PERSPECTIVE

Assessment of visual acuity in multiply handicapped children

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Assessment and management of visual disorders in children with physical and/or intellectual impairment present a complex challenge to the clinician. A comprehensive review of all aspects of vision care in multiply handicapped children is too diverse to address in a single review. This review will focus on the techniques which have been developed for visual acuity assessment in this challenging population. Conventional acuity tests are often impractical and unsuccessful for achieving a reliable measurement of visual acuity in multiply handicapped children.¹ Two visual acuity assessment techniques have gained wide acceptance for testing these children, preferential looking (PL) and visual evoked potentials (VEPs). The success rates of completion of these procedures and acuity estimates achieved are compared and discussed.

Multiply handicapped children have a high incidence of nearly all types of disorders affecting the visual system including refractive errors, strabismus, nystagmus, cataract, optic atrophy, optic nerve hypoplasia, defects of the visual field, and cortical blindness.²⁻⁹ Reported prevalence of visual disorders for different groups of handicapped children is summarised in Table 1. Prevalence for each condition varies widely as studies are based on different populations of handicapped children and different criteria were used to establish the diagnoses. These conditions are not mutually exclusive – for example, 80–86% of children with cerebral palsy have one or more of the above visual disorders.^{9 10}

Table 1 Conditions with multiple handicaps and their associated visual disorders

Handicap	Associated visual disorders	Reported prevalence (%)
Cerebral palsy ^{4 9 10 11}	Refractive error	50–64
	Amblyopia	15–32
	Strabismus	50–69
	Nystagmus	8.6–18
	Visual field defect	1–11
	Optic atrophy	4–10
	Cortical visual impairment	3.1
Complications of prematurity ^{12–15}	Significant refractive error	17–32.5
	Strabismus	9.9–50
	Nystagmus	2.4–10
	Retinopathy of prematurity	69
	Optic atrophy	2.7–20
Hypoxic/ischaemic brain injury ^{16 17}	Cortical visual impairment	*
	Strabismus	24
	Nystagmus	8–8.6
	Visual field defect	36
	Optic atrophy	20
Hydrocephalus ^{5 11 18}	Cortical visual impairment	*
	Amblyopia	*
	Strabismus	*
	Optic atrophy	*
Down's syndrome ^{6 7 11 19 20}	Cortical visual impairment	*
	Refractive error	30–42
	Strabismus	27–36
	Cataract	4–27
	Keratoconus	*
	Impaired accommodation	*

*Data not reported

Visual impairment is known to delay and alter both visual and general development.^{21 22} Undetected visual impairment combined with other handicaps is likely to have an adverse effect on development and may lead to an underestimation of intellectual ability. Warburg reports that mentally handicapped children with visual impairment are inappropriately classed as profoundly handicapped more often than sighted children with equivalent levels of mental handicap.²³ When visual function can be improved by the provision of spectacles and/or visual training to improve fixation and accommodation, social behaviour and motor skills of children at all levels of intellectual impairment have shown improvement.^{24 25} Changes are most evident in the youngest age group.²⁵ Therefore, a reliable estimate of visual acuity in multiply handicapped children is important, to improve vision where possible, to monitor visual development, and to quantify the degree and type of visual impairment. This information can lead to appropriate ophthalmological and/or educational intervention which may improve developmental potential.

Preferential looking

TESTING PROCEDURES

Preferential looking is based on the observation that an infant will look at a striped target in preference to a blank target of equal luminance, when both are presented simultaneously (see Fig 1).²⁶ The finest striped target which the infant will consistently fixate, with greater than chance probability, provides an estimate of grating acuity. Conventional PL methods require several target presentations above and below threshold.^{27 28} For each presentation the observer makes a forced choice judgment of the infant's fixation preference (FPL). Operant conditioning employs positive reinforcement to enhance fixing responses (OPL).²⁹ OPL estimates of acuity agree well

Figure 1 Preferential looking using acuity cards.

Table 2 Use of preferential looking techniques in the visual assessment of multiply handicapped children: a summary of the literature

Study	Method	Patients	Age ranges	Success (reliable acuity estimate)	Test/retest (within 1 octave)	PL V recog (within 1 octave)	Results/comments
Morante <i>et al</i> 1982 ³⁴	FPL	n=30 pre term	34–40 weeks' gestation	90%	*	*	Subjects had significantly poorer results with PL and PP than normals (p<0.001)
Duckman and Selenow 1983 ³⁵	FPL	n=8 Down's	6 months–3 years	92%	*	*	Presented as case histories
Mayer <i>et al</i> 1983 ³⁶	FPL and OPL	n=4 mixed n=181 mixed	6 weeks–18 years	79%	*	*	63% 1 octave <normals mild 1.2–1.5 octave less moderate 2.1 octave less severe 3.2 octave less VA range 56–3.1 cycles/degree
Lennerstrand <i>et al</i> 1983 ³⁷	OPL	n=26 mixed	5–24 years	81%	*	*	VA range >56–25 cycles/degree
Lennerstrand <i>et al</i> 1983 ³⁸	OPL	n=8 mixed	4–19 years	87.5%	*	*	PL and VEP performed on 7 patients VEP acuity <PL acuity in 75% of these
Mohn and van Hof-van Duin 1983 ³⁹	OPL and VEP	n=37 22 congenital 15 acquired	10 weeks–15 years	65%	*	*	Flash VEP on 13 patients close correlation between development of acuity as measured by PL and VEP VA range 15–1 cycles/degree good predictor of VA<3.75 cycles/degree
Dubowitz <i>et al</i> 1983 ⁴⁰	FPL Fantz box Flash VEP	n=96 pre term		70%	*	*	Mild-normal VA for age Severe below normal VA for age
Jenkins <i>et al</i> 1985 ⁴¹	FPL/OPL	n=25 mixed	2–15 years	84%	*	*	
Mohn and van Hof-van Duin 1986 ⁴²	Acuity cards	n=24 developmental delay (mild) n=19 mixed (severe)	21 months–12 years 16 months–22 years	98%	*	*	Developmental delay – normal to within 1 octave of normal Retarded 1–2 octaves <normals Interobserver variability within 1 octave when VA>0.2
Mohn and van Hof-van Duin 1986 ⁴³	FPL and OPL	n=19 developmental delay n=94 retarded	2 months–23 years	85%	*	*	Down's syndrome – range VA 48–4.2 cycles/degree
Hertz 1987 ⁴⁴	Acuity cards	n=22 mixed n=6 profound	8–17 years	86% 67%	*	*	
Hertz 1987 ⁴⁵	Acuity cards	n=33 Down's syndrome (mild) n=19 cerebral palsy (severe)	7–20 years 22 months–7 years	97%B 85%M 100%	73% 47%	90%B 81%M (Down's syndrome only)	
Birch <i>et al</i> 1987 ⁴⁶	OPL	n=20 cerebral palsy and developmental delay	15–194 months	100%	*	*	15% within normal limits 10% no threshold 20%>1 cycle/degree 55%<1 cycle/degree
Sebris <i>et al</i> 1987 ⁴⁷	Acuity cards	n=161 developmental delay and ocular disorders n=39 developmental delay controls	Mean 7.3 years Mean 11.2 years	90%B 86%M 92%B 85%M	*	*	
Hertz <i>et al</i> 1988 ⁴⁸	Acuity cards	n=11 mixed	2–26 years	82%	78%	*	VA range 15.6–0.18 cycles/degree
Hertz and Rosenberg 1988 ⁴⁹	Acuity cards	n=33 cerebral palsy (moderate)	2–7 years	87%	76%	*	VA range 45.6–0.18 cycles/degree
Mohn <i>et al</i> 1988 ³²	Acuity cards	n=115 preterm n=35 mixed n=35 severe	14 weeks–12 years 14 months–12 years 3–33 years	97%B 95%M 86%B 96%M 81%B 93%M 70%PL 95%VEP 100%	* * 89% * *	* * 66% 100%B 95%M (0.5 octave)	VA range 15–0.1 cycles/degrees low acuity for age VA range 8.5 cycles/degree to no threshold PL v VEP – better agreement with better acuity VA range 40–1 cycles/degree
Orel-Bixler <i>et al</i> 1989 ²	Acuity cards and VEP	n=59 mixed	29–83 years		*		
Chandna <i>et al</i> 1989	(a) FPL and Snellen (b) FPL and Catford drum (c) FPL and Catford drum (mono)	n=15 mixed n=40 mixed n=15 mixed	24–81 years 29–82 years	57.5% 32.5%CD 66.6% 33.3%CD			
Adams and Courage 1990 ⁵¹	Acuity cards	n=12 mixed (severe)	13 months–15 years	100%B 33%M	100%	*	VA range 40–2 cycles/degree
Scheuk-Rootlieb <i>et al</i> 1992 ⁵²	Acuity cards	n=164 mixed	6 months–19 years	91%	67–73%	*	VA range 30–6 cycles/degree 71% below visual norms
Hertz and Rosenberg 1992 ⁵³	Acuity cards	n=78 cerebral palsy (mild and severe)	18 months–8 years	99%	83% (mild) 72% (severe)	*	Mild VA range 26.1–7.8 cycles/degree Severe VA range 6.9–0.3 cycles/degree
Bane and Birch 1992 ⁵⁴	FPL and OPL	n=23 cerebral palsy, developmental delay, other	4 months–9 years	PL98% VEP 60%	*	*	PL VA> VEP VA in visually impaired; PL VA< VEP VA in controls
Adams <i>et al</i> 1994 ⁵⁵	Acuity cards and contrast sensitivity	n=22 Down's syndrome	2–173 months	*	*	*	Acuity card estimates agree to within 1 octave with VA estimates from contrast sensitivity function
Courage <i>et al</i> 1994 ⁵⁶	Acuity cards	n=51 Down's syndrome	2 months–18 years	92%	*	*	94% had VA below expected mean VA for age
Getz <i>et al</i> 1994 ⁵⁷	Acuity cards	n=45 visual and neurology impaired preterms n=45 healthy preterms	3–38 months	*	93% 94%	*	Test time 4 (1.8) minutes Test time 2.6 (0.9) minutes
Mackie <i>et al</i> 1994 ⁵⁸	Acuity cards and VEP	n=52 mixed	3–183 months	Acuity cards 85% VEP 88%	*	*	Acuity cards less successfully completed in the severely intellectually impaired

*Data not reported; PL=preferential looking; FPL=forced choice preferential looking; OPL=operant preferential looking; PP=pattern preference; M=monocular test; B=binocular test; VA=visual acuity.

with FPL estimates and repeatability is high.^{28 30} The PL technique has been modified to produce the acuity card procedure. This clinical procedure, developed by McDonald *et al* is a simpler and quicker method of assessment.³¹ Instead of the observer making an objective

assessment of the child's eye movements to achieve a statistical threshold, a subjective interpretation of the child's looking behaviour is made to determine whether the child has seen the target. The acuity card procedure gives results with good agreement and similar variability to

FPL or OPL, and is considered to be a comparable technique.^{31 32} In all future discussion PL will be taken to indicate all forms of PL unless specified.

Expected mean PL thresholds for normal children range from 1.1 cycles/degree at 1 week³³ with maturation to adult levels of acuity of 30 cycles/degree by 36 months.³¹ Abnormal thresholds are commonly reported in terms of octaves above expected levels, where each octave represents a doubling of stripe width.

Since 1982, PL techniques have been reported in at least 28 studies of multiply handicapped children, as summarised in Table 2. Early studies have used mainly FPL and OPL on small numbers of individuals. More recently, the increased use of the flexible acuity card technique has provided more complete information regarding acuity thresholds and repeatability. This technique is obviously more suited to the diversity of ability encountered in the multiply handicapped population.

SUCCESS RATES

Success rates for obtaining a binocular acuity threshold by means of one of the PL techniques vary between 57.5%⁵⁰ and 100%,⁵¹ with the majority of studies reporting success rates over 70% (see Table 2). Thresholds are commonly expressed either as grating acuity estimates (cycles/degree) or as octave loss compared with age-matched normals (see Appendix). These thresholds are preferred to Snellen equivalents as letter recognition thresholds may be lower than grating thresholds in some groups.⁵⁹ Monocular testing has been attempted in two studies, on a group of children with Down's syndrome⁴⁵ and a mixed group of children who were also capable of reading the Snellen chart⁵⁰; both groups were classed as being mildly intellectually impaired. The majority of studies probably favour binocular testing because of lack of cooperation when an eye is occluded, and the limited value of knowledge of monocular acuities for functional management of the child.

Repeatability is an important variable to ensure the reliability of a technique. Studies which have retested children using acuity cards have reported good repeatability.^{32 49 52} However, both severely physically and intellectually impaired children show poorer test reliability than mildly impaired children. These differences are attributed to greater difficulty in interpreting the responses of severely physically impaired children, and higher incidence of oculomotor dysfunction.⁵³ Severely intellectually impaired children have extremely variable attentiveness and may show greater day to day differences in performance, mood, and cooperation than more able children. Hence, variable test results may represent variability in the child rather than variability in the testing procedure.⁵³ Three studies have investigated the agreement between PL acuity and letter acuity.^{2 45 50} Agreement to within 1 octave varies from 66%–100%.

PL AND TYPE OF HANDICAP

Over half of the studies report mixed types of handicap with a very wide range of visual acuities (for example, 3.1 to 56 cycles/degree³⁷). The disadvantage of reporting acuity results without defining type of handicap or the level of physical or intellectual disability is that no information is provided to relate vision with the type or severity of the diverse handicaps involved. Multiply handicapped children can have normal visual acuity^{37 38 45 46 48–52} but detailed studies have consistently found that visual acuity varies inversely with the level of intellectual impairment.^{32 36 42 43 53} As would be expected, children with

more severe neurological damage and intellectual impairment are more likely to have also suffered damage to the visual pathway.

PL studies using defined groups of handicapped children include developmental delay, Down's syndrome, and cerebral palsy. The majority of subjects with developmental delay and Down's syndrome, who are considered to be mildly intellectually and physically impaired, are reported to demonstrate normal or near normal acuity.^{42 43 45} However, recent studies which have investigated contrast sensitivity function and accommodation of children with Down's syndrome have found both functions to be poorer than in normals.^{20 55} Good visual acuity, therefore, does not preclude the presence of other visual dysfunction which may affect developmental progress.

Although all children with cerebral palsy have a motor deficit associated with a static defect or lesion of the brain, this group is extremely heterogeneous.⁵² Physical impairment may be associated with severe intellectual impairment but some children may have a high IQ.⁶⁰ Similarly, a very large range of visual acuities are reported for this group.^{45 46 48} However, the age ranges of the children examined are also large (22 months–7 years⁴⁵). Thus, no general conclusion can be drawn about the level of visual acuity in cerebral palsy. Hertz and Rosenberg studied children with cerebral palsy in more detail and reported poorer visual acuity in those with more severe physical and intellectual impairment (6.9–0.3 cycles/degree).⁵³

The PL technique has been established as a valid method of visual acuity assessment of multiply handicapped children, enabling an acuity threshold to be achieved in previously 'untestable' children. However, PL acuity assessment should always be interpreted within the limitations of the testing procedure. In these populations there is a high prevalence of oculomotor disorders and visual field defects.^{3–5 9} PL acuity estimates can be adversely affected by abnormal eye movements and strabismus which make looking behaviour difficult to assess. The presence of a hemianopic field defect, which is a common finding, can also be a factor as PL stimuli are presented off the visual axis and the stimulus area is relatively small. Presenting the stimulus cards vertically facilitates testing of children with dysfunctional horizontal eye movements and/or hemianopic field defects.^{32 53} Most importantly, the absence of a response to the stimulus may be due to non-visual factors and does not necessarily indicate absence of visual function. An inability to control eye movements sufficiently to produce a looking response, an inability to convert visual input to motor output, and withdrawn behaviour can all produce a negative PL response. These factors may act in a general way or may play an increasing role as the stimulus approaches threshold.⁶¹

Visual evoked potentials

TESTING PROCEDURES

The visual evoked potential (VEP) is a bioelectrical signal generated in the visual cortex of the brain in response to visual stimulation. The stimulus can be either a repeating flash of light (flash VEP); a pattern which is presented repetitively from a luminance matched grey background (pattern onset VEP); or a phase alternated pattern (pattern reversal VEP). The patterns used are typically either checkerboards or sinusoidally modulated gratings. A transient signal results from stimuli, either a flash or a pattern, presented at a slow rate (<2 Hz).⁶² Flash or pattern reversal stimulation presented at higher

Figure 2 Visual acuity assessment using visual evoked potentials.

frequencies (6–8 Hz) produces a 'steady state' signal.⁶³ The high repetition rate of the stimulus results in an overlap of the VEP waveforms so that a 'steady state' response occurs.

Both transient and steady state techniques can be used to determine visual acuity by measuring the VEP to patterns of different sizes. A VEP is recorded to each stimulus size. Threshold is determined by linear extrapolation of the VEP amplitude versus size function to zero microvolts,⁶³ or by determining the minimum size stimulus which produces a reproducible VEP.⁶⁴ A further development of the steady state VEP is the swept spatial frequency VEP, or sweep VEP,⁶⁵ in which the stimulus pattern is reversed and simultaneously increased or decreased in size (the pattern is 'swept' up or down in spatial frequency). The display appears as gratings which are reversing in contrast and changing in size simultaneously, so that a range of sizes are presented in a single recording (see Figure 2). Visual acuity threshold is calculated from the signal to noise ratio which provides a more rapid method of acuity estimation.⁶⁵

Both transient and steady state VEPs have been used successfully for assessing visual acuity in infants since 1976.⁶⁶ The sweep technique was introduced more recently.⁶⁷ Pattern reversal and sweep VEP thresholds mature rapidly to within 1 octave of adult values by 6 months of age.^{65–71} Maturation proceeds more slowly thereafter. Sweep and steady state VEP acuity thresholds are typically 14–20 cycles/degree for 8-month-old infants compared with 30 cycles/degree in adults. Transient VEPs produce thresholds of 6 cycles/degree or better in normal infants of a similar age.^{70–72}

SUCCESS RATES

A small number of studies have reported high success rates for VEP examination of multiply handicapped children. Skarf and Panton report success rates of 50–75% with pattern reversal stimuli in handicapped children under 5 years ($n=150$), and 67% in children under 1 year ($n=64$).⁷³ Saunders *et al* used pattern onset VEPs to assess a profoundly handicapped group with Retts syndrome ($n=11$) who were behaviourally unresponsive to PL stimuli.⁷⁴ VEP acuity thresholds were achieved in 91% of the group and all had acuities better than 1.25 cycles/degree. Odom and Green concluded that pattern onset VEPs were as successful, or more successful than other procedures for assessing acuity of multiply handicapped children ($n=23$).⁷⁵

Some studies have compared acuity estimates from VEPs with those achieved with other tests. Using pattern onset stimuli VEP acuities have been reported as closely

correlated with, but consistently lower than, acuity card estimates ($n=52$).⁵⁸ Similarly, pattern reversal VEPs are also reported as producing lower acuity estimates than OPL ($n=3$)³⁹ and FPL ($n=23$).⁵⁴ Bane and Birch⁵⁴ suggest that this may have been due the presence of central field loss in the visually impaired children examined which is known to degrade VEP amplitude.⁷⁶ Sweep VEPs also produce high success rates (95%; >90%),^{2,77} and close agreement with acuity cards (within 1 octave in 66% of cases)² and optotype acuities.⁷⁷ However, the sweep VEP acuity estimates tend to be higher than those obtained with other acuity tests.

VEPs provide reliable estimates of visual acuity in children without neurological deficits. In multiply handicapped children, nystagmus, central scotomas and poor fixation are prevalent. These conditions are known to impair VEP quality, making acuity assessment difficult and leading to conservative estimates of acuity.^{75–78} Artefacts from muscle spasticity and/or high background levels of the electroencephalogram can also degrade the VEP. The accuracy and the degree of confidence with which VEPs may be used to estimate acuity in multiply handicapped children is difficult to evaluate from the small number of studies available. However, success rates for completion of the test procedures are high even in the severely and profoundly handicapped children who are generally visually unresponsive.^{58–74} This is certainly their main advantage, and with further research and improvement of testing procedures the accuracy of recordings may well improve.

COMPARISON OF PL AND VEP

In the studies discussed above, VEP acuities determined with pattern onset and pattern reversal stimuli are lower than PL acuities,^{39–54,58} and acuities determined with sweep VEP stimuli are higher.^{2,77} Inherent differences in the stimulus presentation and scoring procedures of PL and VEP techniques may produce this disparity. One consideration is the different temporal properties of the stimuli used in PL (stationary) and VEP (contrast reversal) paradigms. Comparisons of PL and VEP techniques on normal infants with identical phase alternating gratings by Sokol *et al* showed better agreement between the thresholds achieved, but the VEP acuity was higher than PL acuity.⁷² In contrast, Dobson *et al* report no difference between PL acuities measured with stationary and phase alternating checkerboards.⁷⁹ As the majority of the studies reviewed here reported lower VEP acuities than PL acuities stimulus motion is probably not a factor. The higher sweep VEP acuities reported probably arise primarily from the more generous method of scoring employed with sweep VEPs.

Comparison of PL and VEPs is further complicated in multiply handicapped children. The various visual conditions which are common in these children may adversely affect the PL and VEP thresholds to a greater or lesser extent. More contamination of the VEP response would lead to more conservative acuity estimates. Another factor is the more complex level of cortical processing required by the PL response compared with the VEP. While both tests examine the integrity of the visual pathway from retina to the visual cortex, a looking response also involves association and motor cortices. This may lead to lower PL acuity estimates than VEP estimates.

RELATED STUDIES

VEPs have been used to investigate visual function of multiply handicapped children without specifically addressing visual acuity. While the concern of this paper is

visual acuity assessment, this work merits a brief discussion.

Cortical visual impairment (CVI), a visual deficit which is not explained by defects in the eye or anterior visual pathways, is common in multiply handicapped children.⁸⁰ VEPs have been employed both to investigate the integrity of the visual pathway and visual cortex in these children and to predict visual and/or neurological outcome. VEP results can differ from clinical results which indicate loss of all visual sensation. Normal VEPs to a flash stimulus have been recorded in some cortically blind children.^{81 82} Frank and Torres found no significant difference in the VEP waveforms to flash stimulus of neurologically impaired children with and without CVI.⁸³ It has been suggested that these results are due to the preservation of primary visual cortex in the absence of visual association areas,^{82 83} or the presence of extrageniculocalcarine pathways from which the VEP is recording.^{81 84} Pattern reversal VEPs are reported as either abnormal or absent in children with CVI.⁸⁴⁻⁸⁶ Flash VEPs appear to have limitations in characterising visual disturbance in CVI, but pattern VEP paradigms appear to be more diagnostic. In children sustaining perinatal asphyxia flash VEPs recorded in the early postnatal period show high predictive value for long term visual (88%)¹⁷ and neurological outcome (94-100%).^{87 88}

Other visual assessment tests

OPTOKINETIC NYSTAGMUS

Optokinetic nystagmus (OKN) is a physiological nystagmus elicited by a series of moving objects (for example, stripes), passing across the visual field. It consists of two components: a slow pursuit phase where the eye follows the target, and a fast saccade in the opposite direction to pick up the target again. If a target of suitable size and speed is presented OKN occurs involuntarily. Visual resolution is estimated by the width of the narrowest stripe eliciting OKN.

OKN has been used to measure infant vision, and a close correlation between OKN acuity and letter acuity has been found.^{89 90} However the technique has not been widely used in the handicapped population. Wyngaarden *et al* investigated the relation between the extent of developmental delay and grating acuity using both OKN and PL in 95 children (5-69 months).⁹¹ They found a moderate but significant correlation between OKN acuity and cognitive performance ($p < 0.05$), but did not compare the OKN acuities with other measures of acuity. The relation between the presence of OKN and visual function has been investigated in several studies.⁹²⁻⁹⁵ In these, children with no previously measurable visual function showed positive, but not necessarily normal, OKN (10%,⁹² 69%,⁹³ 50%,⁹⁴ 100%,⁹⁴ and 30%⁹⁶ of subjects). Some patients with visual loss due to cortical damage may retain brainstem reflex visual responses and therefore perform OKN, but do not consciously see the target. They may also display visual navigation skills (blindsight). Conversely, some children with measurable visual function have been shown to demonstrate no OKN response, when measured subjectively (9%) or objectively (19%).⁹⁴ Nearly all of these subjects demonstrated spontaneous or latent nystagmus which was judged to have affected the results by obscuring any OKN. Visual field defects are also thought to reduce the OKN response as the affected patients have less visual stimuli to pursue: one study reported visual field defects in 60% of the subjects but these defects were not classified.⁹³

The relation between visual function and OKN is complex in children with neurological disorders. It may be

misleading to use OKN as a visual acuity test but it is a very useful indicator of brainstem visual function.

Conclusion

Both PL and VEP techniques provide quantitative measures of visual acuity and are likely to be successfully completed by multiply handicapped children. In the past, clinical judgment of visual acuity for many of these children relied only on a qualitative evaluation of visual behaviour. PL and VEP techniques have been adopted in many specialist centres and are often available in routine clinical practice. The acuity card procedure for measuring PL acuity is particularly accessible as it is easy to learn and to administer.

Some important considerations should be made when interpreting PL or VEP acuities from an individual patient. The first is the reliability of the measurement. Where intrasession reliability has been evaluated, results in most handicapped children are reproduced within 1 octave.^{32 51 53} However, like most other clinical assessments, reliability is reduced among the severely and profoundly handicapped. Since variable attentiveness, poor fixation, motor handicap, and oculomotor abnormalities contribute to poor reliability, a single acuity measurement may be reliable only to within 2 or 3 octaves when these factors are present.

Secondly, the visual stimuli for VEP and PL acuity require pattern resolution whereas conventional visual acuity is a letter recognition task. In a normal adult visual system, the thresholds for pattern resolution (also called grating acuity) and letter recognition at the fovea are equivalent, and there is a temptation to convert pattern resolution visual acuity to familiar Snellen visual acuity units (see Appendix). However, different neural substrates are involved in pattern resolution and letter recognition so that these thresholds can be very different – for example, in amblyopia or in the normal peripheral retina.⁹⁷ Pattern resolution is necessary to enable recognition but it is certainly not sufficient to assume that recognition would occur particularly in the handicapped population where perceptual dysfunction is common.⁹⁶

In many situations, a handicapped child is assessed to determine how well he or she can 'see'. Seeing implies resolution, recognition, and conscious perception but the techniques reviewed here measure resolution only. VEP acuity is a measure of the ability of the visual system to resolve and transmit information about a particular pattern size to the level of the visual cortex. PL acuity demonstrates these functions as well as the ability to attend and make a motor response. Poor pattern resolution acuity gives a poor prognosis for recognition acuity but good pattern resolution acuity does not necessarily indicate a good prognosis for recognition. There are currently no quantitative techniques for measurement of recognition acuity or perception in children who are unable to complete letter matching tasks. A clinical judgment of these functions must be made before making recommendations for social services support or educational intervention.⁹⁸

The present literature is adequate to support the use of PL and VEP visual acuity techniques to assess the acuity of multiply handicapped children. The techniques give complementary information and completion of both allows a more informed assessment of resolution visual acuity. Future studies are needed to improve interpretation when specific adverse conditions, such as oculomotor dysfunction or visual field defects are concurrent. In addition, the association between specific aetiological factors and expected visual acuity needs elucidation.

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Appendix

Conversion of Snellen acuity to cycles/degree and octave loss equivalents

Snellen	Cycles/degree	Octave loss*
6/6	30	0
6/12	15	1
6/18	10	1.6
6/24	7.5	2
6/36	5	2.6
6/48	3.75	3
6/60	3	3.3
6/90	2	3.9
6/120	1.5	4.3
6/240	0.75	5.3
6/480	0.375	6.3

*Octave loss is measured relative to expected visual acuity for the appropriate age. The values given here are for children over 4 years of age with an expected visual acuity of 6/6 Snellen.

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