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Development of visual acuity

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Catford, G. V., and Oliver, A. (1973). *Archives of Disease in Childhood*, **48**, 47. **Development of visual acuity.** A hand-held electrically operated instrument has been devised to assess visual acuity by means of the phenomenon of optokinetic fixation nystagmus.

An accurate determination of visual acuity has been obtained from an early age, and a graph of the normal visual acuity development produced.

It has been confirmed that adult acuity is reached by 3 years of age.

Until now, it has been problematical to decide how much any baby or young child can see, and there has been varied speculation by authors during this century.

In the young, where subjective results are unobtainable or unreliable, to say the least, a method of objective examination must be used (Harcourt, 1969; Lewkonia, 1969).

Optokinetic nystagmus was observed by Purkinje (1825) and evaluated by Helmholtz (1867), and elicitation of this phenomenon may be used as the stimulus and end-point for minimal visual perception and fixation.

The eyes of a normal subject fix and follow the movement of any object to the periphery of the field of fixation, and then jerk quickly back to take up fixation on the next object—such as in 'railway nystagmus'.

It has been found that targets of decreasing size may be presented until they become too small to be fixed and nystagmus is no longer elicited (McGinnis, 1930; Nicolai, 1954; Reinecke, 1961; Reinecke and Cogan, 1958; Wolin and Dillman, 1964; Voipio and Hyvarinen, 1966).

Methods

Use of this phenomenon is made with the present technique. The apparatus consists of a hand-held screen with central aperture (Fig. 1). A drum, with circular targets of equivalent Snellen-type value placed around it, fills the aperture. The drum is rotated by an electrically driven motor which oscillates the appropriate target across the aperture with a slow phase and a quick return.

By turning the drum, the various targets may be presented individually in decreasing size until nystagmus is no longer evoked. An end result is thus quickly obtained before the child tires. The instrument is used at 60 cm which is convenient for clinical bedside or surgery use, and in normal daylight conditions. The targets are comparable to the equivalent Snellen acuity at 6 metres.

The accuracy of the instrument was proved in normal adults by using graded neutral density filters as occluders in front of the eye, and comparing the progressively lowered Snellen distance acuity results with those of the nystagmus drum targets (Fig. 2). There was good correlation in the results above 6/60 acuity, but below this findings were confined to the limitations of the possible densities of the occluders.

Similar results were obtained in 58 eyes of children suffering from squint and varying degrees of amblyopia, and comparing the drum acuities with Snellen results in the lazy squinting eye, as seen in the graph (Fig. 3).

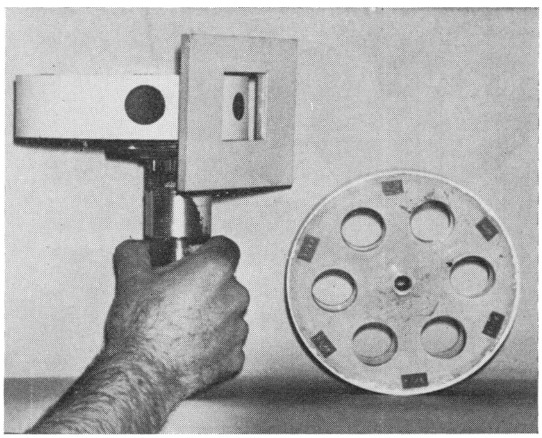

FIG. 1.—*Visual acuity nystagmus drum apparatus.*

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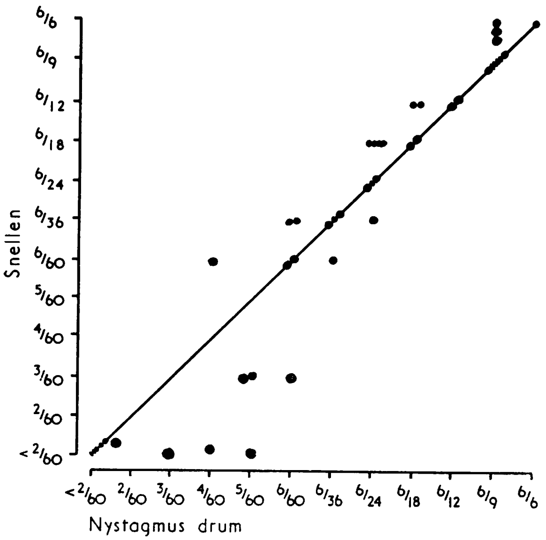

FIG. 2.—*Comparison of adult visual acuity between Snellen type and nystagmus drum, using graded neutral density occluders.*

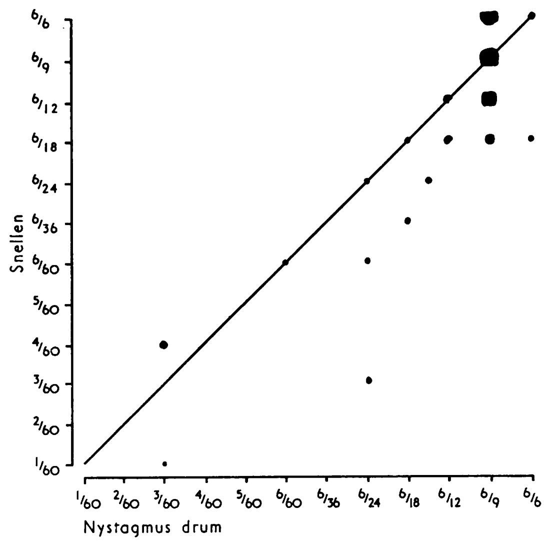

FIG. 3.—*Snellen and drum acuities compared in children with squint and amblyopia.*

The development of visual acuity in young, normal children has been determined by this method. A total of 171 children was examined, of which 118 were under 1 year of age and 53 over 1 year. This gave a representative sample of cases over a vital period when visual development is taking place.

The results have been collected and portrayed as a mathematical average, together with the range of variation in the graph (Fig. 4), so that the average normal visual development is easily seen, as well as the scatter.

Results

It was observed that babies fixate from 2 weeks of age, but that optokinetic nystagmus could not be induced to an individual target, as such, until 6

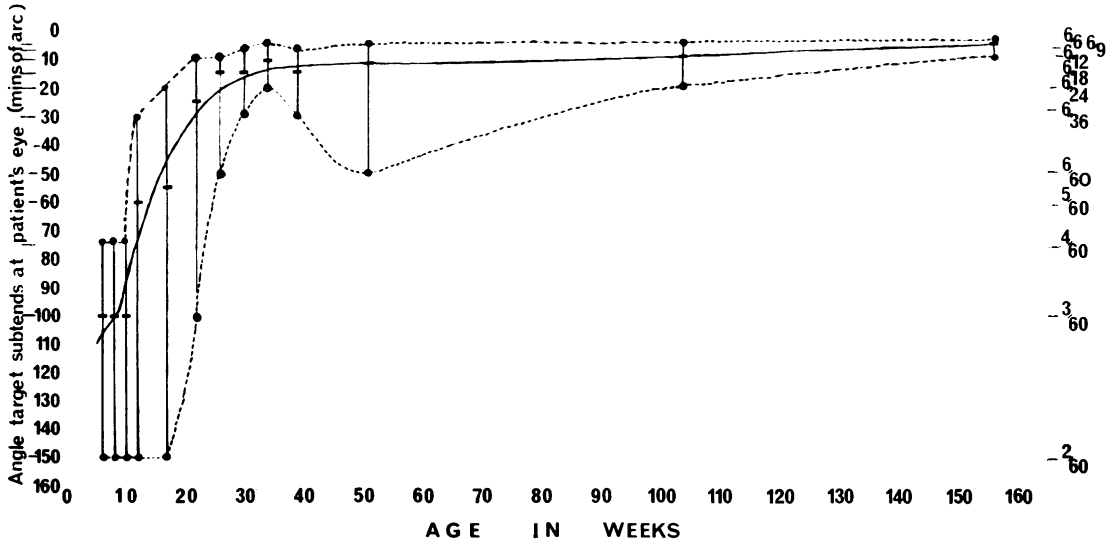

FIG. 4.—*Development of visual acuity in normal children from birth using the nystagmus drum. Mean values and ranges are shown at each age.*

weeks, at which age development has reached the stage for a response to the 2/60 target (McGinnis, 1930). This is in contradistinction to the work of Gorman, Cogan, and Gellis (1957) who obtained nystagmus in some 50% of subjects from birth, but only with a pattern stimulus, as opposed to a single object.

It will be seen that acuity increases to a level of 6/18 at 5 months of age. At 9 months, acuity again increases to reach 6/12 at 18 months, 6/9 at 2 years, and 6/6 at 3 years. It had previously been thought that fixation developed at 3 months of age (Lyle and Bridgeman, 1959), and that 6/6 vision was not achieved until 5 years of age. When the findings were analysed according to sex the curves, though slightly different, followed the same general course and showed no significant difference beyond the normal scatter.

It is also interesting to note the variations of age at which each level of visual acuity is reached. The best subjects had the equivalent 6/6 acuity by 28 weeks, while the worst subjects only managed the 6/24 equivalent at 21 months.

Finally, the visual development curve has been compared with the findings of previous authors (Dayton *et al.*, 1964; Gorman *et al.*, 1957; Ordy *et al.*, 1964, 1965) (Fig. 5).

Curve (a) was the probability curve of Worth, as produced in Lyle and Bridgeman's *Worth and Chavasse's Squint* (1959), and indicates a vision of 6/288 at 6 months and 6/72 at 9 months, with the next positive acuity findings of 6/9 at 3 years.

The composite curve of several authors was shown as curve (b) and indicates an earlier and better achievement of acuity. Curve (c) is the present graph, which confirms that infant acuity is better than previously thought, and gives positive recordings in the developing months, without any supposition.

Sheridan (1969) has stated that no research workers appear to have overcome the problem of testing infants' distance vision under 2 years, and evolved the Worth's modified spheres, but has not yet equated her findings in equivalent Snellen terms.

Ruskell (1967) found no available records of visual acuity in children between 6 months and 3 years.

The nystagmus drum targets have been found to act as an effective attraction for the attention of infants. The drum is easy to alter and an end-point is quickly obtained, which is of great importance in the busy clinic.

Since it is hand held, the instrument can be used anywhere, and this extends its application to domiciliary and field work with the handicapped (as well as possibly to animal species). It should be a useful clinical tool in the objective assessment of visual acuity.

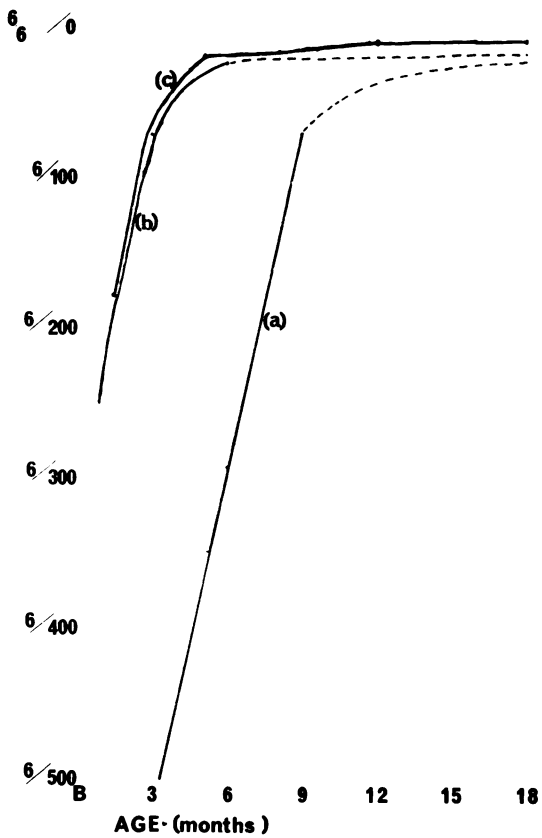

FIG. 5.—*Visual acuity development curves. (a) Probability curve of Worth (Lyle and Bridgeman, 1959; (b) composite curve of previous authors; (c) curve of present study.*

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