Pre-school vision study

GEORGE AMIGO

University of New South Wales, Sydney, Australia

Research into the development of visual functions, especially during the last three decades, has produced strong evidence in favour of early treatment of visual disorders (Lyle and Foley, 1957, Sauberli, 1962). The most important and most damaging of these disorders are amblyopia, eccentric fixation, and anomalous retinal correspondence.

The aim of the present investigation was to design a test battery capable of uncovering these disorders and suited to children aged 3 to 5 years.

A cross-section of the population of children was selected on a mixed denominational and social class basis.

Four nurseries and/or kindergartens were approached in the suburbs of Sydney:

- (1) A denominational kindergarten on the North Shore (sociologically described as upper middle-class)
- (2) A non-denominational kindergarten in the Eastern suburbs (sociological classification lower to upper middle class)
- (3) A denominational kindergarten in the Southern Suburbs (working class)
- (4) A non-denominational day nursery in the Western Suburbs (Mixed working and middle class)

All the tests were carried out during the morning and on consecutive days.

Establishing contact

Children in this age group will not cooperate spontaneously unless they are convinced of the "honourable" intentions of "strangers". Winning their confidence is essential. If they like you and consider you a match to their intelligence they will go along willingly but if you are caught out trying to fool them, no amount of authority or persuasion will change their minds.

The following steps were taken in establishing rapport with the children:

The examiners were introduced to the whole group as Auntie M and Uncle G who came to the nursery to show some new toys and to play with the children. White coats were not worn during these visits. Two children were selected (usually volunteers) and they were taken to the tables where all the "toys" were laid out (Fig. 1, overleaf). One child was tested while the other watched the proceedings (Fig. 2, overleaf).

Examination procedure

The record sheet used is shown in Fig. 3 (overleaf). The relevant tests and apparatus were as follows:

FIG. 1
*Some of the
testing
apparatus*

FIG. 2
*Testing in
progress*

(1) *Stereopsis*

Two types of test patterns were used:

- (a) The first contained a fixed amount of crossed and uncrossed field disparity in the form of a set of

HOME ADDRESS OR SCHOOL _____				DATE _____	
NAME _____		AGE ____ yrs ____ mths		SEX	M ☐ F ☐
HANDED	R ☐ L ☐	PUPIL (mm.)	R ☐ L ☐	ILLUM. F + c. AT EYES	☐

1. TITMUS STEREO TEST	FLY IN STEREO YES ☐ NO ☐	S. A % <input type="text"/>	
-----------------------	---	-----------------------------	--

2. RABBIT-CAGE (L) (R) (Shaft No, 8)	IN ☐	OUT ☐	SEES ☐	
	ESO	EXO		

3. PHORIA (Shaft No, 8)	HORIZONTAL Red ☐ Yellow ☐ Green ☐	ESO	EXO	VERTICAL ☐ + ☐ O ☐ ♥ ☐ ☆	R.H. L.H.
-------------------------	---	-----	-----	--	--------------

4. VISION CUBE E 6 M. R ☐ L ☐	5. VISION NEAR (Shaft No, 8) R ☐ L ☐
--	---

6. CONVERGENCE AMPLITUDE (cm.) <input type="text"/>	7. MOTILITY GOOD ☐ FAULTY ☐	8. HAND-EYE CO-ORDINATION <1cm. ☐ 1-5cm. ☐ >5cm. ☐
--	--	--

9. DYNAMIC RETINOSCOPY AT 40 cm. R ☐ L ☐	10. PLACIDO DISC POSITIVE R ☐ L ☐
---	--

11. VISUSCOPY FOVEAL REFLEX SEEN R ☐ L ☐	12. FIXATION CENTRAL R ☐ L ☐
--	---

13. FUNDUS			
------------	--	--	--

14. RESULT	N.A.D. ☐	FURTHER TEST ☐	SCHOOL NOTIFIED ☐
------------	---------------------------------	---------------------------------------	--

PROBABLE ANOMALY	
REMARKS	

FIG. 3 Record Sheet

double slides viewed in a stereoscope. Each half of the slides contained check marks. This configuration could differentiate between stereopsis, binocular, and unocular vision but could not quantitatively assess stereoscopic sensitivity.

(b) The second utilized the Titmus stereo test, which assesses quantitatively the stereoscopic sensitivity by cross-polarization of unocular views that introduce measured disparities at the near observation distance of 40 cm. Stereoscopic sensitivity is expressed in arc seconds of disparity from 40 to 800 sec. of arc.

(2) *Binocular coordination*

A superimposition slide of the rabbit and cage (Hamblin's Cruise Series) was used in conjunction with the Holmes stereoscope to assess the quality of binocular coordination. This type of test indicates the direction and type but not the extent of phoria-tropia or suppression.

An enlarged cardboard replica of the rabbit and cage was used to reproduce the appearance of the binocular concept. Holding the rabbit in his hand the child was asked to place it in or around the cage as it appeared to him in the original (Fig. 4)

FIG. 4 *Cardboard demonstrator set of rabbit and cage*

(3) *Phoria tests*

A keystone double slide was shown in the Holmes stereoscope. Horizontal heterophoria was assessed by a row of three horizontal strips of red, yellow, and green coloured bars seen by one eye and a vertical arrow seen by the other. Vertical heterophoria was similarly examined by presenting a column of patterns consisting of a square, cross, circle, heart, and star to one eye and a horizontal line to the other.

(4) *Visual acuity*

(a) Distance acuity was determined with the cube E test. One E was shown at a time with its prongs pointing towards one of four positions (right, left, up, or down) and the child had to reproduce the same direction with a cut-out E held in his hand. Correct reproduction of at least four out of five presentations formed the basis of acuity assessment.

(b) Near acuity was determined with the aid of a Keystone pre-school slide containing outlines of familiar shapes: house, chair, rabbit, chicken, ball, etc. The visual angles subtended by these outlines correspond to acuities of 0.5 and 0.25 based on a one-minute optimum resolution. Both distance and near tests were given unilaterally.

(5) *State of the extraocular muscles*

(a) The amplitude of convergence was tested by the objective assessment of break from convergence. The child was asked to view a vertical black line on a white background as this target was slowly pushed up towards him.

(b) Mobility was observed as the child followed a small light source with his eyes into the nine cardinal directions of gaze.

(6) Eye-hand coordination was tested on a projectionometer-type apparatus (Duke-Elder, 1949).

- (7) Dynamic retinoscopy was carried out at 40 cm. and the high neutral point was recorded for each eye separately.
- (8) The Keeler self-luminous placido disc was used to assess any gross corneal astigmatism or irregularities of the central optical zone.
- (9) The fundus was examined with a "Heine" ophthalmoscope. This instrument incorporates a star-fixation target, surrounded by a set of concentric rings at 1° intervals. These are imaged on the retina for the determination of the quality of fixation. In addition, the paracentral area of the fundus and the optic disc were examined and the quality of the foveal reflex noted.

Results

Fig. 5 shows the frequency distribution of the findings in two series of 105 and 100 cases respectively.

SET 1: 105 CASES

52 boys
53 girls

FIG. 5 Frequency distribution of findings

The main reason for this division lies in the different methods used for the assessment of stereoscopic acuity in the two sets.

As mentioned previously, in the first set a qualitative test was used, whereas in the second the test afforded the expression of the results in terms of the angular value of retinal disparity. The data will therefore be discussed separately for the two sets but comparisons will be made between them whenever this is warranted.

(1) Stereopsis

- (a) The first set shows that, out of a total of 105 cases, 15.1 per cent. possessed stereopsis, 62 per cent. binocular vision, 1.9 per cent. unocular vision only, and 21 per cent. were doubtful.

It is quite likely that all of those with binocular vision possessed stereopsis but the test situation was apparently too difficult and therefore unsuitable for this age group.

(b) The Titmus stereo test gave excellent quantitative results in the second set. The mode was 100 sec. of arc. representing 44 per cent. of the cases. 18 per cent. possessed better stereoscopic acuity, 33 per cent. showed less, and 5 per cent. were doubtful. This is an excellent response and indicates the suitability of the test for this age group.

(c) The breakdown of stereoscopic sensitivity according to age groups is shown in Table I. It may be significant that no child under 4 years of age showed a greater sensitivity than 100 sec. of arc.

Table I *Variation in stereopsis with age*

Sec. of arc	Age (yrs)			Total
	3-3.9	4-4.9	5-5.5	
> 400	5	5	1	11
400	1	1	—	2
200	6	12	2	20
100	10	28	6	44
80	—	7	2	9
60	—	3	—	3
50	—	4	—	4
40	—	1	1	2
Total	22	61	12	95

(2) *Heterophoria*

The mode in both sets was esophoria, representing 43 per cent. of the combined cases, 34 per cent. of the cases were orthophoric, and 11 per cent. showed exophoria. The rest of the cases were doubtful.

The large number of esophorias is an unexpected result and it may be an artefact induced by the testing situation.

This points to the need for the development of a different type of heterophoria test.

(3) *Visual acuity*

The mode was between 6/8 and 6/12 for both sets. The combined percentage values were 67 per cent. for the 6/8 to 6/12 acuities, 18 per cent. for the 6/6 or better, and 15 per cent. for 6/12 or worse.

(4) *Refraction*

The distribution in both sets shows leptokurtosis and is asymmetrical, with an increased frequency towards hypermetropia. The mode in both cases falls between emmetropia and 0.25 hyperopia.

The combined distribution is shown in Table II (opposite).

(5) *Anomaly*

This section contains the results of the external and internal examinations.

Table II *Distribution of refractive errors in 205 pre-school children*

Refractive error	Distribution (per cent.)
≥ -0.75	3.9
-0.50 to -0.25	5.0
0.00 to $+0.25$	55.0
$+0.50$ to $+0.75$	17.5
$> +0.75$	13.0
Doubtful	6.2

Table III *Relationship of eccentric fixation and anomaly found during re-test*

Eccentric fixation (No. of cases)	Breakdown of cases on re-test
7	Amblyopia } No Squint Squint Slightly reduced vision Erratic response Central fixation on re-test
4	
1	
1	
4	Appointment not kept
2	

(A) PLACIDO DISC

Regular astigmatism was found in 13 per cent. and 5 per cent. of the first and second sets respectively. All these cases were re-examined by static retinoscopy and keratometry.

In the first set 11 per cent. and in the second 4 per cent. of the cases were confirmed as having an astigmatism equal to or greater than 1 dioptre.

(B) NO FOVEA

Absence of the foveal reflex was seen in 13 per cent. and 31 per cent. of cases in the first and second sets respectively. This number is very high in view of the fact that anatomical development of the fovea is complete at about the age of 4 months (Wolff, 1948; Duke-Elder, 1938). There did not appear to be any relationship between the absence of foveal reflex and any other visuosensory or visuomotor response.

(C) FIXATION

Anomalous fixation was found in approximately 9 per cent. of the combined cases. This represented nineteen children; eight girls and eleven boys out of a total of 205 cases examined. All these children were called in for a full examination. The final evaluation is shown in Table III, which shows that at least eleven of the seventeen cases of eccentric fixation which were re-examined gave a positive result.

(D) INTERNAL AND EXTERNAL ANOMALY

An anomalous fundus picture was found in approximately 5 per cent. of cases and some external anomaly of the eyes or adnexa in 2.5 per cent. of the cases.

(E) SQUINT

Altogether five squint cases (about 2.5 per cent.) were found—three boys and two girls out of a total of 92 boys and 113 girls.

The parents of three of the squinters were aware of their condition.

(6) Eye-hand coordination

This test was included as it was thought that it might facilitate the diagnosis of the presence of a recently developed squint (Chavasse, 1939; Bielschowsky, 1943; Duke-Elder, 1949; Adler, 1959; Swan, 1965).

The present and subsequent data collected from selected cases of known squinters, as well as from a control group of normal coordinators, failed to support this hypothesis (Amigo, 1965).

Conclusions

These results indicate that children in the 3 to 5 years age group readily respond to a proper selection of visuosensory and visuomotor tests and that it is relatively easy to establish rapport with them provided their intelligence is not underestimated.

A number of findings were unexpected and deserve further investigation, as follows:

- (1) The absence of the foveal reflex in a large number of cases.
- (2) The high percentage of esophorias. This may be an artefact created by the awareness of nearness of the test object as it is viewed in a Holmes stereoscope.
- (3) The excellent quantitative responses to disparities in terms of a relative depth experience at near.

This last result is the most important as it suggests the possible use of a modified type of stereopsis test at distance that could replace visual acuity testing and would, by its quantitative nature, indicate binocular normal correspondence.

Summary

The aim of this study was to establish a test battery suitable for the examination of the visual performance of pre-school children and to assess quantitatively the following aspects of their visuosensory and motor functions:

- (a) The state of binocular motor coordination.
- (b) The sensory response of the foveas.
- (c) The condition of the visual pathways.

Results indicated that children in this age group responded well to these tests. Most of the tests could be given by trained lay personnel but some of them required the services of a vision specialist.

References

- ADLER, F. H. (1959) "Physiology of the Eye", 3rd ed. Mosby, St. Louis
- AMIGO, G. (1965) "Eye-Hand Coordination. Unpublished data
- BIELSCHOWSKY, A. (1943) "Lectures on Motor Anomalies", Dartmouth College Press, Hanover, N. H.
- CHAVASSE, F. B. (1939) "Worth's Squint", 7th ed. Ballière, Tindall and Cox, London
- DUKE-ELDER, S. (1938) "Textbook of Ophthalmology", vol. 2. Kimpton, London
- (1949) *Idem*, vol. 4
- LYLE, T. KEITH, and FOLEY, J. (1957) *Brit. J. Ophthalm.*, **41**, 129
- SAUBERLI, R. (1962) *Brit. orthopt. J.*, **19**, 8
- SWAN, K. C. (1965) *Arch. Ophthalm. (Chicago)*, **73**, 189
- WOLFF, E. (1948) "The Anatomy of the Eye and Orbit", 3rd ed. Lewis, London