VISUAL ACUITY TESTING IN THE CHILD

A STUDY BY TIM PETITO
O.D. CANDIDATE
FERRIS STATE COLLEGE OF OPTOMETRY

in conjunction with

JACK E. RICHMAN, O.D.
CHIEF, PEDIATRIC SERVICES
FERRIS STATE COLLEGE OF OPTOMETRY

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INTRODUCTION

For over forty years vision scientists and clinicians have been searching for a valid and reliable test of visual acuity in children 2 to 6 years old. At the same time various professionals and non-professionals have been using visual acuity tests to gather information about the level of visual function a child achieves. Clinical as well as social decisions concerning the vision and in some cases the mental state of children has been made on the basis of less than adequately reliable and valid tests. However, each new test developed has helped define for us the ideal guidelines of a "good" test.

Acuity testing in children is imperative to find visual disorders before they have a significant impact upon the learning or developmental processes. The only realistic way to provide for this testing is to provide easily administered valid tests for use by non-professionals in existing screening programs. However most tests employed today use various symbols, pictures, and objects of questionable psychometric design.

Visual acuity tests for this population should have the following characteristics to be considered valid.

* Pretest education should be minimal.(5)
* The test distance should be ten feet.(3)

* Directional skills should not be involved in the test.(12)(3)(5)(4)

* The child should not be required to interpret the symbols used.(4)(2)

* The examiner should not need to interpret the response of the child.(2)(4)(5)(11)

* The symbols used should be familiar to the child.(9)(7)(1)

* The task involved in the test should be a same/different forced choice.(2)(4)

* Donder's principle of a 1/5 detail to figure ratio should be used.(1)(2)(3)(6)(10)

* Symbols used should be directly related to standard acuity levels.(5)(4)(11)

* The various symbols' blur points of non-recognition should be the same at each acuity level.(2)(4)

* Target size must be variable without effect on the other variables.(4)

* Necessary equipment should be inexpensive, portable, and non-frightening to the child.(8)

These characteristics form the basis for this test.

From these guidelines we have developed a new approach and visual acuity test for pre-school and exceptional children which has,in this study,proven to be both valid and applicable in these populations. To assess the validity of the new test it was compared to standard Snellen acuity in an adult population. Then to assess

the applicability of the test in the target age group it was used as a screening technique in a Head Start population and to assess VA in a group of children diagnosed as having various communication disorders. The use of this test does not require the subject being tested to respond verbally or by finger pointing.

METHODS AND PROCEDURES

The study consisted of three phases. Phase one established the validity and reliability of the the test by comparison with standard Snellen acuities in an adult population. Phase two consisted of testing the clinical applicability of the test in a pre-school group. The third phase was a similar trial with an exceptional population.

The actual test consists of cards having a picture of a car on them. Each car has either "Landolt Rings" or circles serving as wheels. The original cards were produced photographicly using high density Kodolith black and white film. The car body is identical regardless of whether the card contains the critical feature (Landolt Ring) or not. Thus the only difference between the two cards at any acuity level is the presence of a gap (or break) in the wheels of one car and no gap in the wheels of the car on the other card. We have thus named the test the "Broken Wheel" test. The test is administered as a three step process.

The first step is familiarizing the patient with the symbols and pretest instruction. A large (20/100) set of cards is shown to the subject at near. He is asked to identify the car having the

broken wheels. This is a non-VA dependent task for most people and therefore assesses the person's ability to recognize the critical feature when visible to him/her.

Next the large cards are moved to ten feet (the test distance) and step one is repeated. This step insures the subject can perform the task at the test distance and that he/she has at least 20/100 acuity. Each set of cards is presented four times (the cards are shuffled between presentations) and the subject must correctly identify the car with broken wheels all four times. This is designed to make the statistical reliability of the test adequate (i.e. guess level of less than 6%). If the subject cannot give an accurate response 4/4 times asked, every attempt should be made to ascertain whether or not the subject understands the task. If it is apparent he does understand, then visual acuity is less than the target size being used.

Finally, the size of the cars is reduced until the subject can no longer correctly identify the car with broken wheels 4/4 times. The smallest set correct 4/4 times is the visual acuity. If the test is to be used as a screening test ,as in the MCT, only the level necessary to pass needs to be presented in this step.

This test sequence was used in all facets of this investigation. Validity testing (phase one) consisted of comparing the monocular visual acuity (obtained by standard snellen procedures) of 27 adults and the acuity level on the new test. The ages of the adults ranged from 18 to 27 years. The Snellen acuity

ranged from 20/15 to 20/200. No artificial blur was produced (i.e. no plus or minus lenses were used to create refractive errors) to provide the acuity range.

In phase two, the test was administered to 233 Head Start children as the VA portion of the MCT. Ages in this group ranged from 3.1 to 5.3 years. This proves whether or not the Broken Wheel test can be reliably given to the preschool child. Also this provided information as to test time for this population and untestability in this group. Both of those statistics have been used to compare tests in the past.

For the third phase of the study, a group of 49 children requiring special education primarily due to communication disorders was screened using the Broken Wheel/MCT format. The disorders present in this population included; Deaf, Receptive/Expressive speech disorders, Cerebral palsy/Physically impaired. The commonality within this group is that these children had to be tested without a verbal response to the test. In these cases we used "eye pointing" as the response mode. Ages ranged from 4 to 23 years.

RESULTS

The validity tests show that the Broken Wheel and Snellen tests are highly related ($r=.93$) and are not significantly different ($t=2.10$; $df=52$). This means that the Broken Wheel test is indeed a test of visual acuity, at least to the degree the Snellen test is a VA test. The clinical applicability tests show the Broken

Wheel can be used on the age range it was developed for.

In the Head Start group, 211/233 (90.6%) responded correctly to all three steps. This is a 9.4% untestability for the Broken Wheel test. This compares to untestability of 10% to 25% (depending on distance) in the same age group for the "Tumbling E" test (best statistics of the other preschool tests). Testing time ranged from 5 to 7 minutes. This compares to an average for all other preschool VA tests of 3.4 minutes in this age group.(4) The times for the Broken Wheel test are for binocular followed by monocular testing, the "Tumbling E" times are for monocular testing only.

The exceptional group showed an increased test time (range 8 to 10 minutes) but also a lower untestability (4%). No statistics are available to compare with the other tests in this population. We must remember that this group was tested using non-verbal responses, either finger or eye pointing.

DISCUSSION

The three phase clinical test method employed here is a departure from the methods used in the past for investigating a VA test. The previous investigations centered around a clinical or screening application of the test involved on the population it was designed for. Then the average VA and statistical variances are computed for the test application and if these statistics show that the population has acuity equal to or better than previuos test methods produced the test being investigated is concluded to be as "good" or better than other methods.(1)(6)(7)(8)(9) This approach

does not provide the type of reliable validity study done here as the first phase.

As a result of our comparison of the Broken Wheel test to Snellen test results in a normal adult population followed by clinical application with children and exceptional patients we see there now exists a valid, highly usable visual acuity test for children age 2 to 6 years old and those unable to comprehend or respond to standard VA tests. It compares favorably in testing time and clinical use to the most widely used children's acuity test, the "Tumbling E" test.(4)(5) Since the "E" test is a directional task it is not in compliance with the characteristics previously defined for tests in this age group. Other commonly used tests are inadequate in that they do not follow at least one of the guidelines listed earlier.For example it was recently restated that directional tests are the most difficult for pre-schoolers as compared to non-directional tests.(12) The Broken Wheel Acuity Test utilizes cards having a familiar, non-threatening symbol (a car), presented in a forced choice peridigm. The task involved is a simple recognition of the critical feature. The critical feature in this test is a Landolt Ring and provides for both the 1/5 detail to figure relationship and the the ability to directly correllate Broken Wheel acuity to Snellen acuity. This fact should prove invaluable in cases of older children with reduced Snellen acuity, if they were previously tested with the Broken Wheel test. If the Broken Wheel acuity was also reduced the child's problem is one of

long standing if the old acuity was 20/20 the reduction is of recent origin. Tests that do not adhere to the aforementioned requirements do not afford this opportunity since the early test may not be assumed to be valid. For example the lighthouse test has been shown to give acuity levels much better than Snellen acuity in adult populations, and therefore is not valid for youngsters either (table III).(13) The blur-out point of the critical feature is the same as for all Landolt Ring type tests, this is known to be adequate (psychometricly sound). No interpretation of the optotypes used is necessary for the child since both cards are the same (exept for the critical feature). Responses can be oral, by finger/hand pointing, or by eye pointing. If the response is to be eye pointing, the examiner should hold the cards, one to each side of his head so that when the child looks at the car with broken wheels there is no confusion as to which card he/she actually is looking at. Another precaution which should be taken during testing is exercising care not to look at the correct response since the examiner would then essentially be eye pointing for the child.

I do not want to leave the impression this is the only test necessary for testing young children. Since no one test will be applicable in all situations we should maintain a battery of tests which provide the clinician a choice on a per case basis. However, the Broken Wheel test should definitely be included in the group. This represents a new concept in testing the exceptional patient's acuity and another step in refining our clinical techniques for

children in general. There still is a great need for more investigation of visual acuity measurements, tests and their meaning in clinical assessment of children.

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	1 Snellen	2 LH (SC)	3 LH (PLT)	4 Landolt
2	0.87	1.00	0.98	0.93
3	0.87	0.98	1.00	0.93
4	0.92	0.93	0.93	1.00

TABLE I- Shows the correlation between Snellen, Lighthouse (single choice and preferrential looking techniques), and standard landolt acuities in adult populations.

	if Snellen	then BW
	20/20	20/22
VA	20/30	20/32
	20/40	20/45
	20/50	20/55

TABLE II- Shows the acuity levels of adults in Phase I of this study as would be produced if the snellen were converted to decimal equivalent and compared to the decimal equivalent of the broken wheel number. This will show no significant difference between Snellen and Broken Wheel acuity.

	if LH	then Snellen
	20/20	20/30
	20/25	20/40
VA	20/30	20/48
	20/40	20/65
	20/50	20/84

TABLE III- From Larry Olson(13) this table and table II were produced similar by comparing the decimal equivalents of the snellen and lighthouse acuities of an adult population, and shows significant differances between the two tests.