to assert that the Boys with Eye Disease and Squint stood slightly higher in Class than those with eyes from which disease was absent.

Thus, while the presence of eye disease affects to some extent the child's visual acuity, it does not affect his intelligence or influence his success in school life as measured by Place in Class.

(*d*) *Visual Acuity and Food.* As another measure of the possible association between ocular characters and poverty, we took the character of the food provided in the homes. The scheme of categories has already been dealt with†. The following table exhibits our data:

Table CCCXXXV. *Binocular Visual Acuity and Character of Food.*

	Visual Acuity (Central Values)												
Food Categories	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	Totals
Very Good	—	—	—	2	5	—	—	1	1	—	—	—	9
Good	2	2	33	71	40	20	18	16	3	4	—	3	212
Fair	1	1	18	25	22	9	8	6	5	5	1	1	102
Poor	—	—	5	18	8	7	5	3	—	1	2	—	49
Very Poor	—	—	—	1	4	3	—	—	—	—	—	—	8
Totals	3	3	56	117	79	39	31	26	9	10	3	4	380

We have array-means as given below:

Grade of Food	Visual Acuity
Very Good	·8211 ± ·0742
Good	·9263 ± ·0153
Fair	·9007 ± ·0220
Poor	·8831 ± ·0318
Very Poor	·8750 ± ·0787
General Population‡:	·9042 ± ·0114

No array-mean has any significant deviation from the mean of the General Population.

If we determine a biserial correlation coefficient classing "Very Good" and "Good" together and "Fair," "Poor" and "Very Poor" in a second group, we find:

$$r_b = \cdot 0802 \pm \cdot 0435.$$

This again is not significant, but taking into account the general sweep of the array-means we are inclined to suggest that there is a small association of no practical importance between poor food and poor vision. Whether, notwithstanding this, the poorest vision is to be found in the best homes we cannot say. It may only be the smallness of the sample from homes with "Very Good" food, or it may correspond to what we have found for other characters, i.e. that the best homes do not always produce those with the highest grade of physical characters.

* Standard Deviation of Place in Class = 13·3186.

† *Annals of Eugenics*, Vol. I, p. 102.

‡ Standard Deviation = ·3301.

We will now investigate whether certain pathological states are associated with defect of sight, limiting ourselves to Visual Acuity.

(*e*) *Visual Acuity* (*Medical Examination*) *and Rickets.* We have only the data for Girls and to obtain adequate numbers we have been compelled from the anthropometric standpoint to work with the Medical Examination for Visual Acuity (Better Eye). We have already criticised the customary medical recording of vision, adequate though it may be for practical purposes. As we cannot give a quantitative scale to either variate, we are forced to use the mean square contingency or the tetrachoric method.

Our data are exhibited in the following table:

Table CCCXXXVI. *Visual Acuity* (*Best Eye*) *and Rickets. Girls.*

	Signs of Rickets*			
Visual Acuity	1 = No Sign	2 = Suspicion	3 = Definite	Totals
6/6	155	54	20	229
6/9	224	66	17	307
6/12	213	77	24	314
6/18	115	59	14	188
6/24	67	18	4	89
6/36	37	15	9	61
6/60	7	11	—	18
< 6/60	4	—	—	4
Totals	822	300	88	1210

We first formed the accompanying tetrachoric table which led to:

$$r_t = \cdot 0872 \pm \cdot 0316,$$

or r_t is more than 2·5 times its probable error. Thus it seems reasonable to suppose a slight association, but one of no practical importance, between rickets and poor sight.

	1	2 + 3	Totals
6/6 + 6/9	379	157	536
6/12 and rest	443	231	674
Totals	822	388	1210

We may look at the matter from the standpoint of percentages. We have:

	Rickets		
	No Sign	Suspicion	Definite Sign
Highest Acuity, 6/6	18·86 %	18·00 %	22·73 %
Moderate Acuity, 6/9–6/18	68·08	67·33	62·50
Bad Acuity, 6/24 and below	13·06	14·67	14·77

Here we see that, although the Girls with Bad Acuity are 1·7 % more frequent in those with definite signs of rickets than in those with none, yet the Girls with definite signs of rickets have 3·9 % more of the highest acuity class than the Girls without rickets.

Finally, we formed a 3 × 6 contingency table, grouping the classes 6/36, 6/60 and less than 6/60 together. There resulted:

$$\phi'^2 = \cdot 013{,}003, \qquad \bar{\phi}^2 = \cdot 014{,}050.$$

Thus, ϕ'^2 is less than the mean value of $\bar{\phi}^2$ for no association. We cannot therefore definitely assert the existence of any association of visual acuity with rickets.

(*f*) *Visual Acuity and Condition of the Glands and of the Tonsils.* The details of our classification

* See *Annals*, Vol. II, p. 316, (xvi) of our Section D on "Intelligence and the Ocular Characters" for account of these categories.

are given in the first part of the present paper*. The best method of determining the association seems to be a triserial coefficient of correlation. Our data are given below:

Table CCCXXXVII. *Visual Acuity with State of Glands and Tonsils.*

Visual Acuity (Binocular). Special Examination, *Boys*

Class	1·50	1·40	1·29	1·11	·91	·75	·58	·37	·25	·14	·08	·04	Totals
Tonsils													
Healthy	1	1	24	58	39	18	13	9	4	9	3	1	180
Enlarged	—	2	11	27	19	6	6	2	3	1	1	2	80
Operation Needful	—	—	3	4	12	5	5	6	1	—	—	1	37
Totals	1	3	38	89	70	29	24	17	8	10	4	4	297
Glands													
Healthy	—	1	4	12	7	4	3	3	—	2	—	—	36
Slightly Swollen	1	1	28	49	48	17	16	6	5	7	3	3	184
Seriously Enlarged	—	1	6	28	15	8	5	8	3	1	1	1	77
Totals	1	3	38	89	70	29	24	17	8	10	4	4	297

The array-means are as follows:

Grade of Tonsils	Visual Acuity	Grade of Glands	Visual Acuity
Healthy	·8924 ± ·0169	Healthy	·8994 ± ·0377
Enlarged	·9253 ± ·0253	Slightly Swollen	·8909 ± ·0167
Operation Needful	·7673 ± ·0377	Seriously Enlarged	·8668 ± ·0258
General Population†	·8857 ± ·0131	General Population†	·8857 ± ·0131

In the case of Glands, none of the array-means is significantly different from the General Population mean. In the case of Tonsils, those Boys who need operation do show a probably significant reduction in visual acuity, i.e. one about three times the probable error of the difference.

The triserial correlation coefficients are:

For Tonsils: $r_{tri} = \cdot 0842 \pm [\cdot 0624]$; For Glands: $r_{tri} = \cdot 0385 \pm [\cdot 0715]$.

It seems possible therefore that there may be a slight relation between unhealthy tonsils and acuity of vision, but it is more probable that both are a sign of inferior physical constitution rather than that enlarged tonsils reduce visual acuity.

(*g*) *Hours of Homework and Ocular Characters.* Another character which one *a priori* might imagine would be related to ocular characters is the time spent in reading apart from work at school. We endeavoured to get full particulars on this point, partly by inquiry as to hours of homework and partly by endeavouring to ascertain how the leisure hours were spent. A special difficulty arises in the case of the Jewish Boys from their study of Hebrew out of school hours. The measure of these hours had to be taken from statements made by the mothers, and these ladies often did not seem certain as to the hours of school preparation work at home. Further, the number of hours devoted outside school to Hebrew classes as given by mothers and by the teachers of the school by no means tallied. We had therefore to determine as best we might our hours of homework from such data as were available. We are not satisfied with the result. The tendency we think has been to estimate the homework roughly as two or three hours in the evening and multiply the result by 5, 6 or 7 according as the boy did or did not work on Sabaoths and Sundays; this naturally leads to multi-modality in the distribution. The divergence of reports as to homework from teacher and mother may naturally arise from the difference between

* *Annals of Eugenics*, Vol. I, pp. 42–43.

† Standard Deviation = ·3356.

expectation and performance. A teacher—and we speak from past experience—gives homework which he considers may take one or possibly two hours, but the lazy lad does not do it at all, and the dull but conscientious lad may take two to three hours over it. Again, it is conceivable that a boy high in class will work longer to maintain his place. This may first be tested on the following table:

Table CCCXXXVIII. *Hours of Homework per Week and Place in Class.*

Place in Class, Standardised to Size 50

Hours of Homework	1, 2	3, 4	5, 6	7, 8	9, 10	11, 12	13, 14	15, 16	17, 18	19, 20	21, 22	23, 24	25, 26	27, 28	29, 30	31, 32	33, 34	35, 36	37, 38	39, 40	41, 42	43, 44	45, 46	47, 48	49, 50	Totals
0	—	—	—	—	—	—	1	1	—	—	—	—	1	—	1	—	—	—	1	—	—	—	—	—	—	5
1	1	—	—	—	—	—	—	—	—	—	—	0·5	—	—	—	—	1	—	—	—	—	—	—	—	—	2·5
2	1	2	—	1	1	0·5	—	2	1	1	—	3	—	1	—	—	—	1	—	—	3	—	—	0·5	—	18
3	—	—	—	1	2	1·5	1	—	1	—	—	1·5	1	1	1	—	1·5	1	—	—	1	1	—	0·5	—	16
4	—	—	—	1	3	2	0·5	0·5	—	4	1	—	1	1·5	1·5	—	1	—	2	—	1	—	—	—	—	20
5	6	2·5	2	1	3	2	5·5	0·5	2	1·5	2	2	2	1·5	2·5	8	3·5	2	—	1	1·5	2	2	—	3	59
6	1	0·5	1	—	2·5	1	2	1·5	3	1·5	1·5	1·5	—	—	1	1·5	3	—	3	1	2·5	—	2	—	0·5	31·5
7	—	—	0·5	—	1·5	1	1	0·5	—	—	1	0·5	1	1	—	0·5	—	—	—	1·5	—	1	1	—	0·5	12·5
8	—	—	1	—	—	—	2·5	1·5	—	—	1·5	—	—	—	1	—	—	—	1	1·5	—	—	—	—	—	10
9	—	3	0·5	1	—	—	0·5	0·5	1	1	—	—	1	—	—	—	—	—	1	1	—	—	—	2	—	12·5
10	—	1	—	—	—	—	1	1·5	—	—	—	1·5	0·5	—	0·5	—	—	1	2	—	—	1	—	—	—	10
11	—	1	—	1	2	0·5	1	0·5	—	1	—	0·5	2·5	—	0·5	—	—	—	—	—	—	1	1	—	—	12·5
12	2	—	—	3	1	0·5	—	1	1	2·5	3	3	1	1	—	3	2	4	3	—	1	1	1	1	1	36
13	—	1	—	—	—	—	1	1	2	1·5	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	8·5
14	1	1	1	1	—	1·5	1	3·5	2	1	1	1	—	1	—	—	4	—	2	2	1	—	1	—	—	26
15	—	—	—	—	—	0·5	—	0·5	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	2
16	—	—	—	1	—	1	2	—	1	—	—	—	—	1	—	1	1	1	—	—	—	—	—	1	—	10
17	—	—	1	—	—	—	—	—	—	2	—	1	—	1	—	—	0·5	—	—	—	0·5	—	—	—	—	6
18	1	—	0·5	1	—	2	—	—	1	2	—	—	—	1	1	—	0·5	—	—	—	0·5	—	—	—	—	10·5
19	—	—	0·5	1	—	—	—	—	1	—	0·5	—	—	—	—	—	—	1	—	—	—	—	—	—	—	4
20	—	—	—	—	—	—	—	1	—	—	0·5	1	—	—	—	—	—	—	0·5	—	1	0·5	—	—	—	4·5
21	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	0·5	—	—	0·5	—	—	—	2
22	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1
23	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	2
Totals	13	12	8	13	16	14	21	17	16	19	12	17	13	11	10	17	18	11	16	8	13	9	8	5	5	322

We obtained the following hours of homework for given place in class:

Class Place	Array-means in Hours
4·313	8·870 ± ·506
12·747	8·257 ± ·416
20·438	9·398 ± ·429
28·716	8·480 ± ·481
36·028	9·142 ± ·472
44·500	8·588 ± ·540
General Population*:	8·793 ± ·193

There are no significant differences in these means and we cannot argue that the boys highest in class work either the longest or the least number of hours. For the correlation constants we have:

$$\eta'^2_{H.P} = \cdot 006{,}606, \qquad \bar{\eta}^2_{H.P} = 015{,}528 \pm \cdot 006{,}562.$$

$$\text{Product Moment Correlation: } r = \cdot 0087 \pm 0376.$$

There is clearly no significant association between place in class and number of hours of homework done.

Turning the problem round we inquired if larger amounts of homework were associated with

* Standard Deviation: 5·1469 hours. Mean Place in Class: 23·370. Standard Deviation of Place in Class: 12·7942. Both variates are very variable.

greater success at school, as measured by Place in Class. We obtained the following system of array-means, the differences of which are non-significant:

Hours of Homework	Place in Standard Class of 50
3·07 hours	23·195 ± 1·084
5·35 „	23·566 ± ·893
8·47 „	23·583 ± 1·267
11·74 „	23·861 ± 1·220
14·29 „	23·263 ± 1·246
18·90 „	23·233 ± 1·539
General Population:	23·370 ± ·481

Diagram 147 shows how little Place in Class is influenced by Homework, and how a good Place in Class does not connote much Homework. Against this serious charge that Homework is not productive of school distinction must be set the fact that in the case of these Jewish Boys many of the out-of-school hours of work are devoted to the study of Hebrew in the various types of Hebrew schools. These hours devoted to Hebrew may really be detrimental to success in school itself. At the same time it must be remembered that the intensive study of Hebrew may often be undertaken by really clever boys seeking to enter the ministry, and such boys, notwithstanding their long hours of Hebrew reading, ought to stand high in class. However this may be, Homework is certainly not repaid by success in class.

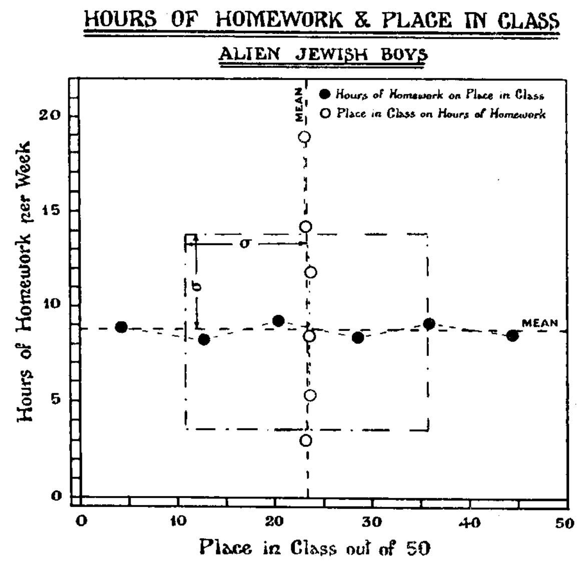

Diagram 147.

After these preliminary investigations we inquired whether there were any association between Hours of Homework and two ocular characters, namely, Visual Acuity and Refraction Class.

Visual Acuity and Hours of Homework. Our conclusion will be based on the following table:

Table CCCXXXIX. *Visual Acuity (Monocular) and Hours of Homework.*

Hours of Homework per Week

Visual Acuity	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Totals
1·50	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	3
1·40	—	2	—	—	2	0·5	3·5	—	—	—	—	1	—	—	—	—	1	1	—	—	—	—	—	—	11
1·29	2	1	5	4	3·5	10	3·5	1	—	—	2	1	16	1	8	4	—	—	2	—	2	2	—	2	70
1·11	7	6	11·5	14·5	12·5	9	5	6·5	7·5	9·5	11	8·5	19	6·5	12	1	3	1	2	—	1	1	—	—	155
·91	2	1·5	7·5	3	7·5	43	27	6·5	8·5	6·5	12	15	12	3	13	1	4	2	6	2	3	1	—	—	187
·75	2	3·5	4·5	4	4·5	11·5	15·5	3	3·5	2	5	6	5·5	4·5	8·5	2·5	1	0·5	1·5	4·5	0·5	—	—	—	94
·58	3	—	9·5	2·5	5	10	9·5	5·5	1	3	4	4	8	1	2·5	0·5	3	1·5	4	0·5	—	—	—	—	78
·37	1	4	4·5	2·5	1	15	8·5	2	0·5	1·5	6·5	2	6	3	3·5	2·5	4·5	3·5	3·5	0·5	1	—	2	—	79
·25	2	—	4	1	2	7	9·5	1·5	—	0·5	2·5	—	3	—	2·5	2·5	2	0·5	0·5	—	—	—	—	—	41
·14	1	—	3·5	2·5	2	11	5	—	—	1	—	2	5	2	3	—	0·5	0·5	2	0·5	1·5	—	—	—	43
·08	—	—	1	—	—	3	4	—	3	—	—	1·5	2·5	—	—	—	2	0·5	0·5	—	—	—	—	—	18
·04	—	—	2	1	1	4	3	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	13
Totals	20	18	53	35	41	124	94	28	24	24	43	41	78	21	53	14	21	12	23	8	9	4	2	2	792

Diagram 148 shows the changes in Visual Acuity with the Hours of Homework. There is clearly no orderly sequence of array-means, the Visual Acuity does not continually decrease with increased Hours of Homework. Indeed, the coefficient of correlation found by the product moment method:

$$r = + \cdot 0264 \pm \cdot 0240,$$

is non-significant, and had it meant anything, it would indicate that the better vision was that of the boys who worked longer hours.

If we seek to discover whether the regression be skew we have:

$$\eta'^2_{V.H} = \cdot 043{,}877,$$

$$\bar{\eta}^2_{V.H} = \cdot 021{,}465 \pm \cdot 004{,}913.$$

Accordingly, η'^2 must be considered significant as compared with $\bar{\eta}^2$. It is, however, very difficult to interpret the system of points given in Diagram 148. We have seen in our section on the influence of Age on the Ocular Characters that there is very little change between the ages of 9·5 and 13·5 in Visual Acuity (see *Annals*, Vol. II, pp. 122–5 and Diagram 48). Before 9·5 there is a fall in Visual Acuity and also between 13·5 and 15 years. The amount of Homework demanded very likely depends on the standard a boy has reached, and probably does not change gradually but at some more or less definite ages. It is thus possible that a spurious association is produced between Visual Acuity and Hours of Homework owing to both being dependent on age. This relationship cannot be corrected by the method of partial correlation because the changes of both variates are not continuous and linear. Such may be the source of the erratic changes in the array-means, which it is difficult to account for on the assumption that prolonged hours of homework render the sight poor. The diagram indicates that 5 and 6 hours' homework produce practically as bad a result as 15 to 17, while the intervening hours, 7 to 14 and 3 to 4, are most satisfactory as regards sight! It does not seem to us possible to infer from these results any detrimental influence of homework on vision.

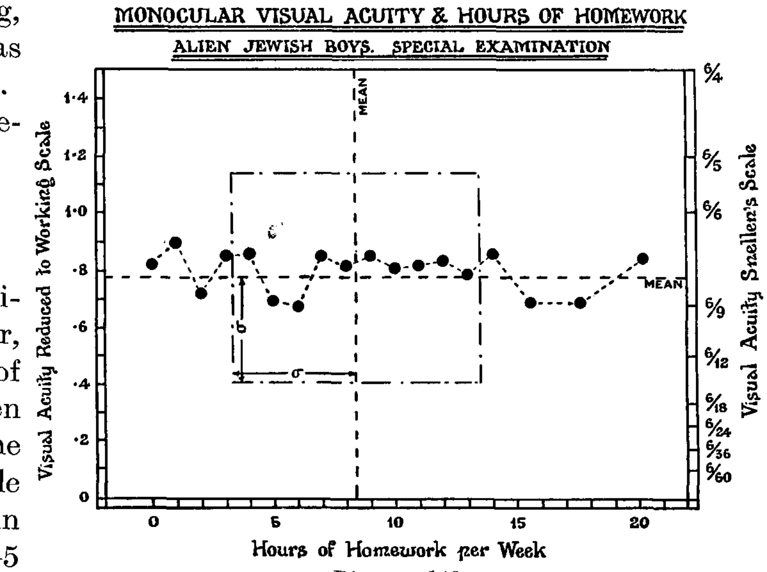

Diagram 148.

Refraction Class and Hours of Homework. The table below contains our data:

Table CCCXL. *Refraction Class and Hours of Homework.*

Hours of Homework per Week

Refraction Class	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Totals
Emmetropia	13	12	24	25	22	60	45	17	15·5	18·5	27·5	24·5	43·5	13·5	27	8·5	9·5	4	11	6	7	3	—	4	441
Hypermetropia	—	—	7	—	4	13	7	2	2·5	1·5	1	3	4·5	0·5	3	1·5	0·5	2	2	—	—	—	—	—	55
Hypermetropic Astigmatism	—	1	2	—	4	3	9	3	—	1	3	—	5·5	0·5	3	1	4	3	3	1	3	—	—	—	50
Mixed Astigmatism	—	—	—	—	1	6	2	1	—	—	—	—	1·5	0·5	—	—	—	—	2	—	—	—	—	—	14
Myopic Astigmatism	1	—	1	—	2	5	6	1	—	4	—	—	4	—	2	—	1	—	—	1	—	—	—	—	28
Myopia	—	4	10	4	6	29	18	1	4	3	3·5	8·5	10	2	7	—	6	2	2	—	—	—	—	—	120
Totals	14	17	44	29	39	116	87	25	22	28	35	36	69	17	42	11	21	11	20	8	10	3	—	4	708

Let us look at the matter first by considering the array-means for each Refraction Class. The correlation ratio of Hours of Homework on Refraction Class is given by:

$$\eta'^2_{H.RC} = \cdot 018{,}430, \qquad \bar{\eta}^2_{H.RC} = \cdot 007{,}062 \pm \cdot 003{,}002.$$

η'^2 is accordingly significant with regard to $\bar{\eta}^2$, although the association ($\eta' = \cdot 1358$) is not of great intensity. We will therefore look at the array-means individually.

Refraction Class	Mean No. of Hours of Homework
Emmetropia	8·564 ± ·162
Hypermetropia	7·827 ± ·458
Hypermetropic Astigmatism	10·550 ± ·481
Mixed Astigmatism	8·107 ± ·909
Myopic Astigmatism	8·036 ± ·643
Myopia	7·646 ± ·310
General Population*:	8·462 ± ·128

Two of these array-means may be considered significant—that for Hypermetropic Astigmatism and that for Myopia. The former have the longest, and the latter the shortest time of homework. It can hardly be therefore that Myopia arises from overlong hours of home reading, although it is possible that the myopic boys do less homework on account of their poor sight. It may not be easy to discover a reason for the long hours of the hypermetropic astigmatics.

Some light on this matter may possibly be reached by considering percentages:

Percentages of Refraction Classes

Hours of Homework	Hypermetropia	Emmetropia	Myopia
0–5	13·13	60·24	26·63
6–11	14·17	63·51	22·32
12–17	16·96	61·99	21·05
18–23	20·01	68·89	11·10
General Population	14·83	62·29	22·88

Here Hypermetropia includes Hypermetropic Astigmatism and Myopia includes Myopic Astigmatism and the few individuals (14) with Mixed Astigmatism. This classification shows that Myopia cannot be the product of long hours of homework, the boys with the longest hours have the least Myopia. Possibly their Myopia prevents them working long hours, but it certainly is not the result of it. On the other hand, it looks as if the more Hypermetropia, the longer the hours of work. A different light, however, is thrown on this point, if we separate the Astigmatism; thus:

Percentages of Refraction

Hours of Homework	Emmetropic	Hypermetropic	Astigmatic	Myopic
0–5	60·24	9·27	10·03	20·46
6–11	63·51	7·30	12·88	16·31
12–17	61·99	7·02	15·20	15·79
18–23	68·89	4·45	22·22	4·44
General Population	62·29	7·77	12·99	16·95

From this it appears that both Myopia and Hypermetropia decrease with lengthening hours of homework, but it is Astigmatism which increases; and practically the whole increase is in Hypermetropic Astigmatism. Thus:

Hours of Homework per Week

	0–5	6–11	12–17	18–23
Hypermetropic Astigmatism	3·86	6·87	9·94	15·56
Mixed Astigmatism	2·70	1·29	1·17	4·44
Myopic Astigmatism	3·47	4·72	4·09	2·22

* Standard Deviation = 5·0409.

If we can trust our material it is *not* Myopia which is emphasised by homework*, too often in badly lighted rooms, but it is Hypermetropic Astigmatism. This is a problem which really deserves an independent investigation. Myopia may develop during school years, but that it is the product of hours of eye-work is a statement often based merely on a *post hoc, propter hoc* attitude of mind. The percentages of the Refraction Classes for each number of hours of homework are given in Diagram 149. If this Diagram be compared with Diagram 49 (*Annals*, Vol. II, p. 127) the reader will find essential differences between them. Hypermetropic Astigmatism increases with Age as it does with Hours of Homework. But Myopia and Myopic Astigmatism which increase with Age decrease with Hours of Homework. We at first thought the diagrams would be very similar, because we imagined Hours of Homework would increase with Age. But on working out this association we found nothing of the kind. Hours of Homework increase till the ninth year and then fall steadily till the boy leaves school. At 10 the boy has about 10 hours of homework per week, at 14·5 years the boy has, on the average, only 7 hours. It is, we think, due to the fact that the elder boys take more Hebrew at school and less out of school hours. Table CCCXLI gives our data.

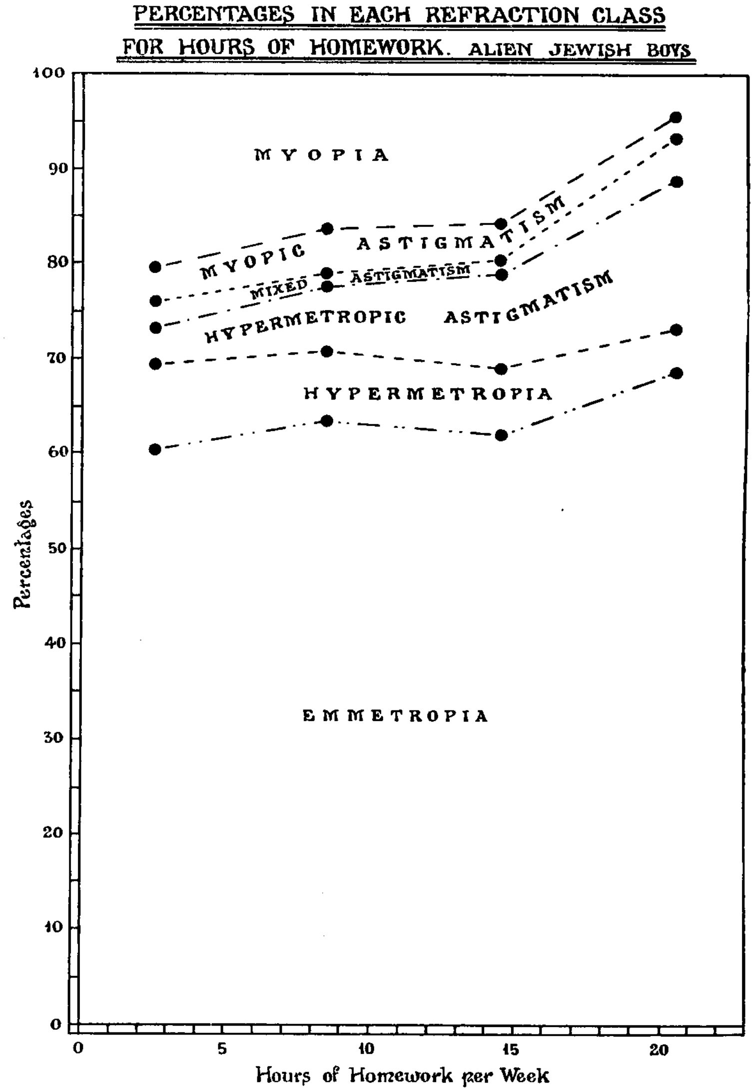

Diagram 149.

Table CCCXLI. *Hours of Homework and Age* (*Boys*).

Hours of Homework

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Totals
6·4583	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
7·4583	1	2	1	1	—	—	1	—	—	—	3	5	—	—	—	—	—	0·5	0·5	—	0·5	0·5	—	—	16
8·4583	3	1	0·5	2	2·5	1	1	0·5	1·5	1	6	1	—	—	1	4	1	—	1	0·5	1·5	—	—	—	30
9·4583	4	2	2·5	2·5	1	1·5	1·5	—	2·5	1·5	5·5	4	9	1·5	2	—	3	0·5	4·5	1	—	—	1	—	51
10·4583	—	0·5	4·5	6	5	1	4·5	1	2·5	3	3	2	6	2	13	—	1	0·5	1·5	2	—	1	—	—	60
11·4583	2	0·5	5	2·5	1·5	7	4·5	4	—	1	1	1·5	8	1·5	2·5	0·5	—	1	1	—	1	—	—	1	47
12·4583	—	1	10·5	1·5	8·5	22	23·5	6	3	4	2	3·5	10	5·5	5	1	4	3	1	—	2	—	—	1	118
13·4583	—	2	1·5	0·5	2·5	23·5	8	2·5	1·5	2·5	2	2·5	6	—	3	1·5	0·5	0·5	1	0·5	0·5	0·5	—	—	63
14·4583	—	—	1	—	—	6	4	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	12
15·4583	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—	1	—	—	—	—	—	3
Totals	10	9	26·5	17	21	62	48	14	12	14	22·5	19·5	39	10·5	27·5	7	9·5	6	11·5	4	5·5	2	1	2	401

* "Schools are the main hotbeds for the propagation of nearsightedness." "Nearsightedness is acquired by straining the eyes." "Prevalence of nearsightedness among the young engaged in studies," and so forth are the usual statements.

Mean Age: 11·3863 years; Standard Deviation, Age: 1·8043 years.
Mean Homework: 8·4938 hours; „ „ Homework: 5·1004 hours.

Product Moment Coefficient of Correlation:

$$r = -\cdot 1214 \pm \cdot 0332,$$

i.e. less Homework with greater age.

Correlation Ratio of Homework on Age:

$$\eta'^2_{H.A} = \cdot 027{,}433, \qquad \bar{\eta}^2_{H.A} = \cdot 017{,}456 \pm \cdot 006{,}230.$$

While $\eta'^2_{H.A}$ is not definitely significant having regard to the value of $\bar{\eta}^2_{H.A}$, r is significant, and the array-means give a fairly continuous series.

Age in Years	Mean Hours of Homework
7·40	8·176 ± ·834
8·46	9·067 ± ·628
9·46	9·833 ± ·482
10·46	9·600 ± ·444
11·46	8·202 ± ·502
12·46	8·004 ± ·317
13·46	7·659 ± ·433
14·66	7·000 ± ·888
General Population:	8·494 ± ·172

Diagram 150 gives the Regression Line. If we are in doubt about the significance of η' (= ·1656) we can at least be sure that the Hours of Homework do not increase with Age, and therefore, as far as our Hours of Homework can be trusted, it is not those hours which are the source of Myopia. It really does look as if the Myopic Boys cut down their hours of close study after school hours.

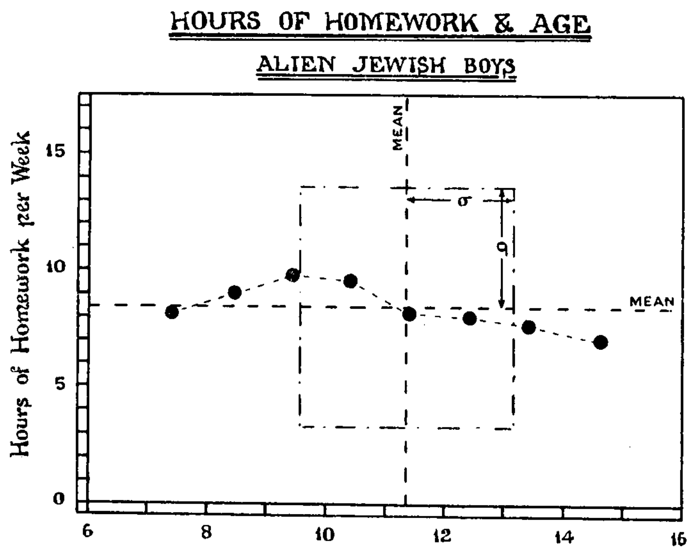

Diagram 150.

(vii) *Summary.*

We have now to sum up the results obtained by measuring the association of ocular characters with environmental factors. Some of the chief values of the correlational constants are given in Table CCCXLII, p. 76. A mere glance at them shows that the effects of environment on sight are in the great bulk of cases non-significant. In the few cases where some of them are significant (especially in the cases of Corneal Refraction and Corneal Astigmatism with economic conditions) it is very difficult to give a rational explanation of them unless we assume that to a minor degree astigmatism can be produced by personal uncleanliness and by poverty. The boys of the dirtiest class have certainly more astigmatism than those of any of the others. This personal cleanliness is also, as we have seen, associated with a greater prevalence of eye disease. When we note how little corneal astigmatism changes with age, we are inclined to ask, if diseases of the eye due to dirt have been found to modify the cornea? We have not found in the usual textbooks any statement on this point, but it is one which practising ophthalmologists might bear in mind. The general influence on sight of environmental conditions seems negligible. Personal habits may induce diseases of the eye which affect certain ocular characters. But we have sought in vain for any substantial influence of environment on sight as measured by the usual characters observed for the eye. Even Hours of Homework do not appear to be productive of either Myopia or any other phase of bad sight. To this point we shall return when dealing with the study of Hebrew.

Table CCCXLII. *General Summary of Association of Sight with Environment.*

Ocular Characteristic *

Environmental Factor	Visual Acuity (Binocular)	Refraction Class	General Refraction	Corneal Refraction	General Astigmatism	Corneal Astigmatism
Cleanliness of Person	r_t and η'^2 non-significant	r_t and ϕ'^2 non-significant	$r_b = + \cdot 0088 \pm \cdot 0494$	$r_b = - \cdot 0179 \pm \cdot 0706$	$r_b = + \cdot 1221 \pm \cdot 0483$	$r_b = + \cdot 1718 \pm \cdot 0674$ $r_b = \cdot 0666 \pm \cdot 0346$†
Cleanliness of Home	$r_b = - \cdot 0160 \pm \cdot 0449$	$r_t = - \cdot 0621 \pm \cdot 0395$ ϕ'^2 hardly significant	$r_b = - \cdot 1429 \pm \cdot 0376$ $r_t = - \cdot 0982 \pm \cdot 0406$	$r_b = + \cdot 0595 \pm \cdot 0649$	$r_b = + \cdot 0126 \pm \cdot 0389$	$r_b = + \cdot 0683 \pm \cdot 0647$
Lighting of Rooms	$r_b = \cdot 0116 \pm \cdot 0546$	$r_t = - \cdot 0893 \pm \cdot 0397$ ϕ'^2 non-significant	$r_b = + \cdot 0176 \pm \cdot 0392$	$r_b = - \cdot 0360 \pm \cdot 0687$	$r_b = + \cdot 0030 \pm \cdot 0392$	$r_b = + \cdot 0523 \pm \cdot 0688$
Ventilation of Rooms	$r_b = + \cdot 0306 \pm \cdot 0441$	$r_t = + \cdot 0515 \pm \cdot 0403$ ϕ'^2 hardly significant	$r_b = - \cdot 0447 \pm \cdot 0401$	$r_b = + \cdot 0507 \pm \cdot 0651$	$r_b = - \cdot 0408 \pm \cdot 0401$	$r_b = + \cdot 1656 \pm \cdot 0625$
Overcrowding (Persons per Room)	$r = - \cdot 0159 \pm \cdot 0352$ η'^2 non-significant	η'^2 and ϕ'^2 non-significant	$r = - \cdot 0509 \pm \cdot 0251$ η'^2 possibly significant	$r = + \cdot 0302 \pm \cdot 0412$ η'^2 probably significant	$r = - \cdot 0489 \pm \cdot 0251$† η'^2 probably significant	$r = - \cdot 1205 \pm \cdot 0406$
Rent "per Adult"	$r = + \cdot 1168 \pm \cdot 0379$ η'^2 non-significant	η'^2 non-significant	η'^2 non-significant	$r = + \cdot 0522 \pm \cdot 0462$ η'^2 not significant	$r = + \cdot 0192 \pm \cdot 0280$ η'^2 non-significant	$r = + \cdot 0505 \pm \cdot 0462$ η'^2 non-significant
Income "per Adult"	$r = - \cdot 0100 \pm \cdot 0386$ η'^2 non-significant	ϕ'^2 non-significant	$r = + \cdot 0212 \pm \cdot 0278$ η'^2 non-significant	$r = - \cdot 1113 \pm \cdot 0447$ η'^2 significant	$r = - \cdot 0014 \pm \cdot 0278$ η'^2 non-significant	η'^2 significant $\eta' = \cdot 3737$
Food	$r_t = + \cdot 0802 \pm \cdot 0435$	—	—	—	—	—
Rickets	$r_t = + \cdot 0872 \pm \cdot 0316$ ϕ'^2 non-significant	— —	—	—	—	—
Tonsils	r‡ $= + \cdot 0842 \pm [\cdot 0624]$	—	—	—	—	—
Glands	r‡ $= + \cdot 0385 \pm [\cdot 0715]$	—	—	—	—	—
Hours of Homework	$r = + \cdot 0264 \pm \cdot 0240$ η'^2 significant	η'^2 significant but difficult to interpret	—	—	—	—

Our final conclusion here must be that poor environment is *not* the source of defective vision in these Jewish Boys and the inference is that it will not be found to be so either in the case of Gentile children.

* r = product moment correlation coefficient; r_b = biserial correlation coefficient; r_t = tetrachoric correlation coefficient; η'^2 = uncorrected square of correlation ratio; ϕ'^2 = mean squared uncorrected contingency.

† Sign of Astigmatism regarded.

‡ Triserial coefficient of correlation, i.e. found from three-rowed table.

(To be continued)