A Comparison of Contrast Sensitivity between People with a Colourvision Defect and those with Normal Colourvision

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Abstract

This study tested the prediction that people with reduced colour vision would show improved contrast sensitivity, as a compensatory adaptation. Twenty eyes with normal colour responses on the Farnsworth-Munsell 28 Hue test and the Ishihara test, and twenty-five eyes which showed colour vision defects on these tests, were compared on the Vectorvision CSV 1000 contrast sensitivity test. The prediction was not supported by the data. Eyes with colour vision defects showed reduced contrast sensitivity for lower spatial frequencies. This effect was strongest in eyes with more severe colour defects. Colour vision defects were not related to contrast sensitivity for higher spatial frequencies. Increased age and reduced visual acuity predicted poorer contrast sensitivity at higher spatial frequencies.

Key Words:
Contrast sensitivity, colour vision defects, Ishihara test, Farnsworth-Munsell 28 Hue test, Vectorvision CSV 1000, spatial frequencies.

Introduction

When we consider occupations such as the defence force, bus drivers, and electricians, there is one thing that all of them have in common. None of these occupations employ people who are colour blind.

In the general population it is seen as a liability to be colour blind, but what if people with a colour vision defect could compensate for their lack of colour appreciation by using an alternative visual function such as shade or contrast?

Colour vision defects can be congenital or acquired. In people with congenital colour vision defects, usually one cone photoreceptor is not functioning normally (anomalous trichromat), or may not be functioning at all (dichromatic). Therefore, in the case of someone with an abnormally functioning cone they will use "abnormal proportions of these [cones] to colour match".[1] In the case of someone with only two types of cone photoreceptors, they are only able to use these two cones to colour match. In both of these cases the result is an altered perception of colour. According to Fitzgerald and Billson,[1] if the green cone, for example, is not functioning normally, the person will be able to distinguish between pure reds and greens, but will have trouble with colours that are a mixture of red and green. These people have 'deuteranomalous colour vision'. If the green cone is not working at all, or is absent, the person will have trouble distinguishing between pure reds and greens, and will see everything in either blue, yellow, grey, or black. These people are termed 'deuteranopic'.

From this it can be seen that people with colour vision defects clearly need to use other visual cues apart from hue to be able to tell certain colours apart. Ravin, Anderson, and Lanthony[2] while discussing the famous artist Charles Meryon stated, "Despite his colour

Accommodation Values in a Normal Sydney Population, is the RAF Rule Still Valid?

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Introduction

The evaluation of the dynamic components of the near response forms a major part of an assessment of a person who has symptoms for near, or who has difficulty in changing focus. The close association of accommodation with age means that measures obtained in a clinical assessment must be compared with age related normal values to determine whether or not any abnormality is present.

In Australia, the most commonly used instrument to assess accommodation is the RAF rule. This instrument has the advantage of being able to determine the amount of accommodation occurring (in dioptres) and to match this against age related values. It also enables a simple measurement of the accommodation and convergence near point (in cms). The 'normal' values indicated on this device are those determined by Duane in 1912[1]. These are taken from a comprehensive study of normal accommodation, where the near blur point was measured and converted to diopters, assuming that any refractive error was corrected. It is likely that the 'mean' values are actually median values as they are always exactly midway between the upper and lower values.
(See Figure 1).

Clinical norms must be matched to those of the relevant population, and, in an urban Australian society at the end of the 20th century, the question must be asked as to whether values determined over eighty five years ago are still appropriate to use as normal for our population.

Figure 1. *Duane's normal values of accommodation for age measured in 1912.[1]*

Borish[2] reports other studies which have been made on age related accommodation values, which are summarised in Table 1. Some measures are notably different from Duane's, possibly due to the different measuring techniques which were used (especially those of Donders in 1864). Even the most recent (Turner, 1958) was published forty years ago. It is likely that the subjects in these studies were mostly of western European origin, whereas the current urban Australian population (Sydney in this study) has significant numbers of citizens with other ethnic origins.

Different clinicians have different measuring techniques; for example, the speed at which the target is moved will influence the recorded near point of accommodation. Some clinicians take only one measure, others measure several times. Unless each examiner uses the exact techniques that were used by Duane, values that differ from his will not necessarily represent abnormalities. In determining general values that can be used by all, there is also merit having input by many examiners in the determination of normal values for a particular population of subjects and examiners.

Table 1. *Summary of accommodation for age studies.*

Age (Years)	Donders (1864)	Duane (1912)	Sheard (1917)	Jackson (1922)	Turner (1958)
0-10					
11-15	19.7	13.4	12.0	14.0	13.0
16-20	16.0	12.3	11.0	12.0	10.6
21-25	12.7	11.2	9.0	10.0	9.5
26-30	10.4	10.0	7.5	9.0	7.9
31-35	8.2	8.7	6.5	8.0	6.0
36-40	6.3	7.3	5.0	7.0	5.75
41-45	5.0	5.7	3.75	5.5	4.4
46-50	3.8	3.9	2.75	4.0	2.5
51-55	2.6	2.1		2.5	1.6
56-60	1.75	1.4		1.25	1.1
61-65	1.0	1.2		0.5	0.7
66-70		1.1			
71-75		1.0			
76-80					
81-85					

For these reasons, a study of accommodation values in the Sydney population was carried out to determine current standards, and to compare these findings with the commonly accepted norms.

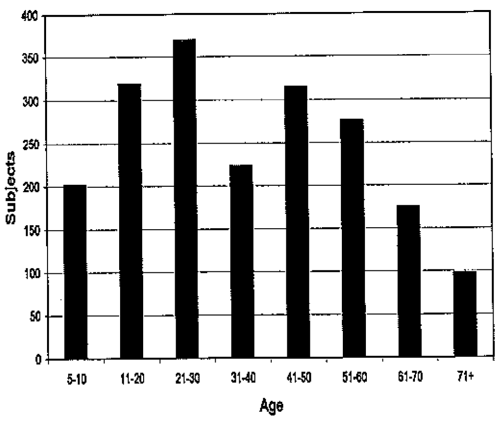

Figure 2. *Subject numbers in age categories.*

Method

The normal values of accommodation were measured in 1,978 subjects over a two year period (1995 -1996) by a total of 40 third year orthoptics students. These students had all been assessed as being competent in the appropriate measuring technique, and, in many cases, were supervised by a clinician during the testing.

Subjects

Subjects were included if there was no known or suspected anomaly of the ciliary muscle or the lens. The following were exclusion criteria:

- aphakia (or pseudophakia)
- cataract
- known anomalies of accommodation (eg, accommodative spasm)
- medication which affects accommodation
- the squinting eye in uniocular strabismus
- amblyopia

As normal values were needed, the examiners were encouraged to take measurements from a non-clinical population, ie from amongst their family and friends, and non patients in the clinics. Although attempts were made to achieve relatively similar subject numbers in all age groups it was inevitable that larger numbers were found from the young to middle age adult population. The presence of cataract also excluded many of the older subjects. Even so, 273 subjects over the age of sixty were assessed. The distribution of subjects is shown in Figure 2.

Procedure

The RAF rule was used where this was available, using the incorporated reduced vision chart or the four lines of different sized near print. Where this was not available, a ruler was placed against the subject's infraorbital ridge and an accommodative target was brought towards the eye along the edge of the ruler. The near point was measured in centimetres and converted to dioptres (using the formula 100/cms).

The subjects wore appropriate distance correction. If there was any known undercorrection, the full distance correction was used. Where progressive lenses (or bifocals) were incorporated in the glasses, care was taken to ensure that the subject was looking through the distance section of the glasses. Where the near point was more remote than 50cms (the length of the RAF Rule), this distance was measured and the results converted to dioptres.

Each eye was assessed separately.

Results were recorded in the age groups, from six to ten years, and thereafter in five year age groups to age 85 years.

The subjects' initials, age and clinic code were recorded to detect any duplicate measurements. At the end of the relevant period, the data was analysed using EpiInfo and Minitab.

Results and Discussion

Valid measures on 1,978 subjects were obtained. When right and left eyes were compared there was a statistically significant difference between the two eyes ($t = -2.4$, $p = 0.017$), however the actual difference of 0.57D is so small and clinically meaningless that it was decided to disregard it. The probable reason for the statistically significant difference was the very large sample size. (This is an example of a difference between practical and statistical significance.) The resulting data from each eye were therefore pooled.

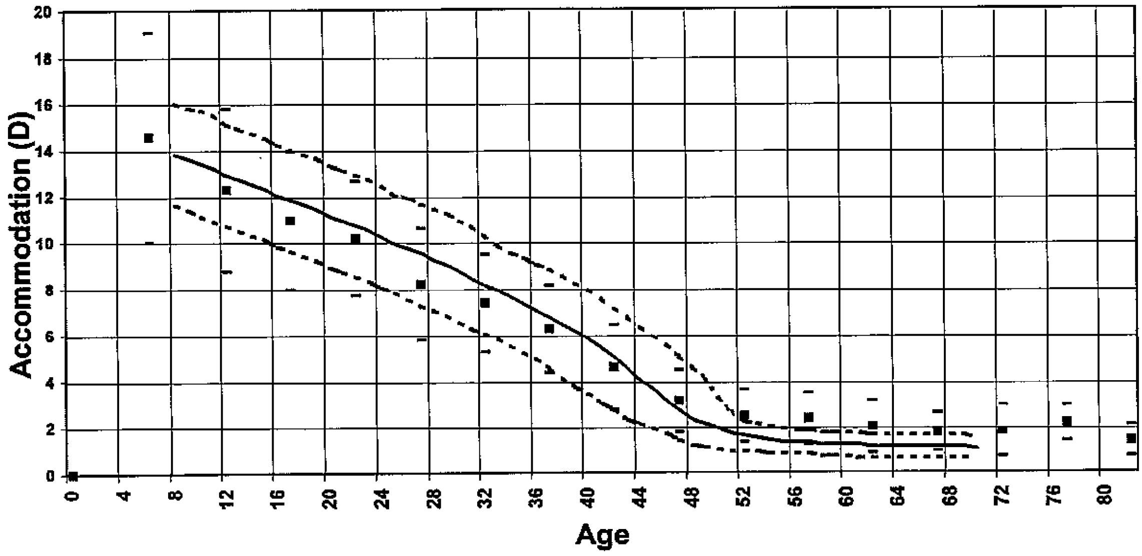

Figure 3. *Mean and SD of current study compared with Duane's values. Continuous and dotted lines show Duane's values. Current values are superimposed, as squares and dashes.*

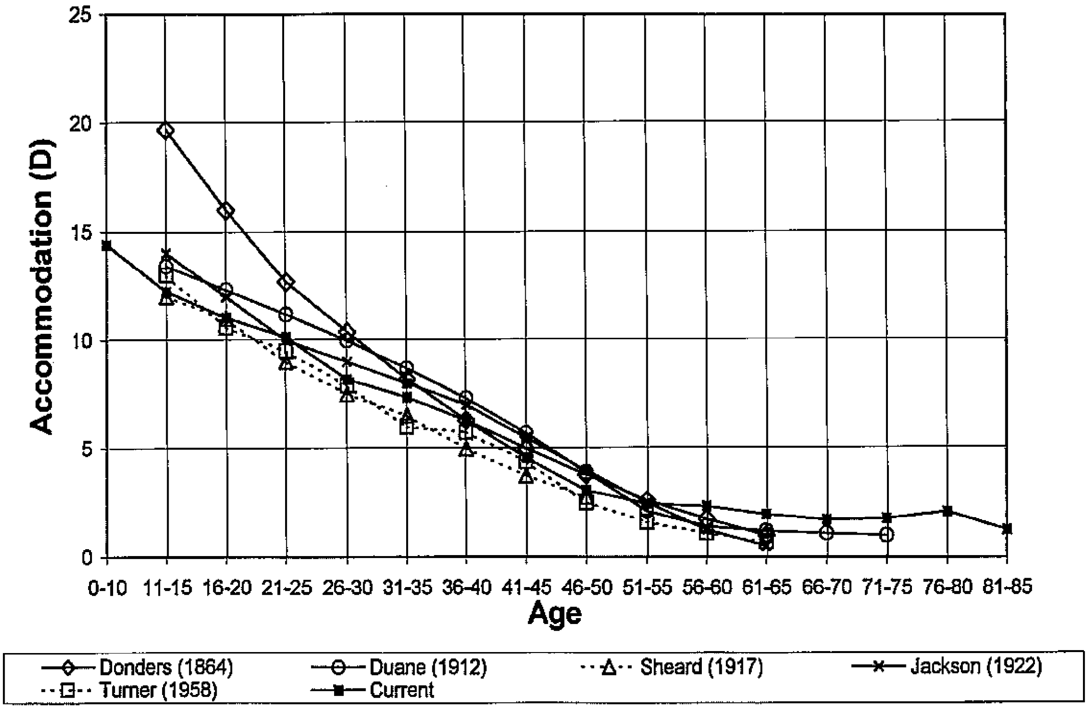

Figure 4. *Mean accommodation for age values in the current study compared with previous work.*

Values for the mean and plus or minus one standard deviation study are shown in Table 2, and are compared with the Duane values ('median' 'minimum' and 'maximum') in Figure 3.

Table 2. *Normative accommodation values in this study.*

Current Study

Age	-1 SD	Mean	+1 SD
6-10	10.0	14.5	19.1
11-15	8.8	12.3	15.8
16-20	8.0	10.9	13.9
21-25	7.7	10.2	12.6
26-30	5.8	8.2	10.6
31-35	5.2	7.3	9.4
36-40	4.3	6.2	8.1
41-45	2.7	4.5	6.4
46-50	1.7	3.1	4.4
51-55	1.3	2.4	3.6
56-60	1.2	2.3	3.4
61-65	0.8	2.0	3.1
65-70	0.9	1.7	2.6
71-75	0.7	1.8	2.9
76-80	1.3	2.1	2.9
81-85	0.7	1.3	2.0

It can be seen that the values obtained in this study are close to (although slightly lower than) the Duane values up to around 50 years of age, after which they are consistently better (by about 1.5D). The trends in each study imply that this improvement persists up to the age of 80 (although data are not available after the age of 70 from Duane). It is interesting to note that the values are very similar for subjects in their forties in each study, ie, the onset of presbyopia would appear to remain the same.

There is a greater spread of values in young children in this study, probably due to the difficulty in obtaining accurate data from these subjects. This is particularly evident in those under eight years, suggesting that these values should be considered with caution, although the mean value remains very consistent with Duane's study.

When the mean values are compared with other studies (see Figure 4), values under the age of fifty are very consistent, so that for a general indication of whether a patient's accommodation is normal, the RAF Rule still remains an appropriate measure. However, as this device only gives mean values, one must take care in deciding whether different measures are abnormal or within the normal range as given in Table 2.

Evaluation of accommodation in subjects over 50 is not normally carried out, so the moderately improved values in the older population, which persist when compared with other studies (see Figure 4), and the additional data given for those over 70 years have less clinical relevance. Nevertheless these findings are of interest. They could possibly be due to measurement errors, however the consistency of measures in the younger subjects make this unlikely. Other explanations could include:

- Better health in older age, due to improved medical care and lifestyle, leading to improved ciliary muscle tone and/or delayed hardening of the lens.
- Possible increase in the amount of close work undertaken by the current population group which may also affect the ciliary muscle and lens.
- A different demographic group, with significant numbers of subjects from Asia and Eastern Europe being represented in the Australian urban population.

Each of these possibilities would, of course, require further study to evaluate fully. What is clear from this study is the need for clinicians to be cautious in using data that has not been validated in the current population when determining possible abnormalities.

Conclusion

Measures of accommodation up to the age of 50 are very similar to those of previous studies, however after this age the values are moderately and consistently better than those previously published.

Acknowledgements

Obviously full acknowledgement needs to be made to the forty students who obtained the data for this study. Not only did they gain valuable experience in a common measuring technique; they were able to be involved in a clinical research project, which has real implications for their future clinical practice.

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