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COMMUNICATIONS

AN INVESTIGATION INTO THE EFFECT UPON
THE EYES OF OCCUPATIONS INVOLVING
CLOSE WORK

Being a résumé of work done for the Physiology of
Vision Committee of the Medical Research Council

BY

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LONDON

THE investigations here described were undertaken in order to determine what effect (if any) upon the eyes is brought about by continuous close work, such as is necessitated in many branches of industry. It was thought probable that any deleterious effect would be most readily discovered in young adults in the second decade of life, since among those engaged upon such work the eyes, being still to some extent in the period of growth and development, are in the most labile state. We were, therefore, fortunate in being allowed access to the London School of Printing, and being given the opportunity of examining the apprentices working therein. The pupils here are youths, the majority of whom are between 14 and 20 years of age, and they may reasonably be taken as representative of the average physical standard. Since the institution is a day school, and the students work on the average between 9 a.m. and 6 p.m., going home at night, the conditions correspond closely to those of the average worker. The work which goes on in the school is of a very varied character, and includes such occupations as composing, where the opportunities of eye-strain are very considerable, as well as others such as training as warehousemen and binders, when the eyes are not used to any great degree. To a large extent, therefore,

controls were provided within the confines of the investigation itself. The pupils are of a relatively high standard of intelligence, so that their interest and co-operation were readily obtained for the purposes of the investigation, while the conditions of their apprenticeship made it possible for their individual cases to be continuously observed for periods of several years. The present report is based upon the examination of 244 apprentices: a considerably greater number of observations were taken, but only those are recorded in which four successive examinations were possible at nine months' intervals.

The questions which it was thought expedient to investigate were:

1. The visual acuity.
2. The refractive error (if any).
3. The power of accommodation.
4. The state of the muscle balance.
5. The presence and degree of binocular and stereoscopic vision.

The visual acuity was measured by Snellen's test types, placed at six metres distance in a darkened room, and illuminated locally by electric lights giving a relatively uniform illumination over the test card of three to four foot-candles.

The refraction was done by retinoscopy, a plane mirror being used. As a routine no mydriatic was employed, except in a few cases where accommodative disturbances were found to be present, when homatropine and cocaine drops were employed; in these cases the vision and the refraction are recorded as given in a post-mydriatic test.*

The power of accommodation was measured unilaterally and binocularly with the accommodation card of Duane.

The state of the muscle balance was estimated for distance by the Maddox rod test, the correction being made by prisms; for near vision the Maddox wing test was used.

Binocular and stereoscopic vision were investigated by the Worth amblyoscope.

The subjects examined may be divided as follows:—

Compositors	... ..	80
Machinists and Letter Press Printers	... ..	72
Binders and Warehousemen	... ..	44
Lithographers	... ..	10
Stereotypers	... ..	12
General students (doing everything)	... ..	26
	Total	244

* The routine use of a mydriatic was found to interfere too much with the work of the school to be practicable.

Compositors

The compositors work in a large room provided with over-head windows, illuminated diffusely in the evening by over-head lights suspended from the ceiling. There is no local lighting provided. Each worker stands in front of a sloping bench which contains numerous small trays of type, each containing a large number of types of an individual letter. From out of these they pick letters and set them in a block by hand, thus building up lines of print. In this work a considerable amount of eye-strain may occur, as the types are frequently small, and after a certain amount of use are not easy to read. The types are made of an alloy of lead, antimony, and tin, which, when new, presents a bright metallic surface involving a considerable amount of glare. New types, however, form the minority of those used.

REFRACTION

The 80 compositors may be classified thus according to their refractions.

Emmetropic ...	12 subjects	15 per cent.
Myopic ...	34 subjects	42·5 per cent.
Hypermetropic	32 subjects	40 per cent.
Mixed ...	2 subjects	2·5 per cent.

1. *Emmetropes*. 12 subjects.

All the emmetropes remained so with the exception of two, in whom the refraction became slightly myopic. The highest myopic change in any meridian was $-0\cdot5$ D.

2. *Myopes*. 34 subjects.

For purposes of classification these were divided into two categories:—

- (a) Less than $-1\cdot0$ dioptré of myopia in the most ametropic meridian.
 - (b) Greater than $-1\cdot0$ dioptré of myopia in the most ametropic meridian.
- (a) *Less than $-1\cdot0$ D.* 22 subjects.

Of these

- (a) There remained stationary 4 subjects.
- (b) The myopia progressed in 18 subjects.

In no case did any diminution of the error take place.

In those cases wherein the myopia increased the amount of increase was small, averaging $-0\cdot5$ D. The highest increase was less than $-1\cdot0$ D.

- (b) *Myopia greater than -1.0 D.* 12 subjects.

Of these

- (a) There remained stationary 4 subjects.
 (b) The myopia progressed in 8 subjects.

Again the advance of myopia was in each case relatively small, with the exception of two cases wherein an increase of -1.5 D. was registered within the period of three years. The average increase was 0.5 D.

3. *Hypermetropes.* 32 subjects.

Of these

- (a) There remained stationary 22 subjects.
 (b) The hypermetropia diminished in 10 subjects.

This finding is what one would expect in the ordinary course of events. The tendency is for hypermetropia to decrease in youth—if any change takes place—and the changes recorded were small, usually under 0.5 D., except in three cases.

4. *Mixed.* There were two cases of smaller errors both of which remained stationary. In both the error was -0.25 D. sphere $+0.5$ D. cylinder.

An analysis of these figures reveals the following facts:—

With regard to the initial state of the refraction the percentage of myopes is high (42.5 per cent.)

With regard to the progress of the refraction—

1. Emmetropes. 83.3 per cent. remained stationary.
 16.7 per cent. became myopic: in these the change was small.
2. Myopes. (a) Small errors.
 18.2 per cent. remained stationary.
 81.8 per cent. progressed by an average of -0.5 D.
 (b) Large errors.
 33.3 per cent. remained stationary.
 66.6 per cent. progressed by an average of -0.5 D.
 In 16.6 per cent. the increase was rapid (-0.75 to -1.5 D).
3. Hypermetropes.
 69 per cent. remained stationary.
 31 per cent. became less hypermetropic.
 In 12.5 per cent. the decrease was rapid.

These results of a record of three years' change show a change in direction towards myopia more than would be expected.

MUSCLE BALANCE.—An examination of the muscle balance showed that 52 of the 80 subjects (65 per cent.) had heterophoria of more than 1° prism.

1. The most common error was esophoria (85 per cent.), the average error for distance being 3° prism, and for near vision being 6° prism.

Hyperphoria occurred in 10 per cent., the error being small and averaging 1.5° prism.

Exophoria occurred in 5 per cent., the error being small and averaging 2° prism.

Repeated examinations of the muscle balance showed no definite trend for the better or for the worse, and, while the error in the majority of cases remained to all intents and purposes stationary throughout in the majority of cases, in others it altered in a very variable degree. Moreover, it changed in degree from day to day and at different times during the same day: thus, on the whole, heterophoria was less evident on Monday than on Friday, and the same individual would show a considerably greater degree of imbalance at 6 p.m., than was elicited at 10 a.m. One would expect it to vary in this way directly with the degree of muscular fatigue. The measurements are, therefore, not given in detail, and they should be accepted only as a rough approximation of a quantity too variable to estimate accurately.

The muscle balance reveals a very high percentage of esophoria, which was practically invariably of the type which is due to convergence excess. While a certain amount of this may be an advantage for near work, the degree of the error appears to be too pronounced to be passed over unnoticed. It is noticeable that it occurred almost as much among the myopes as among the hypermetropes, although it was not so marked in the former.

The visual acuity with the proportionate correction almost invariably came up to 6/6, and investigation of the power of accommodation and the degree of binocular and stereoscopic vision led to no results of interest.

Machinists and Letterpress Printers

The work conducted by this class is varied; most of it involves no great eye-strain. To a large extent it consists of watching mechanical machinery. In colour reproductions, however, fine work is entailed where the coloured lines in illustrations have to be superimposed with an accuracy amounting in some cases to 1/1000 inch. The cutting out of half-tone blocks also involves a considerable amount of near work. The room wherein this work is done is lit by overhead windows, supplemented by side windows, and at night by diffuse light from the ceiling.

REFRACTION

The 72 subjects of this class may be classified thus according to their refraction :—

Emmetropic	...	nil.	
Myopic	...	22 subjects	30·5 per cent.
Hypermetropic	...	50 subjects	69·5 per cent.

1. *Myopes.*

- (a) Less than $-1\cdot0$ D. in the most ametropic meridian :
14 subjects.

Of these

- (a) There remained stationary 8 subjects.
(b) The myopia progressed in 6 subjects.
In no case did the increase in myopia exceed $-0\cdot5$ D.

- (b) A myopia greater than $-1\cdot0$ D. : 8 subjects.

Of these

- (a) There remained stationary—4 subjects.
(b) It progressed in 4 subjects.

The highest progression was of $-1\cdot5$ D.; the average progression was $-0\cdot5$ D.

2. *Hypermetropes.* 50 subjects.

Of these

- (a) There remained stationary—35 subjects.
(b) The hypermetropia diminished in 15 subjects.
In all of these the diminution was small and was well within physiological limits (about $-0\cdot5$ D.), and could be taken to correspond to the degree of change which one could reasonably anticipate in a group of normal subjects of this age.

An analysis of these figures reveals the following facts :—

1. Emmetropes. Nil.
2. Myopes. (a) Small errors.
57·1 per cent. remained stationary.
42·9 per cent. progressed with an average of $-0\cdot5$ D.
(b) Large errors.
50 per cent. remained stationary.
50 per cent. progressed with an average of $-0\cdot5$ D.

3. *Hypermetropes*. 70 per cent. remained stationary.
30 per cent. became slightly less hypermetropic.

The HETEROPHORIA shown by this group of subjects was as follows:—

The error was limited almost entirely to esophoria—45 subjects (64·3 per cent.) It was small, averaging 2° prism for distance vision, and a 4° prism for near vision. The type of esophoria again was of the nature of excess of convergence.

Exophoria was found in four subjects: the average error was 2° prism.

Hyperphoria was found in three subjects: the average error was 2° prism.

Warehousemen and Binders

The warehousemen and binders work as a general rule in a large room with benches alongside the walls, which are well provided with side windows. The work is varied and does not involve any particular eye-strain; the sewing and glueing of books, the making and fitting of bindings, etc.

REFRACTION

The 44 subjects of this class may be classified thus according to their refraction:—

Emmetropic	...	2 subjects	4·5 per cent.
Myopic	... ..	12 subjects	27·3 per cent.
Hypermetropic	...	26 subjects	59·1 per cent.
Mixed	... ..	4 subjects	9·1 per cent.

1. *Emmetropes*. The refraction of the two emmetropes remained stationary.

2. *Myopes*. The 12 myopes all had a refractive error less than -1·0 D.

66·6 per cent. remained stationary.

33·3 per cent. progressed by an average of -0·25 D., and the greatest deterioration was -0·5 D.

3. *Hypermetropes*. Of the 26 hypermetropes only three (11·5 per cent.) got slightly less hypermetropic; in no case was the diminution more than -0·25 D.

4. *Mixed Cases*. Of the four mixed cases, three (75 per cent.) remained stationary and one became more myopic.

MUSCLE BALANCE.—An investigation of the muscle balance revealed comparatively slight abnormalities, six of them (13·6 per cent.) having a small degree of esophoria averaging 2° prism.

Lithographers

Lithography involves no great degree of eye-strain. The copying and making of impressions on a stone or zinc plate is done in a well-lighted room with side-windows. Ten subjects of this class were under examination.

REFRACTION

These may be classified thus according to their refraction:—

Emmetropic	1 subject.
Hypermetropic	6 subjects.
Myopic	3 subjects.

1. *Emmetropes*. The emmetrope remained stationary throughout the period of observation.

2. *Myopes*. Of the three myopes one remained stationary, and two progressed, one by -0·5 D. and the other by -1·0 D. in the meridian of greatest refraction.

3. *Hypermetropes*. In the six hypermetropes the refraction remained stationary in five, while one subject got more hypermetropic; in this last the error changed from +1·25 to +1·75 D. sphere.

MUSCLE BALANCE.—An examination of the muscle balance revealed the fact that two subjects (20 per cent.) had a small degree of esophoria (averaging 3° prism) and that one subject (8·3 per cent.) had a small degree of hypophoria averaging 2° prism.

Stereotypers

The work of stereotypers is varied and is carried on in a dark basement illuminated by diffuse and local light. In some of the types of work there is a considerable amount of glare from the bright surface of metal. Only 12 subjects of this class were available for examination.

REFRACTION

The examination of refraction of these showed

Emmetropic	nil.
Myopic	6 subjects.
Hypermetropic	6 subjects.

1. *Myopes*. There remained stationary two subjects (33·3 per cent.) The myopia progressed in four subjects (66·6 per cent.) In each case progression was small, less than $-0\cdot5$ D.

2. *Hypermetropes*. Of the six subjects—

- (a) There remained stationary four subjects.
- (b) A slight myopia developed in one involving a decrease of hypermetropia of $+0\cdot37$ D.
- (c) A slight increase in hypermetropia occurred in one, the increase being $0\cdot25$ D.

MUSCLE BALANCE.—An examination of the muscle balance of these subjects showed that four (33·3 per cent.) had a slight degree of esophoria.

Students engaged in all Occupations

There is a considerable number of students who go through the entire curriculum of studies at the Printing School: 26 of these were kept under examination.

REFRACTION

These may be divided into the following classes according to their refraction—

Emmetropic	...	...	...	nil.
Myopic	...	...	...	8 subjects.
Hypermetropic	...	...	...	17 subjects.
Mixed	...	...	...	1 subject.

1. *Myopes*. Of the eight subjects—

- (a) Five remained stationary.
- (b) Three progressed. They all had an error less than $-1\cdot0$ D. sphere, except one, but the amount of progression in each case was less than $-0\cdot5$ D.

2. *Hypermetropes*. Of the 17 subjects, two only showed a change in the direction of myopia amounting to $-0\cdot5$ D.

3. *Mixed*. The subject with mixed astigmatism remained stationary.

MUSCLE BALANCE.—Of the 26 cases, four subjects (15·3 per cent.) showed a heterophoria. Of these three (11·5 per cent.) had esophoria due to excess of convergence of 2° , 3° , and 7° prism respectively, and one had a hyperphoria of 3° prism.

Summary

A résumé in statistical form of these results is appended: the first figures in each column give the percentage of cases, and the figures in brackets give the actual numbers.

Number of Subjects	Composi- tors	Machinists	Ware- housemen	Litho- graphers	Stereo- typers	General
	80	72	44	10	12	26
Initial Refraction						
1. Emmetropes - -	15 (12)	Nil	4.5 (2)	10 (1)	Nil	Nil
2. Myopes - - -	42.5 (34)	30.5 (22)	27 (12)	30 (3)	50 (6)	31 (8)
3. Hypermetropes -	40 (32)	69.5 (50)	59.5 (26)	60 (6)	50 (6)	65 (17)
4. Mixed - - -	2.5 (2)	Nil	9 (4)	Nil	Nil	4 (1)
Heterophoria - - -	65 (52)	69.5 (50)	13.5 (6)	20 (2)	33 (4)	11.5 (3)
Change of Refraction						
I. Emmetropes:—						
(a) Stationary - -	83 (8)		100 (2)	100 (1)	Nil	Nil
(b) Became myopic - -	16 (2)	Nil	Nil	Nil		
(c) Became hypermetropic - -	Nil		Nil	Nil		
II. Myopes Total						
(a) Stationary - -	23 (8)	54.5 (12)	67 (8)	33 (1)	33 (2)	62.5 (5)
(b) Progressed - -	77 (26)	45.5 (10)	33 (4)	67 (2)	67 (4)	37.5 (3)
*Small Errors						
(a) Stationary - -	18 (4)	57 (8)	67 (8)	33 (1)	33 (2)	72 (5)
(b) Progressed - -	82 (18)	43 (6)	33 (4)	67 (2)	67 (4)	28 (2)
(i) Increase small*	82 (18)	43 (6)	33 (4)	67 (2)	67 (4)	28 (2)
(ii) Increase large*	Nil	Nil	Nil	Nil	Nil	Nil
(c) Diminished - -	Nil	Nil	Nil	Nil	Nil	Nil
*Large Errors						
(a) Stationary - -	33 (4)	50 (4)				Nil
(b) Progressed - -	67 (8)	50 (4)				100 (1)
(i) Increase small*	50 (6)	37.5 (3)	Nil	Nil	Nil	100 (1)
(ii) Increase large*	17 (2)	12.5 (1)				Nil
(c) Decrease - - -	Nil	Nil				Nil
III. Hypermetropes						
(a) Stationary - -	69 (22)	70 (35)	88.5 (23)	83.5 (5)	67 (4)	88 (15)
(b) Progressed - -	Nil	Nil	Nil	16.5 (1)	16.5 (1)	Nil
(c) Diminished - -	31 (10)	30 (15)	11.5 (3)	Nil	16.5 (1)	12 (2)
(i) Diminution small - -	28 (9)	30 (15)	11.5 (3)	Nil	16.5 (1)	12 (2)
(ii) Diminution large - -	3 (1)	Nil	Nil	Nil	Nil	Nil
IV. Mixed						
(a) Stationary - -	100 (2)		75 (3)			100 (1)
(b) Became myopic - -	Nil	Nil	25 (1)	Nil	Nil	Nil
(c) Became hypermetropic - -	Nil		Nil			Nil

*Small in each case represents less than 1.0 dioptre in the meridian of greatest ametropia;

Large an error greater than 1.0 dioptre.

On the whole it may be taken as a general rule that the composers are engaged on the work which entails the greatest strain on the eyes. In the majority of the other branches of the work of the school not only is less near work involved, but it is almost invariably of a more varied character. It may therefore be interesting to compare the subjects in two classes—compositors and other occupations.

NUMBER.	Compositors	Others
	80	164
<i>Initial Refraction</i>		
1. Emmetropes - - - - -	15 (12)	2 (3)
2. Myopes - - - - -	42·5 (34)	31 (51)
3. Hypermetropes - - - - -	40 (32)	64 (105)
4. Mixed - - - - -	2·5 (2)	3 (5)
Heterophoria - - - - -	65 (52)	39·5 (65)
<i>Change of Refraction</i>		
I. <i>Emmetropes</i>		
(a) Stationary - - - - -	83·3 (8)	100 (3)
(b) Became myopic - - - - -	16·7 (2)	Nil
II. <i>Myopes</i>		
(a) Stationary - - - - -	23 (8)	55 (28)
(b) Progressed - - - - -	77 (26)	45 (23)
(i) Small errors:		
(a) Stationary - - - - -	18·2 (4)	5·7 (24)
(b) Progressed to small degree - - - - -	81·8 (18)	43 (18)
(c) Progressed to large degree - - - - -	Nil	Nil
(ii) Large errors:		
(a) Stationary - - - - -	33·3 (4)	44·5 (4)
(b) Progressed - - - - -	66·7 (8)	55·5 (5)
(i) To small degree - - - - -	50 (6)	44·5 (4)
(ii) To large degree - - - - -	16·7 (2)	11 (1)
III. <i>Hypermetropia</i>		
(a) Stationary - - - - -	69 (22)	78 (82)
(b) Became myopic - - - - -	31 (10)	20 (21)
(i) To small degree - - - - -	28 (9)	20 (21)
(ii) To large degree - - - - -	3 (1)	Nil
(c) Became more hypermetropic - - - - -	Nil	2 (2)
IV. <i>Mixed</i>		
(a) Stationary - - - - -	100 (2)	80 (4)
(b) Became myopic - - - - -	Nil	20 (1)

Conclusions

Reviewing these figures it is obvious that the composers do not bear comparison well with those engaged in other occupations.

Not only do their numbers contain initially a considerably higher percentage of myopes, but the number in which the refractive error increases towards myopia is also higher. Moreover, the percentage suffering from a considerable amount of muscular imbalance is higher.

These figures suggest that the occupation which entails the greatest degree of eye-strain has the most deleterious effect upon vision; and that one of the results of such an occupation is to encourage the development of short-sightedness. It is to be noted that some of the members of this class do complain of inadequacy of the illumination in the room, especially when working with artificial light.

It is to be remembered, of course, that the age period over which observations were taken represents a relatively labile phase in the refraction of the eye: and it is not to be expected that the same degree of progression will be evident later in life.

THE DRAINAGE OF THE INTRA-OCULAR FLUIDS

BY

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It will be recalled that a paper was read by F. Ridley in the session of the Ophthalmological Society of the current year on the mechanism of the drainage of the intra-ocular fluids; appearing now in print (*Brit. Jl. of Experimental Pathology*, Vol. XI, p. 217, abstracted on p. 633) its contents can be adequately followed. The arguments which are brought forward in the attempt to re-establish an old hypothesis that the greater part of the drainage of the aqueous humour occurs not through the canal of Schlemm but through the cornea into the conjunctival sac, merit some comment, even at the cost of some repetition of what has been already published.

Ridley, after considering the anatomical relations at the canal of Schlemm in the light of the work of T. Henderson (1908) and Arthur Thomson (1911) [most of the questions raised are adequately answered in the classical work of Maggiore, 1917] concludes that "since minute particles such as those of Indian ink do not pass into the lumen of the canal from the anterior chamber (Nuel and Benoit, 1895), there is evidence that no such direct communication