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COLOUR VISION: ISHIHARA AND CITY UNIVERSITY TESTS

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Abstract

The aim of this study was to compare the results recorded from two colour vision tests. The City University Colour Vision Test (CUCVT 2nd ed. 1980) and Tests for Colour Blindness by Ishihara (Ishihara, 24 plates, 1974) were used to assess colour acuity in a population of kindergarten children (n = 81). Traditionally, Ishihara has been used to detect red/green colour deficiencies, and the CUCVT aims to detect blue-yellow anomalies as well as red/green. We found that there was no significant difference in error recording between the two tests with regard of time taken, instructions, given, level of illuminations, or presentation order. However, CUCVT did not agree with the Ishihara in detecting red/green defects in this population, and appears to be more sensitive or biased towards eliciting errors of a blue/yellow nature.

Key words: *Red/green, blue/yellow, colour deficiencies, colour acuity, kindergarten children.*

INTRODUCTION

The aim of this study was to compare the results recorded from two colour vision tests. The City University Colour Vision Test (CUCVT 2nd Ed. 1980) and Tests for Colour Blindness by Ishihara (Ishihara, 24 plates, 1974) were used to assess colour acuity in a population of kindergarten children ($n = 81$). The Ishihara test has traditionally been the test of choice for detecting congenital (red/green) colour defects. The CUCVT was chosen because of brevity, ease of understanding and claims to detect red/green as well as blue/yellow defects. According to Hill et al,[1] the CUCVT demonstrated poor internal validity and least overall complete agreement by comparison with the Ishihara and four other tests. The retesting reliability of the CUCVT was said to be deficient where originally defective results subsequently were normal, and changes occurred in classification and degree of colour defect with retesting. The test is said to rely on "colour difference estimations" which is unique in a colour test, being hue discrimination rather than colour confusion.

The ideal colour vision test should demonstrate reliability in measurement, quantification of a defect and ease of administration. These features should be maintained through a known range of test conditions; such as illumination required for test administration.

In clinical practice the Ishihara test is often used solely to assess colour acuity. The pseu-

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doisochromatic stimuli of this test demands that a subject identify one stimulus as different from a background stimulus.

The colours of the stimuli are those which a red/green deficient subject will confuse. The CUCVT is not yet widely used in clinical practice. Hue discrimination is the basis of this test. Five stimuli are presented, requiring the subject to match one stimulus to one indicated by the examiner. The hues chosen as stimuli are those which a red/green or blue/yellow deficient subject will confuse. Verriest[2] compared hue tests to isochromatic tests, and claimed the CUCVT to be comparatively more sensitive in detecting acquired colour defects than congenital ones. This study reported that the Ishihara is amongst the most sensitive tests of red/green deficiency while the CUCVT is amongst the most sensitive tests for blue/yellow but not red/green deficiencies. However, Fitzgerald[3] reported that the CUCVT is the most reliable screening test for both congenital and acquired colour defects, although the study was of only 15 colour defective adults. The present study investigated whether significant differences existed between the tests' sensitivity to colour vision defects when changes in time and instruction of administration and illumination occurred, in a specific population.

METHOD

Children attending kindergartens of the Melbourne City Council take part in a vision screening service conducted by the School of Orthoptics, Lincoln Institute of Health Sciences. This prospective study of 81 children incorporated colour vision assessment into the existing programme. Ages ranged from 3-5 years, with a mean 4.02 years. First year orthoptic undergraduate students conducted the testing under the supervision of an orthoptist. The children were assessed in the kindergarten environment.

A new set of the City University Colour Vision test (CUCVT) second edition, 1980 was purchased, along with a new set of the Test for Colour Blindness by Ishihara, 24 plates, 1974.

A standard light meter, commonly used by orthoptists for visual perimetry, was employed to measure illumination levels before each test presentation. This was recorded with each test result as lighting varied considerably with each kindergarten and possible effects on colour vision recordings needed to be examined. The gradations of illumination were in multiples of 179 lux; being 179, 328, 715 and 1430 lux.

A Cassio's stopwatch was used by the supervising orthoptist to measure the time taken by each subject for each test.

Timing commenced after the first plate of each test had been presented and after the initial explanation. Timing ceased when a response had been given for the last plate. There was no time limit imposed on the subjects.

Permission for the entire visual assessment was given by the Melbourne City Council, however the subjects were unaware that they were involved in a study. Similarly, as a double-blind procedure, the undergraduate students administering the tests were also unaware of the study or its objectives. The students were given very specific instructions to put to each subject, (see Table 1), and the number of instruction recorded.

As detection of congenital colour vision problems is a main purpose of screening for

TABLE 1
Instructions

ISHIHARA
Instruction No. 1 "What numbers can you see?"
OR (if the subject had difficulty)
Instruction No. 2 "Draw the number with your finger."
(Indicate where to begin.)
CUCVT
Instruction No. 1. "See the spot in the middle/centre." (Point to it). "Show me another one that's nearly the same colour."
OR (if the subject had difficulty)
Instruction No. 2. "There are two spots nearly the same colour; this is number one." (Point to it.) "Where is number two?"

colour defects in this age-group, tests were conducted with both eyes open, and not monocularly, as would be expected when suspecting acquired defects. In all instances, testing was performed in rooms where lighting was a mixture of natural and artificial; and subjects and testers were seated at children's tables facing the 'plates' perpendicularly.

The colour vision assessments were made prior to any other visual testing to avoid elements of fatigue or other effects. To control for any presentation order effects, the students were instructed to present first to the subject, the test which had been presented second to the previous subject.

RESULTS

The subjects were a group of kindergarten children ($n=81$), with a mean age 4.02 years, 42% males and 58% females. The Ishihara test was presented first in 54% instances, and CUCVT presented first 46% of the time. When using the Ishihara test, 10% of the children were given Instruction No. 1, and 90% were given Instruction No. 2. This was not random choice, but aimed at levels of abilities of the child as appropriate. Using the CUCVT, 98% of the children were given Instruction No. 1, and 2% were given Instruction No. 2.

The times taken to complete the tests were:

Ishihara: Av. 2 mins 56 secs. Range 1 min 8 secs-6 mins 28 secs. Seventeen plates were used, with a mean time per plate as 10.34 seconds.

CUCVT: Av. 1 min 41 secs. Range 33 secs-4 mins 39 secs. Ten plates were used, with a mean time per plate as 10.09 seconds.

The illumination levels varied from 179 lux to 1430 lux, with mean 570 lux.

Using the Ishihara test, 18.75% (15) of the group recorded errors. Of these 15, five subjects recorded two or more errors. In this group of five, the mean number of errors was 3.6, with a range 2-4 errors. Overall, the number of errors recorded at two or more was 6.25% of the group of 81. Using the CUCVT, 49.37% (39) of the group recorded errors. Of these 39, 16 subjects recorded two or more errors. In this group of 16, the mean number of errors was 1.85, with the range 1-6 errors. Overall, the number of errors recorded at two or more, was 20.25% of the group of 81.

T-tests analyses ($p<0.05$) were performed. Of the errors detected using the Ishihara, 87% (13) had been given Instruction No. 2, and 13% (2) had been given Instruction No. 1. There was found to be no significant difference ($t=0.97$ DF = 13) in the number of errors detected and the choice of instruction. This was similarly found in the 39 errors recorded using the CUCVT ($t=0.62$, DF = 38) where 5% (2) had been given Instruction No. 2, and 95% (37) were given Instruction No. 1.

There was also found to be no significant difference between the order of test presentation and the number of errors recorded (Ishihara $t=1.48$, DF = 13 CUCVT $t=0.36$, DF = 37) or errors of "two or more" (Ishihara $t=0$, DF = 3, CUCVT $t=0.14$, DF = 14). Illumination levels less than, equal to, or greater than 600 lux, using both colour tests, showed no significant difference in the number of errors recorded (Ishihara $t=0.11$, DF = 13, CUCVT $t=1.18$, DF = 37) or errors of "two or more" (Ishihara $t=1.4$, DF = 3 CUCVT $t=0.51$, DF = 14). Although no Ishihara tests were performed in illuminations <300 lux, seven CUCVT tests were done at <300 lux. Three of these recorded errors, but the number of errors found in illumination <300 lux was not significantly different to the number of errors found in illumination >300 lux.

Of the five subjects recording errors of two or more on the Ishihara, and 16 with the CUCVT, only three were common to both groups. All three children had the CUCVT presented first and the Ishihara second.

DISCUSSION

Unlimited time per plate was allowed for each subject with each test, as Taylor[4] has warned of possibly inducing tritan defects with restricted viewing time. This was found to occur in groups of normal and selected colour defective subjects, when time was reduced to 3.75 seconds per plate. The instructions of each test recommend

TABLE 2
Levels of Referral

1. Nakajima A, et al, used the following guidelines for error referrals using the Ishihara test:
   3-9 errors — doubtful.
   10+ errors — defective, to be confirmed by other methods
2. Instructions in the Ishihara test give:
   3-5 errors — doubtful.
   6+ errors — defective, follow-up assessment with anomaloscope.
3. CUCVT instructions, state for the Ishihara test and the CUCVT, that three errors are border-line, and 4+ errors are defective, to be retested, and fully evaluated using three or more tests.

completion of a plate within three seconds. The subjects of our study took approximately 10 seconds per plate, the average time taken overall, being one minute less for the CUCVT, as this has 10 plates and the Ishihara has 17 plates.

Hill[1] considers that illumination levels do not affect error scores using the Ishihara and CUCVT when testing at 200 lux, 400 lux or 600 lux. However, it is recommended to use 400 lux ± 100 lux for the Farnsworth-Munsell 100 hue test. For these reasons, this study looked at errors scored above and below 600 lux (level recommended in CUCVT instructions), and above and below 300 lux, to as low as 179 lux. It is clinically important to note that no difference in error score occurred with these changes in illumination, as so often clinical environments can vary in their availabilities of light intensities.

As there seemed to be some discrepancies in number of errors indicative of a defect (see Table 2), this study defined two or more errors on either test as borderline or defective; 20.25% (16) of this group recorded errors at this level using the CUCVT, and 6.25% (5) were recorded, using the Ishihara. Of these 16 and five subjects respectively, three were common to both tests. Of these three children, all had had the CUCVT presented first to them. There were two females and one male.

If the borderline to referrable criteria is to apply to one but not both tests, 22.22% of this population requires follow-up. If this criteria, however, must occur on both tests (or have at least six errors on one test), then 4.9% of this population requires follow-up. (Congenital colour defects are said to affect 8% males, 0.5% females, averaging 4.25% of the population). Three children showed errors common to both tests, and one child showed six errors on the CUCVT, but none on the Ishihara. There was no difference in male/female percentages of errors recorded.

From the recording of the Ishihara test it was not possible to categorise the errors detected, however, of the 16 subjects recording errors, using the CUCVT, 15 chose tritan errors alone or in combination with protan or deutan errors. The range of overall errors was 1-6, the range of tritan errors 1-5. Two subjects each recorded two tritan errors alone and one subject showed one deutan error in combination with five tritan errors out of the total possible score of 10. This leads to the possibility that the CUCVT may be more sensitive or biased towards detecting blue/yellow defects as opposed to, or even at the expense of detecting red/green problems. There is also the factor that with the arrangement of dots on this test, tritan responses are situated on the right-hand side which may be easier to indicate than a left-handed response.

Three children did not finish one of the tests, all being second presentations. One subject did not finish the Ishihara, and had recorded two errors on the CUCVT. The two subjects who did not finish the CUCVT, had not recorded errors on the Ishihara. The probable element here is fatigue or lack of co-operation for a second test.

CONCLUSION

These findings support those of Hill[1] in that there is a poor correlation between the Ishihara and CUCVT when screening for congenital red/green colour deficiencies in four year olds. Although the CUCVT is a much quicker test to perform (one minute less overall), the level of difficulty was comparable to the Ishihara and did not have a bearing on the number of subjects failing to finish, or on the number of errors recorded. Normal clinical examintion does not require sophisticated lighting conditions for

either test. No effect on errors scored was found by order of presentation of tests, or instructions given.

Neuber[5] recommended the use of three or more colour tests when quantifying acquired colour defects stating the pseudoisochromatic tests to be least reliable for this group, with hue tests more reliable. The converse may indeed apply for congenital colour problems, with the hue tests being least reliable.

The recommendations of this study are for subjects three to five years. Where two or more errors are recorded, a retest is required, especially with the CUCVT which has poor retest reliability. Three colour tests should be performed to quantify and describe a colour defect. The CUCVT seems to be sensitive to blue/yellow rather than red/green defects, therefore the Ishihara test may be more appropriate as the initial test of choice for this age group. Further areas requiring investigation include the detection of tritan errors (CUCVT) and handedness; the retest reliability of both tests, investigating the lowest level of illumination before effects on errors are seen, and comparing the Ishihara with a pseudoisochromatic test that incorporates blue/yellow as well as red/green confusion.

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