A Test of Visual Function Applicable to Children with Severe Cognitive Impairments.

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Abstract

Many tests of vision have been developed to ensure the accurate measurement of this important sense. Some of these tests have been modified to facilitate testing in cases of special need, yet despite these modifications some severely cognitively impaired children are unable to comply with the requirements of visual acuity testing. This paper reports some of the evaluation findings of a new test of visual function designed to facilitate testing of severely intellectually and/or multi-handicapped children. Results from trials of two phases of the new test are presented. Phase 1, validation trials with 96 cognitively normal children and phase 2, evaluation trials with 73 intellectually, multi-handicapped children are presented. Phase 1 trials indicated the new test demonstrated strong positive correlation with standard clinic tests and had good internal validity. Phase 2 indicated the new test was significantly more successful in facilitating testing of the target population than standard clinic tests.

Key words:
Vision test, computer generated test, intellectual and multi-handicap, functional vision.

Introduction

Vision is the major sensory modality through which knowledge is gained with a large area of the brain devoted to analysis of visual information. The eyes are unique as sensory organs in having two types of receptor, thus facilitating analysis of the many facets of visual stimuli presented to them.[1,2]

Many tests have been developed to assess components of vision in order to enhance understanding of the mechanism, and to facilitate early detection of visual dysfunction. These tests are concerned with the three basic components of vision:

- The minimum visible
- The minimum resolvable
- The spatial minimum discriminable

More recently the impact of contrast on these three components has also been considered. The minimum resolvable is the component most commonly tested in the clinical setting and can be further subdivided into minimum separable ie the ability to distinguish two objects as separate, such as Teller acuity or Landolt's C[3-5] or minimum legible which involves the higher processing task of recognition, such as Snellen acuity or Kay pictures[3,6]. Predominantly, test development has reflected methods of obtaining the most accurate levels of visual acuity, necessitating sensitivity to the smallest changes in function. Criteria manipulated included: optotype legibility both in terms of letter similarities and contrast; optotype shape ie grating, C or letter; and progression of optotype size ie arithmetic or geometric.[3,7]

Test development has also reflected changes in the reasons for investigating vision. The need to test pre-verbal children resulted in a series of tests

with optotypes modified as pictograms,[6,8,9] or gratings.[5] Some tests are modified in terms of response mode, such as, matching or visual pointing.[5,6,10] The need to assess low vision patients for the prescription of optical aids resulted in the development of charts more sensitive at lower acuity levels which could be easily manipulated in terms of test distance, such as the logMAR chart.[11] More recently test developers have considered modifications necessary to facilitate testing of multi-handicapped children who are unable to respond to conventional tests of visual acuity.[12-17] Similar to tests for the pre-verbal paediatric population these tests have been developed by modification of conventional tests of vision. The modifications being the subject matter of the optotype and response mode to be used.

Based on clinical observation and reports in the literature some children are unable to respond to these modified tests. Such children have severe cognitive disabilities and or severe multi-handicaps. The problems testing these children include:

The low interest level of the optotypes used.

The lack of cognitive ability to identify or match letters and shapes.

The lack of fine motor skills to provide a pointing or matching response.

The lack of verbal development to provide a response.

Objective tests of vision such as VER have been suggested as providing a measure of vision independent of the patient's ability to respond or co-operate with the test.[18] As an increasing number of researchers acknowledge, there is a lack of relationship between measured acuity and functional vision.[19-21] Consequently the application of such objective test measures is not appropriate as an indication of the level of vision available for daily function. Knowledge of visual function is essential to the development of educational and skill training programs. The test of vision described in this paper was developed to facilitate testing children with severe cognitive impairment and/or severe multi-handicap to provide an indication of vision which might be applied to daily function.

Method

The data presented in this paper relate to the validation trials of the pilot test program, VizAssess and analysis of evaluation trials of the subsequent revised program VizTest. These are computerised tests of visual function.[22]

Subjects:

1. VizAssess validation: 96 children attending a paediatric ophthalmology clinic in Melbourne. The children were of varied intellectual ability with an age range of three to twenty one years. Forty seven subjects were male and forty nine were female.

2. VizTest evaluation: There were three subject populations.

- Seventy three intellectually/multi-handicapped children attending a Special Development School and School for the Visually Impaired in Melbourne, Australia.
- Forty two intellectually/multi-handicapped children attending a school for the deaf blind and two special schools in Sydney, Australia.
- Twenty eight children who were intellectually/multi-handicapped, severely visually impaired or both, attending a blind school and two special schools in London, UK.

Procedure:

1. VizAssess validation: Visual acuity was assessed using the computer test and an appropriate clinical test of acuity. Testing was carried out independently by two examiners, with each examiner blind to the results of the other. Visual acuity on the computer test was considered to be the smallest sized optotype the subject correctly recognised or could follow on screen on at least two occasions. All testing was commenced at 1 metre and if no response was obtained to the 6/30 optotype the test distance was reduced to 0.5 metre and the subject re-tested. Subjects who needed to move closer than 0.5 metre had their results recorded as less than 6/60. Clinical testing was undertaken with a test of acuity appropriate to the age and ability level of the subject. Most subjects were tested with the Medmont Visual Acuity tester: however, some children unable to cope with the logMAR format of the Medmont were tested with Kay Pictures or Sheridan Gardiner Singles. Clinical test distances varied from 6 metres to 0.5 metre depending on the needs of the subject. Clinical testing preceded computer testing in all cases. Computer testing began with module 2 followed by modules 1 and 3. Module 2 was selected first as this facilitated quick determination of optotype size for the subject, this size was then used with modules 1 and 3. If a subject recognised the optotypes at the selected size more easily on subsequent modules the optotype was reduced in size.

2. VizTest evaluation: Test protocol for VizTest was the same at all test sites. Subjects were tested with module 1 followed by module 2, and if a response was gained to module 2 then module 3 was tried. Testing was performed at 1 metre monocularly if the subject cooperated and BEO if

not. If test distance was reduced the result was recorded as less than 6/60. Clinical assessment of acuity varied between test sites.

• Melbourne: Subjects from the Special Development School were assessed using the computer test and Kay picture test. The order of test presentation was alternated between subjects. Kay pictures were presented at three metres, testing being done monocularly where possible or with both eyes open. Both tests were administered by the investigator. Students from the school for visually impaired were unable to co-operate with conventional clinic testing.

• Sydney: Subjects were assessed with the computer test and Catford drum(at half a metre), Cardiff acuity cards or Sheridan Gardiner singles (at 3 metres). VizTest was administered by the investigator and the clinic test by the orthoptist normally working at the location. Each examiner was blind to the results of the other.

• London: Subjects were tested with the computer test by the investigator and the clinical assessment of vision was taken from the most recently recorded clinical measure. The computer test was performed at one metre if a 15 inch display monitor was available and at 0.75 metre if a lap top computer display was used. The reduction in test distance was proportionate to the decrease in display screen area.

The computer tests.

VizAssess was described in a previous paper reporting the results of trials with severely multi-handicapped children[22].

VizTest consists of 3 modules. Each module enables the selection of images from a drop down menu.

Module 1: Visual attention. This module is designed to combine movement with a colourful image to attract the patient's attention. A range of pictures is available including commonly seen images, cartoon images and patterns. Each image is presented within an area 68 x 79 cm and can be made to "jump" from one side of the display to the other. This module is not intended to indicate any measured level of acuity, only to determine if visual attention can be gained.

Module 2: Vision category. This module incorporates the presentations of the three modules of VizAssess. A range of colour images can be presented on screen in one of three sizes. The images selected were considered to be of familiar content to the target subjects and included animals, plants, food, vehicles and people.

• Size. A coloured image is displayed in the centre of the screen at the smallest size of 28 x 23 mm. The image can be increased in size to 56 x 46 mm and 112 x 92 mm. The images do not display specific outline widths or contrast elements similar to Snellen design and outside dimensions are similar to Snellen equivalents of 1/18, between 1/36 to 1/60, and > 1/60 respectively. The pictures are not intended to measure precise visual acuity, rather to indicate a level of function.

• Movement. A coloured image can be selected in one of the three sizes described above. This image is moved horizontally across the screen in either direction. The speed of movement can be varied from fast 4.4cm/sec to slow 1.4cm/sec.

• Display. A coloured image can be selected in one of the three available sizes and displayed at the top, bottom, left or right of the screen. Display position is randomly generated and not predictable.

Module 3: Vision measure. This module has two components, acuity and contrast.

• Acuity: Black on white line drawings are displayed on screen. The drawings are created of line widths equivalent to Snellen line widths of 6/12, 6/24 and 6/60 optotypes. Overall size is not equivalent to Snellen design with each image appearing within a square 9.5 x 9.5 cm. A key square is presented for matching purposes and a blank square can be displayed to test reliability.

• Contrast: A line drawing is presented at high or low contrast in a square 9.5 x 9.5 cm. When the image is selected a random generator places the image to the right or left side of the screen.

Results

VizAssess validation.

Data were divided into groups based on pathology. Subjects whose pathology would be favoured by a near test distance, ie those with nystagmus and myopia, were analyzed separately to one another and to the rest of the paediatric population. Data analysis is based on data from each eye independently. The results of correlations between each module and the standard and between modules are summarized in Tables 1 - 3.

Modules	Spearmans rho	p value
M1: Standard	0.721	0.0005
M2: Standard	0.661	0.0015
M3: Standard	0.661	0.0015
M1: M2	0.959	0.0001
M1: M3	0.959	0.0001
M2: M3	1.0	0.0001

Table 1

Sub group Myopes

N = 24

Table 2

Sub group Nystagmus

N = 43

Modules	Spearmans rho	p value
M1: Standard	0.744	0.0001
M2: Standard	0.765	0.0001
M3: Standard	0.744	0.0001
M1: M2	0.867	0.0001
M1: M3	0.955	0.0001
M2: M3	0.913	0.0001

Table 3

Remainder of paediatric population

N = 125

Modules	Spearmans rho	p value
M1: Standard	0.803	0.0001
M2: Standard	0.790	0.0001
M3: Standard	0.798	0.0001
M1: M2	0.924	0.0001
M1: M3	0.963	0.0001
M2: M3	0.962	0.0001

Correlation between each module and the standard test was positive and of moderate correlation. The normal paediatric population demonstrated the strongest correlation between all modules and the standard, with the myopic group demonstrating the weakest correlation. Correlation between computer modules was positive and strong in all groups.

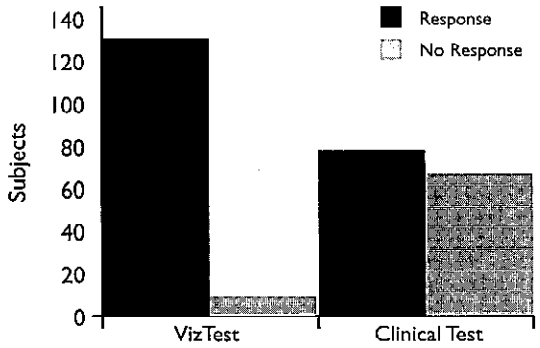

Figure 1 *Number of subjects demonstrating a response to VizTest and the clinic tests (n = 143)*

Figure 1 indicates that 132 (92%) of subjects were able to respond to VizTest where as only 78 (54%) were able to respond to a clinical test of vision and the difference between test response rates was significant *($chi^2 = 4.49$, $p = 0.034$)*. Response rates did vary between trial sites and these data are presented separately in Figure 2.

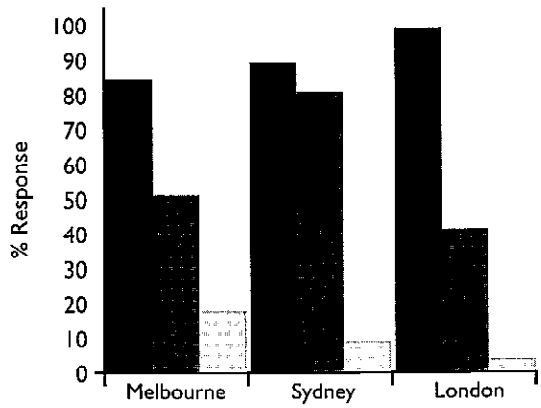

Figure 2 *Responses to VizTest and Standard test at three test locations (n = 143)*

VTest
Clinic
No Response

The Melbourne and London populations demonstrate a much higher response rate to VizTest than to the clinical test and while the Sydney population also demonstrates a higher response rate to VizTest, the difference between response rates to VizTest verses clinical is much less. The difference in response rates for the Melbourne and London populations was significant to a two tail paired t test *(Melbourne $t = 6.86$, $p = 0.0001$ and London $t = 5.7$, $p = 0.0001$)*. The difference in response rate for the Sydney population was not significant to two tail paired t test at the 0.05 level *($t = 1.78$, $p = 0.0831$)*.

Analysis of the combined data from the three trial sites of subjects able to respond to both VizTest and a standard clinic tests is reported in Table 4.

Discussion

Results were recorded as a vision category, the categories used were based on the WHO disability classification of > 6/12 = normal; < 6/18 = moderate low vision; and < 6/60 = severe low vision (legal blindness in some countries)[23]. This method of recording was chosen as construction of the test shapes did not allow complete equivalence to the Snellen optotypes; and vision category is an appropriate indicator of functional vision which is the purpose of this test.

The original test VizAssess demonstrated good positive correlation when compared to standard clinical tests. Results of analysis from the paediatric population indicate that the computer test is internally consistent across all groups. The weakest correlation was that between modules 1 and 2 in the nystagmus sub-group at 0.867, the strongest being between modules 2 and 3 of the myopic sub-group at 1.0. The remaining correlations were all within the 0.9 range (Tables 1 - 3). Correlations to the standard tests were positive but weaker. The normal population gave the strongest correlations at 0.8 for module 1 and 0.7 for modules 2 and 3; the nystagmus group reduced to 0.7 for all modules; with the myopic group being 0.7 for module 1 and 0.6 for modules 2 and 3. This loss of correlation may be related to the pathology. The myopic group not being heterogeneous in terms of correction, under corrected myopes may have been advantaged by the near distance of the computer test.

A further confounding factor in the paediatric trial population was the use of a range of vision tests for the standard test. This population was heterogeneous in terms of intellectual capacity

and the vision test used in the clinical setting was chosen to suit the child's level of function. The standard test therefore varied in response requirement, complexity of optotype, type of test presentation and test distance. In the clinical setting where this test will ultimately be used, test procedures are not standardized between clinical practices. Comparison of VizAssess to a range of commonly used clinical tests was deemed to provide useful data whilst acknowledging the introduction of a further variable. Analysis of the correlations achieved with the computer test indicate a high p value (.0001 in most cases, Tables 1 - 3) supporting the test being a suitable indicator of visual function in a paediatric population, with the exception of under corrected myopes.

Analysis of evaluation trial data for VizTest indicates that this revised test has successfully attracted attention and facilitated responses from the target population. Results from both the Melbourne and London trials indicate that a significantly larger number of children were assessable using VizTest than with a standard clinic test [Melbourne 63 (86%):37 (51%) and London 27 (96%):12 (43%)], this is seen in Figure 2. Whilst the Sydney trial indicated more children were assessable using VizTest the difference between groups was less 38 (88%):35 (81%). The difference in response rate may reflect some of the differences in the study populations. In both the Melbourne and London trials subjects were in an environment where routine ocular examination did not occur. The Sydney subjects attended schools where an orthoptist provided regular assessment (although this may not be more than an annual assessment).

The subjects in this study are from a population who are noted for liking routine and familiarity of environment. The Sydney subjects were tested in the office of the school nurse and in the presence of the school nurse which gave a high level of familiarity to this test situation. The majority of Melbourne subjects were tested on a withdrawl from class basis, they were tested without the support of a familiar person in an administrative area of the school which would not be well known to them. The London subjects were tested in the presence of a familiar person but not in a particularly familiar environment. In the Sydney study the standard test was administered by the consulting orthoptist who was familiar to at least some of the children, where as in the Melbourne study the standard test was presented by a person unfamiliar to the subjects. The standard vision for the London subjects was obtained from a clinical record and had generally been assessed by a person unfamiliar with the children and often in a strange environment (hospital clinic).

	VizTest	Clinic
Visually Impaired	12	0
Full Sight	15	44

Specificity = 1.0 Sensitivity = 0.44

Table 4 *Specificity and sensitivity of Viz Test (n = 71)*

Another variation between studies was the test used as standard. Both the Melbourne and London populations were tested with tests requiring a matching response based on recognition of a pictogram or letter (Kay, Sheridan Gardiner singles). These tests are commonly used in the clinical environment to test multi-handicapped children. In addition, a number of subjects in the London study had been recorded as not previously testable. The Sydney population was tested with the Catford drum, a test which does not require recognition of a pictogram or letter, and requires an ocular following response. The Catford drum is a test which has been criticized in terms of the accuracy of assessment and because of the noise associated with the small motor moving the drum. This noise might be attracting the child's attention resulting in a response, leading to a false assumption that the response is indicative of vision. VizTest provides no such aural cues.

The trials conducted with VizTest with severely intellectually/multi- handicapped children at three trial sites were not intended to be validation trials. However using the combined data from the three trial sites VizTest demonstrated excellent specificity with moderate sensitivity. Based on this data VizTest tends to under-detect visual impairment. Module 3 of VizTest was the only module to give some quantification of vision, in terms of a vision category. Data from module 3 was correlated with data from the standard clinic tests for those subjects responding to both tests. Correlation with the Melbourne and London populations were moderate and positive (0.597 and 0.634 respectively). The Sydney population demonstrated very weak correlation (0.011). See Figures 3, 4 and 5.

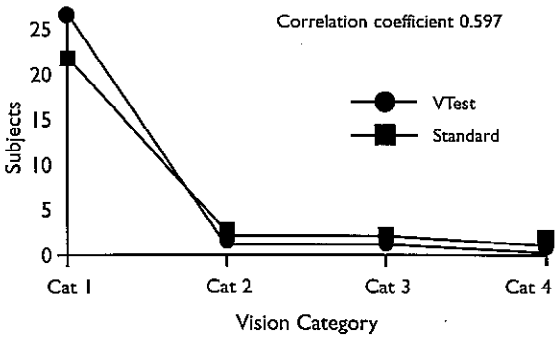

Figure 3

Correlation of vision category VizTest / Standard, Melbourne

This difference between the Sydney and other populations may be a result of the test used as standard. Tests based on optotypes of Snellen design were used in Melbourne and London (Kay, Sheridan Gardiner) where as the standard test with the Sydney population were predominantly the Catford drum or Cardiff Cards. The module of VizTest which was used to indicate vision category in this series of trials was module 3 which was closer in cognitive requirement to Kay or Sheridan Gardiner. The use of module 3 as the indicator of vision category also reduced the number of subjects for whom data was obtained, consequently reducing statistical viability.

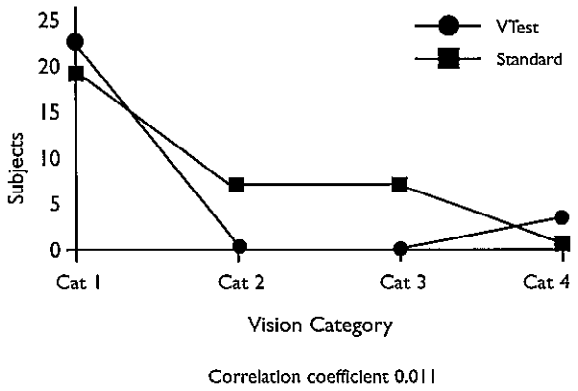

Figure 4 *Correlation of vision category VizTest/Standard Sydney*

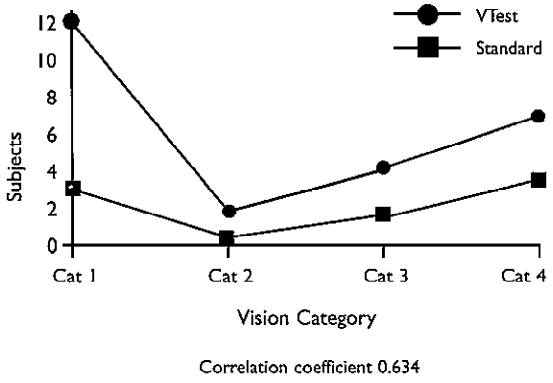

Figure 5 *Correlation of vision category VizTest/Standard London*

Conclusion

In conclusion the initial test, VizAssess, demonstrated that the computer did provide a test medium which was of interest to the target population. The ability to move the stimulus optotypes was successful in gaining subjects' attention and facilitated visual pointing as a response mode when subjects did not have the fine motor skill to finger point or verbal skill to name an optotype. Further trialing with a general paediatric population supported VizAssess as a good predictor of visual category when compared with a standard test of acuity. The revised computer test VizTest on preliminary analysis successfully attracted attention and facilitated responses from the target population and provided a moderately reliable indicator of vision category. These data support the use of computer presentation with colourful and familiar pictures as a target of interest to severely intellectually/multi-handicapped children. The data provide further support of the use of movement to facilitate responses from non verbal multi-handicapped subjects. Validation testing with cognitively normal subjects is continuing.

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