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. 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. 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.

Visual impairment is known to delay and alter both visual and general development. 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. 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. Changes are most evident in the youngest age group. 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). 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. For each presentation the observer makes a forced choice judgment of the infant’s fixation preference (FPL). Operant conditioning employs positive reinforcement to enhance fixed responses (OPL). OPL estimates of acuity agree well with age group.
### Table 2 Use of preferential looking techniques in the visual assessment of multiply handicapped children: a summary of the literature

<table>
<thead>
<tr>
<th>Study</th>
<th>Method</th>
<th>Patients</th>
<th>Age ranges</th>
<th>Success (reliable estimate)</th>
<th>Test/ret (within 1 octave)</th>
<th>PL V recy (within 1 octave)</th>
<th>Results/comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morante et al 1982&lt;sup&gt;34&lt;/sup&gt;</td>
<td>FPL</td>
<td>n=30</td>
<td>34-40 weeks gestation</td>
<td>90%</td>
<td>*</td>
<td>*</td>
<td>Subjects had significantly poorer results with PL and PP than normals (p&lt;0.001) presented as case histories.</td>
</tr>
<tr>
<td>Duckman and Selnow 1983&lt;sup&gt;35&lt;/sup&gt;</td>
<td>FPL</td>
<td>n=8</td>
<td>Down's</td>
<td>92%</td>
<td>*</td>
<td>*</td>
<td>63% 1 octave &lt;normals mild 1-2-1-5 octave less moderate 2-1 octave less severe 3-2 octave less.</td>
</tr>
<tr>
<td>Mayer et al 1983&lt;sup&gt;36&lt;/sup&gt;</td>
<td>FPL and OPL</td>
<td>n=181</td>
<td>mixed</td>
<td>79%</td>
<td>*</td>
<td>*</td>
<td>Presented as case histories.</td>
</tr>
<tr>
<td>Lennernstrand et al 1983&lt;sup&gt;37&lt;/sup&gt;</td>
<td>OPL</td>
<td>n=26</td>
<td>5-24 years</td>
<td>81%</td>
<td>*</td>
<td>*</td>
<td>VA range 56-3 cycles/degree</td>
</tr>
<tr>
<td>Lennernstrand et al 1983&lt;sup&gt;38&lt;/sup&gt;</td>
<td>OPL</td>
<td>n=8</td>
<td>4-19 years</td>
<td>87%-5%</td>
<td>*</td>
<td>*</td>
<td>VA range &gt;56-25 cycles/degree</td>
</tr>
<tr>
<td>Mohn and van Hof-van Duin 1983&lt;sup&gt;39&lt;/sup&gt;</td>
<td>OPL and VEP</td>
<td>n=37</td>
<td>10-15 weeks</td>
<td>65%</td>
<td>*</td>
<td>*</td>
<td>PL and VEP performed on 7 patients VEP acuity &lt;PL acuity in 75% of these.</td>
</tr>
<tr>
<td>Dubowitz et al 1984&lt;sup&gt;40&lt;/sup&gt;</td>
<td>FPL</td>
<td>n=96</td>
<td>pre term</td>
<td>70%</td>
<td>*</td>
<td>*</td>
<td>Flash VEP on 13 patients close correlation between development of acuity as measured by PL and VEP.</td>
</tr>
<tr>
<td>Jenkins et al 1985&lt;sup&gt;41&lt;/sup&gt;</td>
<td>FPL/OLP</td>
<td>n=25</td>
<td>2-15 years</td>
<td>84%</td>
<td>*</td>
<td>*</td>
<td>VA range 15-1 cycles/degree good predictor of VA &lt;3-75 cycles/degree.</td>
</tr>
<tr>
<td>Mohn and van Hof-van Duin 1986&lt;sup&gt;42&lt;/sup&gt;</td>
<td>Acuity</td>
<td>n=24</td>
<td>development delay (mild)</td>
<td>98%</td>
<td>*</td>
<td>*</td>
<td>Mild-normal VA for age severe below normal VA for age.</td>
</tr>
<tr>
<td>Mohn and van Hof-van Duin 1986&lt;sup&gt;43&lt;/sup&gt;</td>
<td>Acuity</td>
<td>n=9</td>
<td>16 months-22 years</td>
<td>85%</td>
<td>*</td>
<td>*</td>
<td>Developmental delay – normal to within 1 octave normal. Retarded 1-2 octaves &lt;normals Interobserver variability within 1 octave when VA&gt;0-2.</td>
</tr>
<tr>
<td>Hertz 1987&lt;sup&gt;44&lt;/sup&gt;</td>
<td>Acuity cards</td>
<td>n=19</td>
<td>Down's syndrome (mild)</td>
<td>70%</td>
<td>*</td>
<td>*</td>
<td>Down's syndrome – range VA 48-4-2 cycles/degree.</td>
</tr>
<tr>
<td>Hertz 1987&lt;sup&gt;45&lt;/sup&gt;</td>
<td>Acuity cards</td>
<td>n=19</td>
<td>cerebral delay (severe)</td>
<td>100%</td>
<td>*</td>
<td>47%</td>
<td>(Down's syndrome only).</td>
</tr>
<tr>
<td>Birch et al 1976&lt;sup&gt;46&lt;/sup&gt;</td>
<td>Acuity</td>
<td>n=13</td>
<td>2-7 years</td>
<td>78%</td>
<td>*</td>
<td>*</td>
<td>VA range 15-5-0-1 cycles/degree low acuity for age.</td>
</tr>
<tr>
<td>Sebris et al 1974&lt;sup&gt;47&lt;/sup&gt;</td>
<td>Acuity</td>
<td>n=161</td>
<td>development delay and ocular disorders</td>
<td>90%B</td>
<td>*</td>
<td>*</td>
<td>VA range 15-6-0-1 cycles/degree.</td>
</tr>
<tr>
<td>Hertz and Rosenberg 1986&lt;sup&gt;48&lt;/sup&gt;</td>
<td>Acuity</td>
<td>n=33</td>
<td>cerebral delay (severe)</td>
<td>87%</td>
<td>*</td>
<td>*</td>
<td>VA range 46-6-2-0-1 cycles/degree.</td>
</tr>
<tr>
<td>Mohn et al 1988&lt;sup&gt;49&lt;/sup&gt;</td>
<td>Acuity cards</td>
<td>n=115</td>
<td>preterm</td>
<td>82%</td>
<td>*</td>
<td>*</td>
<td>VA range 15-5-0-1 cycles/degrees.</td>
</tr>
<tr>
<td>Orel-Bialer et al 1982&lt;sup&gt;50&lt;/sup&gt;</td>
<td>Acuity cards</td>
<td>n=59</td>
<td>preterm</td>
<td>82%</td>
<td>*</td>
<td>*</td>
<td>VA range 46-6-2-0-1 cycles/degree.</td>
</tr>
<tr>
<td>Chandra et al 1980&lt;sup&gt;51&lt;/sup&gt;</td>
<td>Acuity cards</td>
<td>n=15</td>
<td>2-7 years</td>
<td>78%</td>
<td>*</td>
<td>*</td>
<td>VA range 45-6-1-0-0-1 cycles/degree.</td>
</tr>
<tr>
<td>1989</td>
<td>Acuity cards</td>
<td>n=40</td>
<td>24-81 years</td>
<td>57-5%</td>
<td>*</td>
<td>*</td>
<td>VA range 4-1-0-1 cycles/degree.</td>
</tr>
<tr>
<td>Adams and Course 1981&lt;sup&gt;52&lt;/sup&gt;</td>
<td>Acuity</td>
<td>n=12</td>
<td>development delay (severe)</td>
<td>100%</td>
<td>*</td>
<td>*</td>
<td>VA range 40-2 cycles/degree.</td>
</tr>
<tr>
<td>Scheur-Roethel et al 1992&lt;sup&gt;53&lt;/sup&gt;</td>
<td>Acuity cards</td>
<td>n=164</td>
<td>mixed</td>
<td>100%</td>
<td>*</td>
<td>*</td>
<td>VA range 40-2 cycles/degree.</td>
</tr>
<tr>
<td>Hertz and Rosenberg 1992&lt;sup&gt;54&lt;/sup&gt;</td>
<td>Acuity cards</td>
<td>n=78</td>
<td>cerebral delay (mild)</td>
<td>99%</td>
<td>*</td>
<td>*</td>
<td>Mild VA range 26-1-7-8 cycles/degree.</td>
</tr>
<tr>
<td>Bane and Birch 1992&lt;sup&gt;55&lt;/sup&gt;</td>
<td>Acuity cards</td>
<td>n=23</td>
<td>cerebral delay (severe)</td>
<td>99%</td>
<td>*</td>
<td>*</td>
<td>VA range 6-0-0-0-3 cycles/degree.</td>
</tr>
<tr>
<td>Adams et al 1994&lt;sup&gt;56&lt;/sup&gt;</td>
<td>Acuity cards and contrast sensitivity</td>
<td>n=22 Down's syndrome</td>
<td>2-173 months</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>Acuity card estimates agree to within 1 octave with VA estimates from contrast sensitivity function.</td>
</tr>
<tr>
<td>Courage et al 1994&lt;sup&gt;57&lt;/sup&gt;</td>
<td>Acuity cards</td>
<td>n=51</td>
<td>Down's syndrome</td>
<td>92%</td>
<td>*</td>
<td>*</td>
<td>94% had VA below expected mean.</td>
</tr>
<tr>
<td>Getz et al 1994&lt;sup&gt;58&lt;/sup&gt;</td>
<td>Acuity cards</td>
<td>n=45</td>
<td>visual and neurology impaired preterm</td>
<td>93%</td>
<td>*</td>
<td>*</td>
<td>VA for age. Test time 4 (1-8) minutes.</td>
</tr>
<tr>
<td>Mackie et al 1994&lt;sup&gt;59&lt;/sup&gt;</td>
<td>Acuity cards and VEP</td>
<td>n=52</td>
<td>3-183 months</td>
<td>85%</td>
<td>*</td>
<td>VEP 88%</td>
<td>Test time 2-6 (0-9) minutes.</td>
</tr>
</tbody>
</table>

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

with FPL estimates and repeatability is high. 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. 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.\textsuperscript{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 week\textsuperscript{33} with maturation to adult levels of acuity of 30 cycles/degree by 36 months.\textsuperscript{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 57-95%\textsuperscript{30} and 100%,\textsuperscript{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.\textsuperscript{59} Monocular testing has been attempted in two studies, on a group of children with Down's syndrome\textsuperscript{45} and a mixed group of children who were also capable of reading the Snellen chart;\textsuperscript{56} 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{53} Three studies have investigated the agreement between PL acuity and letter acuity.\textsuperscript{2,49,50} 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/degree\textsuperscript{37}). 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\textsuperscript{37,45,46,48-52} but detailed studies have consistently found that visual acuity varies inversely with the level of intellectual impairment.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{52} Physical impairment may be associated with severe intellectual impairment but some children may have a high IQ.\textsuperscript{60} Similarly, a very large range of visual acuities are reported for this group.\textsuperscript{45,46,48} However, the age ranges of the children examined are also large (22 months-7 years\textsuperscript{45}).

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).\textsuperscript{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.\textsuperscript{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 in measuring 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.\textsuperscript{3,53} 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.\textsuperscript{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).\textsuperscript{52} Flash or pattern reversal stimulation presented at higher
Assessment of visual acuity in multiply handicapped children

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.55-71 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)70 and FPL (n=23).54 Bane and Birch54 suggest that this may have been due to 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 of anterior visual pathways, is common in multiply handicapped children. 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. Frank and Torres found no significant difference in the VEP waveforms to flash stimulus of neurologically impaired children with and without CVI. It has been suggested that these results are due to the preservation of primary visual cortex in the absence of visual association areas, or the presence of extrageniculocalcarine pathways from which the VEP is recording. Pattern reversal VEPs are reported as either abnormal or absent in children with CVI. 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%) and neurological outcome (94–100%).

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. 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). They found a moderate but significant correlation between OKN acuity and cognitive performance (p<0.5), 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. In these, children with no previously measurable visual function showed positive, but not necessarily normal, OKN (10%, 69%, 50%, 100% and 30% 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%). 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.

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. 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. Pattern resolution is necessary to enable recognition but it is certainly not sufficient to assume that recognition would occur particularly in the handicapped population. 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.

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.

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.
Appendix

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

<table>
<thead>
<tr>
<th>Snellen</th>
<th>Cycles/degree</th>
<th>Octave loss *</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/6</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>6/12</td>
<td>15</td>
<td>0.5</td>
</tr>
<tr>
<td>6/18</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>6/24</td>
<td>7.5</td>
<td>2</td>
</tr>
<tr>
<td>6/36</td>
<td>5</td>
<td>2.6</td>
</tr>
<tr>
<td>6/48</td>
<td>3.75</td>
<td>3</td>
</tr>
<tr>
<td>6/60</td>
<td>2</td>
<td>3.9</td>
</tr>
<tr>
<td>6/90</td>
<td>1.5</td>
<td>4.3</td>
</tr>
<tr>
<td>6/120</td>
<td>0.75</td>
<td>5.6</td>
</tr>
<tr>
<td>6/480</td>
<td>0.375</td>
<td>6.3</td>
</tr>
</tbody>
</table>

*Octave loss is relative to expected 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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