Strabismus 0927-3972/96/US$ 10.50

Strabismus – 1996, Vol. 4, No. 2, pp. 89-97

Buren (The Netherlands) 1996

Accepted 28 March 1996

An acuity cards cookbook

François Vital-Durand

Cerveau et Vision, INSERM Unité 371, 69675 Bron, France

Abstract Acuity cards are being more commonly used in clinical and screening practice. The author describes his experience from over 6000 infants tested with the method, using two commercially available sets of cards to provide users with comprehensive guidelines to allow them to get the most out of this useful test.

Key words Infant acuity testing; acuity cards; procedure; preferential looking technique

Correspondence to: Cerveau et Vision, Inserm U 371, 18 avenue du doyen Lépine, 69675 Bron Cedex, France. Tel. (33) 72 13 15 84, Fax (33) 72 13 15 99, e-mail: vital@lyon151.inserm.fr

Acknowledgements: This work was supported by Inserm and Mutuelle Générale de l'Éducation Nationale. We wish to thank Viviane Kriss for her help with the translation of this paper.

Introduction

Acuity cards are a psychophysical test for measuring spatial resolution (visual acuity), suitable for infants and preverbal children, although it could, in principle, be used at any age.* The test makes advantage of the propensity of young infants to look at a salient pattern presented on a uniform background with the mean luminance of the pattern being equal to that of the background.[1-3] The 'preferential looking' technique uses this tendency, possibly reinforcing it with verbal encouragement in order to foster the child's attention to the limits of their resolution capacities. Mayer and Dobson[4] introduced the presentation of a toy to reinforce the child's cooperation. The reliability of the measure as well as its limits has been ascertained by numerous interobserver agreement studies until recently (*e.g.*,[5,6]) with a description of the early development of visual resolution.[7,8] The technique was soon introduced in clinical assessment of infants, including known pathological cases[9-15] and screening programs,[16-18] although some limits to the reliability of the test as a screening procedure have been indicated.[19]

This paper is based on some 6000 tests performed on an unselected population of infants, mostly referred by pediatricians and general practitioners on various grounds. Most of the infants were tested with Teller Acuity Cards (Vistech) from 1988 to 1994 and since then with Bébé Vision Tropique© (BVT) cards.** The procedures are identical for the two types of cards and the results are comparable.

The conduct of the test requires a good relationship with the child, an appropriate setting of the room devoid of distractors and a precise procedure. These are described in the following paragraphs together with indications for evaluating the results obtained.

I Description of the cards

These are lightweight boards (50 × 25

* This paper is not intended to include a review of the literature. Some references are given to help the curious reader.

** The author declares to have some commercial interest in BVT acuity cards.

cm) with a uniformly grey background, on one half of which there is a printed pattern. A peephole, at the center of the card, allows the examiner to observe the infant's direction of gaze and fixation. TAC have a vertical series of black and white bars (a grating), of high contrast, whose luminance profile is square. BVT cards have a concentric circular pattern which has a sinusoidal luminance profile (Fig. 1). The pattern is characterized by a mean luminance identical to that of the background which is constant throughout the series of cards. The pattern has a high contrast, in the range in which the response is the same as that which would be obtained with 100% contrast, which cannot be achieved technically.

The cards have been printed to ensure a mean pattern luminance equal to that of the background. This is difficult to obtain but very important in order that the child cannot detect the location of the pattern on the basis of a brighter or darker zone. In order to avoid the edge effect that may be seen in patterns with sharp edges like the TAC,[20,21] the pattern edges of BVT cards are gradually attenuated (Vital-Durand *et al.*, in preparation). Use of a concentric circular pattern avoids errors in measuring resolution when astigmatism is present. However, it should be noted that the 'edge effect' for which TAC have been criticized is of too low a contrast to be seen by a young observer, for whom the test was designed.

The series of TAC consists of 18 cards, covering a range of frequencies from 0.23 to 38 cycles/cm. Allowing for adjustment of the distance of presentation from 38 to 84 cm, this allows measurements of acuity in range of 20/2700 to 20/11 Snellen equivalents. Obviously this is a greater range than would usually be needed to measure acuity clinically in preverbal infants. TAC are interspaced by about one half octave interval. An octave is the interval that separates two values, one of which is half or twice the other: for example, there is a difference of an octave between 5.5 and 11 cycles/cm.

BVT cards provide a series of 13 cards, covering a range of spatial frequencies from 0.3 to 14 cycles/cm. By varying the distance of presentation from 40 to 85 cm the resolution can be measured in a range of 20/3000 to 20/28 Snellen equivalents. Table 1 gives conversion values in Decimals, Snellen equivalents, Metric and LogMAR, for cards presented at 40, 57 or 85 cm. The BVT patterns were designed by computer and printed on a very high resolution printer in order to avoid aliasing. The cards are protected against wear and tear and smearing by an extremely fine film. This protective layer introduces some low frequency contrast distortion that is far from being detectable by a toddler.

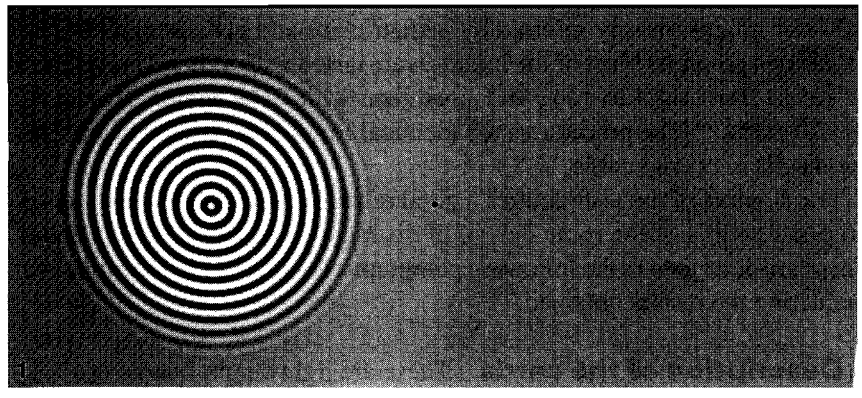

Fig. 1. One BVT acuity card is shown to present the circular concentric pattern.

II Setting-up the test

1 LOCATION A space of 2.00 m by 1.5 m is required in a well-lit room with no salient stimuli that might distract the child's attention.

2 SCREEN With very young children, and with children who have insufficient head tonus control, the cards may be presented directly in front of the child's line of vision. In some difficult cases, the eyes may be observed by looking over the card. In this situation the observer should take care to wear clothing with no salient contrasts.

When testing children aged over four months, it is essential to have a screen with an opening through which the cards are presented. Use of a screen prevents the child from being distracted by either the environment or the observer.

The screen is made of grey material, similar in color to the cards, and its sides mask a large part of the field of vision (Fig. 2). The screen can be placed on the ground, or if a light folding screen is used, placed on a narrow table.

On the observer's side, the screen should have a protruding bracket, which allows the observer to place the card right in front of the opening and this prevents the child from noticing the fingers holding the card.

3 LIGHTING The cards and the screen must be lit indirectly and uniformly to reflect around 70 candelas/m^2. This level is obtained with a halogen light source reflected off the ceiling or reflective panel; the light source is therefore placed behind the child. No shadow should project on to the cards or

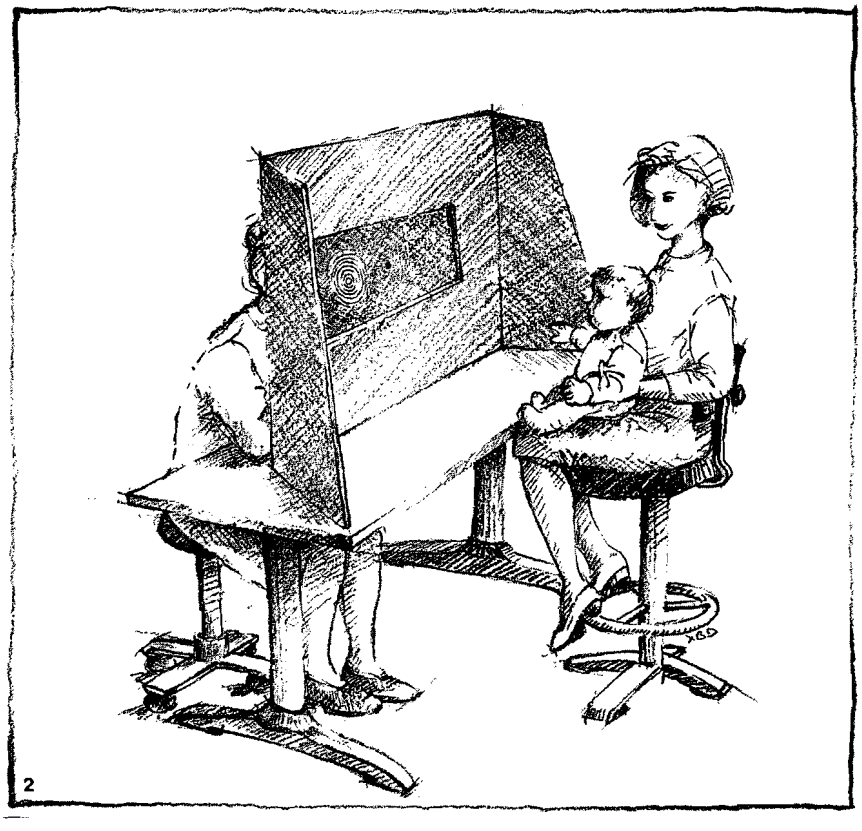

Fig. 2. A screen is used to conceal the environment and to focus the child's attention on the opening where the cards are presented. This test situation is suitable for children older than four to five months: the person holding the child, the screen and the observer are shown. Notice the person holding the child is sitting on a chair which has a footrest.

screen. Avoid natural lighting which is prone to considerable variations.

Very young children or albinos are photophobic. The luminance level can be lowered by up to 20 candelas/m^2, and this is taken into account in the results. It has been estimated, however, that luminance variation can lower resolution by about 1/3 of an octave, *i.e.*, the interval between two cards.

III Testing procedures

1 WELCOMING THE CHILD The child may not be used to strangers, so avoid coming too near the child and in particular touching the child at the beginning of the session. Avoid wearing glasses with heavy frames. The person accompanying the child sits on a swivel chair which has a high back and footrest (Fig. 2) located at a distance appropriate for the chosen distance of presentation. The person is sitting on the chair which restricts her movements, and the child seated on her knees is fairly high up which means the observer does not have to bend down to meet the child's gaze. The person accompanying the child should be asked to sit back in the chair and to keep her back straight during the test. This position ensures that the child is sitting upright on the person's lap.

The person accompanying the child must stay still during the examination and above all not tilt her head, which might attract the child's attention. It is preferable to explain the test after it has been performed to prevent the holder trying to influence the child's reaction. The child should be sitting astride the holder's knees. Some children (especially the very young), have difficulty in looking outside the angle formed by their legs, especially in monocular testing. The examiner should be very careful when testing children suffering from neuromotor disorders, to position them so that their movements can be free. This also applies to children with torticollis and those who do not have control of their posture. In this situation the examination can be performed without the screen.

2 THE EXAMINER The observer sits on an adjustable stool with wheels and can move around the screen to put on the eye patch without having to get up. The best way for an examiner to learn the test procedure is from a trained person. It is always preferable to start testing children who have no apparent problem, and about 50 tests need to have been performed before being sure the results are reliable.

3 TEST DISTANCE The choice of distance can only be suggested since it depends on the age and physical condition of the child. Before three months of age, the infant is seated on the lap of the accompanying person or in a baby seat in front of the screen. The cards are presented 40 cm from the infant. The distance can be increased later if necessary. From four to six months, the cards are presented at 57 cm. After six months, but earlier if possible, the cards are presented at 85 cm. This has two major advantages: the relative inaccuracy of the distance is reduced and a significant ametropia is more likely to be detected, because the child cannot compensate by accommodation, especially when the child is myopic. Ametropias are generally better detected when the cards are presented at 85 cm.

These distances were chosen because 57 cm is the distance at which 1 cm is equal to 1 degree; 40 and 85 are located at approximately + or – half of

57, *i.e.*, at an interval corresponding to half an octave. At a distance of 57 cm, 1 cycle/cm on the card is equal to 1 cycle/degree.

4 WEARING AN OPTICAL CORRECTION Ametropia is often discovered during objective retinoscopy performed during the first test after measuring resolution. If a correction has been prescribed, and the child in general wears it, the following measurements are taken with the correction.

The eye patch required for the monocular test can be attached over the frames but ensure that the child does not cheat by looking over it. For a variety of reasons, a child with ametropia may not, however, wear the correction and this may not always be admitted when asking the parents. In this situation, try to measure the acuity both with and without the optical correction.

5 PROCEDURE FOR MEASURING RESOLUTION Present the cards in order of increasing spatial frequency, but with the pattern randomly on one side or the other. The observer should never know which side the pattern is on when presenting the card.

5.1 Measuring binocular resolution The test starts with the measurement of binocular vision. Although this is of little clinical advantage, the child gets used to the test situation and the observer can adapt to the child's behavior. The test usually starts by presenting a card with a pattern four times greater than the likely threshold.

Present the card only once if the direction of the gaze is clear. Turn the card over to check that the child has responded correctly and congratulate the child verbally. Then the next cards are presented, each card once only, unless the pattern is on the same side twice in succession, in which case turn the last card round so that the child learns to explore both sides. When the child's gaze becomes less clear, the card is presented a minimum of four times, twice consecutively on the same side. This method ensures that the child does not learn to alternate its gaze to either side without paying attention.

5.2 Use of an eye patch for monocular testing Using an adhesive eye patch is the only satisfactory method to cover the eye. In order to put it on without the child categorically refusing it, we usually begin by giving the child the backing paper. The child's hand is occupied by the paper which prevents too much attention being paid to the patch.

A biscuit or lollipop can also be used to keep the child quiet. Especially after eight months the parents may sometimes have to hold the child's hands. The speed at which the observer can start the test again is a good gauge of the success of monocular testing.

5.3 Measuring monocular resolution This test is more rapid than binocular testing because, traditionally, the eye thought to be the weaker is tested first, to prevent a lower resolution due to fatigue or lack of attention. In the latter situation, the measurement of the first eye can always be repeated.

Start by presenting the card two intervals below the threshold obtained on binocular vision testing. In the best of situations, only two cards need to be presented because the monocular vision threshold is normally one card below the binocular threshold, with two exceptions: (1) Sometimes the binocu-

lar threshold is low and the same value is obtained as for monocular vision. (2) The child is less cooperative after the eye patch has been put on and the threshold obtained is two cards below the binocular threshold. If this occurs, it is necessary to check that both eyes respond in the same manner. In all situations, the difference of one card between the two eyes is acceptable on condition that the last eye to be tested yields the lower value.

5.4 Threshold determination The threshold can be estimated as the value of the highest spatial frequency for which four correct responses are obtained in a trial where the card is presented four times in succession, with two consecutive presentations on the same side when conditions are favorable. Conditions are considered favorable when a series has no errors and fixation is obvious. If this is not the case, the series can be started again, presenting the card four or more times.

5.5 Response variability Several types of response can be observed according to age and the individual child, which can be grouped in the following categories:

- A clear response. The child gazes very rapidly at the pattern, taking only the time needed to place the eye in front of the opening.
- A hesitant response, which can particularly occur when approaching the threshold limit, and the child may alternate between the two sides. The child will fixate one side for longer, however, and finally return to this side.
- A slow response, the child fixates the central opening and continues for a few seconds before a rapid saccade to the side on which the pattern is observed. This response indicates resistance to doing the test and occurs in particular at values close to the threshold and in monocular testing. To overcome such a refusal, present a much more salient card with a pattern lower in frequency by one or two octaves.

5.6 Difficult situations We recommend that binocular and monocular tests be performed rapidly, with a minimal break to change the eyepatch between series. While the test is being performed, keep the child interested by making noises and talking to the child, although some children prefer quasi-silence. Clucking noises, whistling and clicking attract children's attention. Some very shy children, those with an autistic tendency and some aged over 12 months, do not look at the examiner. Children who object to being observed are generally interested in what is shown to them, and will look at the card as soon as they no longer see the examiner. It is possible for a child who usually has good vision to respond by avoiding looking at large stripes, and systematically turning away from the stimulus.

If this occurs, progress rapidly to present cards with high frequencies until a value is reached for which the child has to look carefully for the pattern.

If there is an isolated error when the first cards are presented, then progress to the next card. If the error recurs, present the card two cards below this frequency and continue the progression presenting the card four times, as if this value were the threshold. When a clear response does not occur, the examiner can always start again and present the card, after having turned it around several times to make it impossible to know which side the pattern is on.

IV Measurement units To avoid confusion, it is better to express acuity in angular measurements (minutes, seconds, or cycles/degree of visual angle), but these units are not used clinically. Table 1 contains visual acuity values (for spatial resolution) in decimals, in Snellen equivalents, metric and Logmar.

V Age of child tested Resolution can be measured as soon as a baby is born but the observer needs to have specific experience in this situation. After four months the test becomes easier to perform, and is very easy with children aged from six to 11 months. After 18 months, it becomes considerably more difficult to perform the test and some children refuse to participate altogether.

VI Reference acuity values Resolution of babies born at term is about one cycle per degree (c/deg). By three months of age, resolution has increased to 3 c/deg. From three to 12 months resolution increases by 1 cycle every month, reaching 12 c/deg by one year. Then resolution improvement tends to slow down, or the child is less responsive, so that a resolution of 18 c/deg at 24 months is considered normal. By 2.5 year a child can be tested with optotypes.

VII The diagnosis of amblyopia or low vision In the literature, amblyopia is defined as difference in acuity between two eyes despite the use of a correction for ametropia. In adults, a difference of two lines between the two eyes is often considered as diagnostic of amblyopia. This definition obviously does not apply to children who have low levels of acuity. For children it would be better to define acuity on the proportional difference with respect to the better value, for example, a half octave. Thus a child would have amblyopia in the situation with two values of 6 and 4.5 cycles/degree.

Often the diagnosis of amblyopia is put forward after solely testing visual resolution, but it can only be confirmed after orthoptic examination. The child's behavor should always be taken into consideration.

A child suspected of having poor vision can be examined at two months with a certain possibility of success. Usually, these children are referred dur-

TABLE 1. Conversion table between acuity scales (rounded values). The table gives the equivalence between cycles/cm (indicated on each card) and the principal systems of units used. For each system the values are given at three distances: 40, 57 and 85 cm because these values are roughly one half octave apart. Some figures have been rounded up or down to the nearest value.

Card N°	*c/cm*	*Decimal at 40 cm*	*Decimal at 57 cm*	*Decimal at 85 cm*	*Snellen at 40 cm*	*Snellen at 57 cm*	*Snellen at 85 cm*	*Metric at 40 cm*	*Metric at 57 cm*	*Metric at 85 cm*	*LogMAR at 40 cm*	*LogMAR at 57 cm*	*LogMAR at 85 cm*
					20/	20/	20/	6/	6/	6/			
13	14.0	0.33	0.47	0.69	61	43	29	18	13	9	0.5	0.3	0.2
12	11.0	0.26	0.37	0.54	78	55	37	23	16	11	0.6	0.4	0.3
11	9.0	0.21	0.30	0.45	95	67	45	29	20	13	0.7	0.5	0.4
10	7.0	0.16	0.23	0.35	123	86	58	37	26	17	0.8	0.6	0.5
9	5.5	0.13	0.18	0.27	156	109	74	47	33	22	0.9	0.7	0.6
8	4.5	0.10	0.15	0.22	191	133	90	57	40	27	1.0	0.8	0.7
7	3.5	0.08	0.12	0.17	246	171	116	74	51	35	1.1	0.9	0.8
6	2.8	0.06	0.09	0.14	313	218	147	94	65	44	1.2	1.0	0.9
5	1.8	0.04	0.06	0.09	491	343	231	147	103	69	1.4	1.2	1.1
4	1.1	0.03	0.04	0.06	761	531	358	228	159	107	1.6	1.4	1.3
3	0.7	0.02	0.02	0.03	1264	882	595	379	265	178	1.8	1.6	1.5
2	0.4	0.01	0.01	0.02	1953	1364	919	586	409	276	2.0	1.8	1.7
1	0.3	0.01	0.01	0.01	3069	2143	1444	921	643	433	2.2	2.0	1.9

ing their third month. Even if the first test is conclusive, a second test is performed to confirm the possible resolution level.

VIII Test duration The test should generally be performed rapidly and without interruptions. A trained observer can make three estimations in five to six minutes with a normal child, but of course this is prolonged in difficult cases.

IX Ametropia detection Acuity cards are not designed to measure ametropia, especially if the cards are presented 57 cm from the child. Test performance is not altered by a refractive error of several diopters if the resolution level of the age concerned is taken into account. A large refractive error may not be detected, and a poor performance attributed to lack of cooperation. To overcome this card limitation, the child should be seated 85 cm from the screen because at this distance, it is more difficult for the child to compensate for its visual deficit.

X Conclusions Acuity cards are a valuable test to assess amblyopia and low vision. It is certainly not a screening test for refractive errors. Like any other test it requires proper training and experience to be a reliable tool to estimate the depth and the recovery of amblyopia, as well as the development of infants with low vision. Never forget that most infants with impaired vision may have some visual capacities left that will not be used without a proper educational scheme to promote their development.

References

1 Fantz RL, Ordy JM, Udelf MS. Maturation of pattern vision in infants during the first six months. J Comp Physiol Psychol 1962; 55:907-917.

2 Teller DY, McDonald MA, Preston K, Sebris SL, Dobson V. Assessment of visual acuity in infants and children: the acuity card procedure. Dev Med Child Neurol 1986; 28:779-789.

3 McDonald MA, Sebris SL, Mohn G, Teller DY, Dobson V. Monocular acuity in normal infants: the acuity card procedure. Am J Opt Physiol Opt 1986; 63:127-134.

4 Mayer DL, Dobson MV. Visual acuity development in infants and young children, as assessed by operant preferential looking. Vis Res 1982; 22:1141-1151.

5 Mash C, Dobson V, Carpenter N. Interobserver agreement for measurement of grating acuity and interocular acuity differences with the Teller Acuity Card procedure. Vision Res 1995; 35:303-312.

6 Dobson V. Visual acuity testing in infants: from laboratory to clinic. In K Simons (editor). Early Visual Development: Normal and Abnormal. New York: Oxford University Press, 1993; 318-334.

7 Vital-Durand F. Acuity card procedures and the linearity of grating resolution development during the first year of human infants. Behav Brain Res 1992; 49:99-106.

8 Mayer DL, Beiser AF, Warner AF, Pratt EM, Raye KN, Lang JM. Monocular acuity norms for the Teller acuity cards between ages one month and four years. Invest Ophthalmol Vis Sci 1995; 36:671-685.

9 Sebris SL, Dobson V, McDonald MA, Teller Y. Acuity cards for visual acuity assessment of infants and children in clinical settings. Clin Vision Sci 1987; 2:45-58.

10 Van Hof-van Duin J, Mohn G. The development of visual acuity in normal fullterm and preterm infants. Vision Res 1986; 26:909-916.

11 Hertz BG. Acuity card testing of retarded children. Behav Brain Res 1987; 24:85-92.

12 Birch EE, Hale LA, Stager D, Fuller D, Birch D. Operant acuity of toddlers and developmentally delayed children with low vision. J Pediat Ophthalmol Strabismus 1987; 24:64-69.

13 Chandna A, Pearson CM, Doran RML. Preferential looking in clinical practice: a year's experience. Eye 1988; 2:488-495.

14 Mohn G, Van Hof-Van Duin J, Fetter WPF, DeGroot L, Hage M. Acuity assessment in non-verbal infants and children: clinical experience with the acuity card procedure. Dev Med Child Neurol 1988; 30:232-244.

15 Luna B, Dobson V, Biglan AW. Development of grating acuity in infants with regressed stage 3 retinopathy of prematurity. Invest Ophthalmol Vis Sci 1989; 31:2082-2087.

16 Preston KL, Freedman HL. The Teller Acuity Card procedure: an acuity screening technique for

preverbal children. Am Orthopt J 1988; 38:24-32.
17 Schmidt PP. Effectiveness of vision-screening in pre-school populations with preferential looking cards used for assessment of visual acuity. Optom Vis Sci 1991; 68:210-219.
18 Vital-Durand F, Ayzac L, Pinzaru G. Acuity cards and the determination of risk factors in 6-18 months infants. In F Vital-Durand, J Atkinson, O Braddick (editors). Infant Vision. Oxford: Oxford University Press, 1996; 185-200.
19 Katz B, Sireteanu R. The Teller Acuity Card test: a useful method for the clinical routine? Clin Vis Sci 1990; 5:307-323.
20 Robinson J, Moseley MJ, Fielder AR. Grating acuity cards: spurious resolution and the edge artifact? Clin Vision Sci 1988; 3:285-288.
21 Teller DY. The design of acuity cards: a reply to Robinson, Moseley and Fielder 1988. Clin Vision Sci 1990; 6:81-83.