MEASUREMENT OF NEAR VISUAL ACUITY

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The search for a reliable and valid near visual acuity chart for the pediatric population is a continuing quest for practitioners. The standard Snellen acuity chart cannot be used for populations where the characters are not recognizable. Therefore, various pediatric acuity charts have been developed to cater to this sector. These acuity charts must be valid not only for children with normal acuity, but also for children with subnormal acuity. In patients with functional amblyopia a definitive acuity level may not be elicited on charts that do not minimize the crowding effects.[10] This could conceivably lead a practitioner to erroneously estimate a patient's acuity to be at a level other than his/her functional acuity level. Any acuity difficulty must be identified in children as early as possible. This would allow for maximum chance for success with treatment and minimum impairment of learning and comprehension in the classroom. Thus, when choosing a testing procedure, one must consider all the factors that may influence the outcome. There are many factors that can effect the measurement of acuity. Some of the factors that need to be considered are discussed below.

First, as is obvious, the subject's refractive error effects acuity.[1] Second, the contrast of the chart and retinal image can alter the measured acuity. Acuity is essentially unchanged if the target contrast is above 20 percent or if the retinal contrast is above 2 percent.[2] Third, luminances adversely effects acuity only at extremes.[3] "Visual acuity remains constant over a wide range of photopic luminances, extending from the level of full moonlight to that of a bright sunny day."[4] Fourth, pupil size will vary to maximize acuity at all luminance levels.[4,5] Fifth, interaction effects can cause acuity to decrease when the targets do not have equal contour interaction on all sides.[6,7,8] This unequal interaction effect interferes with recognition of the character. It is imaginable that a character that is missed by a subject could have been identified if the interaction effects were eliminated. The opposite situation could also occur. Sixth, acuity is maximized with characters that have horizonal or vertical detail as opposed to a oblique orientation.[4] Finally, the developmental aspects of the child must be considered. In the pediatric population, the child's understanding, knowledge and attention must be evaluated.

Next, the acuity test itself must be examined. The following are the objectives and characteristics desired for a good pediatric acuity chart:[9]

1. Pretest patient education should be minimal;
2. Test distance should be evaluated;
3. Directional orientation skills should not be involved;
4. Child should not be required to verbally interpret the symbols;
5. Examiner should not need to interpret the Child's verbal responses;
6. Symbols uséd should be familar to the child;
7. Test response should use a same/different type of forced choice paradigm;
8. Donder's principle of 1:5 detail to figure ratio

in optotype should be used;

9. Symbols used should have construct validity and reliability with standard Snellen optotypes;
10. Symbol's blur points on non-recognition should be the same at each acuity level;
11. Symbol target size must be variable for the acuity levels without affecting the other variables;
12. All necessary equipment should be inexpensive, portable and nonfrightening to the child.

It is important to address these criteria when deciding on an acuity chart or when evaluating a new chart. The more of the above points met by the test, the more likely the test will be successful for a large portion of the pediatric population.

PURPOSE

This paper will compare and contrast various pediatric near point acuity charts. The various charts will be correlated to the standard Snellen chart. And, the advantages and disadvantages encountered while using each chart will be discussed.

METHODS AND PROCEDURES

The first part of our comparison consisted of an adult sample. Four near acuity charts were used to measure the acuity of fifty-five adults in a metropolitan eye clinic. These tests were the Childs Recognition, Tumbling E, Snellen, and a new Landolt C near acuity charts. The Childs Recognition and Landolt C near charts utilized a 13 inch test distance. The

Tumbling E and the Snellen charts used a 16 inch test distance. Therefore, these two distances were strictly and carefully adhered to for the respective charts while the testing was conducted. Visual acuities were taken without the subject's habitual correction. The subjects were instructed to identify the orientation of the Tumbling E chart or the Landolt C chart. The subjects were allowed to respond by pointing or verbalizing the direction of the character. Verbal identification of the Childs Recognition and Snellen characters were necessary. THe visual acuity was taken to be the smallest resolvable line in which the subject correctly identified 3/4 (75%) of the characters. The room illumination ranged from 68 ftC to 85 ftC. The subjects ages ranged from 20 years old to 62 years old. Monocular and binocular acuities were taken. The measured acuities spanned from 20/20 to 20/260.

The second part of the evaluation was conducted on 218 elementary school aged children. The children were tested in a suburban elementary school from a large metropolitan area. The ages ranged from 6 years old to 11 years old. The subjects were approximately 50 percent white and 50 percent black. No pretest test was taken. Again, the test distances of 13 inches and 16 inches were clearly marked and adhered to while the testing was conducted. The room illumination was 76 ftC with minimal variation. Monocular and binocular acuities were taken without the child's habitual correction. As indicated previously, the Childs Recognition chart and the Landolt C chart used a

13 inch test distance. The Snellen and Tumbling E charts were tested at 16 inches.

To ensure that the child was able to identify the characters or the direction of the characters, the following information was noted and methods used:

1. Was the child familiar with the alphabet; if so, the child was to verbally identify the characters;
2. Was the child able to identify the characters on the Childs Recognition chart; each child was allowed to identify the characters with any name he/she was familiar with;
3. Was the child able to distinguish right, left, up and down; the child was allowed to verbalize, point or orientate a seperate character to match the target character.

The visual acuity ranged from 20/20 to 20/100. Again, the measured acuity was determined by the smallest resolvable line in which 3/4 (75%) of the characters were correctly identified.

RESULTS

For statistical analysis, the visual acuities were converted to Snellen fractions. For the adult sample, the means for the Childs Recognition, Tumbling E, Landolt C and Snellen charts were .59, .67, .80 and .78 respectively. The standard deviations were .15, .21, .29 and .30 with respect to the Childs Recognition chart, the Tumbling E chart, the Landolt C chart and the Snellen chart. The correlation coefficients were calculated for each chart relative to the standard Snellen chart. However, since the charts measured different maximum acuities (i.e. 20/20 for Snellen vs. 20/30 for Childs Recognition), only the data points less than or equal to the acuity level of the chart which had the lowest maximum acuity (i.e. Snellen vs. Childs Recognition only V.A.'s less than or equal to 20/30) were used. The results showed that the Landolt C and Tumbling E charts had an extremely high correlation to the measured Snellen acuity. Thus, the tests are reliable and valid. In addition, they appear to be measuring essentially the same acuity level as the Snellen acuity level. The Childs Recognition chart also showed a significant correlation to the Snellen acuity, however not to the same degree as the Landolt C and Tumbling E tests correlate. The correlation coefficients for the Childs Recognition, Tumbling E and Landolt C charts are .78 (n=35), .93 (n=50) and .98 (n=51).

In the pediatric sample, the means were .66, .76, .88 and .92 for the Childs Recognition, Tumbling E, Landolt C and Snellen tests respectively. The corresponding standard deviations were .06, .12, .17, and .20. The correlation coefficients with respect to the Snellen test, calculated as described above, for the Childs REcognition, Tumbling E and Landolt C charts are .41 (n=29), .83 (n=106) and .84 (n=651). In this sample the Childs Recognition chart did not show a significant correlation to the Snellen acuity. In contrast, the Tumbling E and the Landolt C charts did show a statistically significant correlation to the measured Snellen acuity level. These results are summarized in Table 1.

The total number of data used for statistical analysis for the adult monocular and binocular acuities was 165, unless otherwise noted. For the pediatric sample the number was 651, again unless otherwise noted.

DISCUSSION

All four of the visual acuity charts had advantages and disadvantages with respect to the previously set forth criteria. In addition, a comparison of the Childs Recognition, Tumbling E and Landolt C charts to the Snellen acuity provided varying results.

The first chart tested was the Childs Recognition chart. This test consisted of characters resembling familiar objects.

One advantage of this chart is that the children were able to recognize most of the figures. If the child was unfamiliar with any individual character, he/she was allowed to call the figure by any name he/she liked. Also, no directionalization was necessary to conduct acuity testing with this chart.

A disadvantage of this chart included giving a visual acuity consistently better than the acuity measured by the Snellen acuity chart. This difference manifested itself by a one or two line discrepancy. The mean Snellen fraction acuity for this chart for the adult population was .59 with a standard deviation of .15.. For the pediatric population, the mean acuity was .66 with a standard deviation of .06. Given the above mean and

Table 1: Summary of Statistical Analysis

Near Visual Acuity Chart	ADULTS mean	ADULTS std. dev.	ADULTS corr. coeff.	CHILDREN mean	CHILDREN std. dev.	CHILDREN corr. coeff.
Childs Recognition	.59	.15	.78	.66	.06	.41
Tumbling E	.67	.21	.93	.76	.12	.83
Landolt C	.80	.29	.98	.88	.17	.84
Snellen	.78	.30	--	.92	.20	--

sample standard deviation, the majority of the pediatric sample data fall more than two standard deviations (95%) from the Snellen mean. One reason for the discrepancy results from the different maximum acuity each chart could measure. The Childs Recognition chart measures to 20/30, while the Snellen chart measures to 20/20. This necessitates a large difference in mean acuities for the two charts. A second and more significant reason is that the Childs Recognition test did give acuities better than those measured by the other tests for subjects with acuity below 20/30. Another disadvantage was that some of the figures were more easily identified. For example, the "duck" figure, in many instances, could be resolved on an acuity line better than the recorded measured acuity. The visual angles of the detail on the figures cannot be maintained at a level better than 20/30. After reviewing the results, it is suspect a consistent detail ratio is also maintained near this level of acuity.[11] Finally, at times, understanding what the child was saying proved to be difficult. This chart has the hazard of predicting an acuity in a subject that is greater than the Snellen acuity. This could cause a practitioner to miss a subtle acuity loss in a patient.

The Tumbling E chart was designed to measure acuity by having patients identify the orientation of the letter E.

This near visual acuity chart had the advantage of maintaining Donder's principle of 1:5 detail to figure ratio at all acuity levels. All subjects were familiar with the figure E.

In addition, the subjects were able to easily identify the direction of the "E" by employing one of the methods described in the Methods section under point 3. Although this test doesn't use the 1 in 2 forced choice paradigm, it does use a 1 in 4 paradigm.

The main disadvantage was encountered when the pediatric subjects needed significant pre-test instruction. In some cases, each of the three methods were tried before a successful mode of identification could be established. This test also did not hold the child's interest to the extent that the Childs Recognition test did. Also, as the lower visual acuity lines are neared, the crowding effects were not minimized.

The mean of the adult sample was .67 with a standard deviation of .21. For the pediatric sample, the mean was .76 and the standard deviation was .12. The maximum measurable acuity for the chart used was 20/25. Therefore, the correlation between this chart and the Snellen acuity appears poor upon visual inspection. However, in subjects with acuity less than or equal to 20/25, the two tests proved to have a significant correlation. The calculated correlation coefficient for this subgroup was r=.83 (n=106). Thus this test is a reliable and valid measure of acuity.

The Landolt C near visual acuity chart was designed using the letter "C" with contour interaction lines on all four sides of each character. The spacing between the figure "C" and the contour lines are kept at a constant ratio to avoid the crowding effect.

The advantages and disadvantages were essentially the same as those for the Tumbling E acuity chart. Again the children were given the choice of using one of the three methods of identifying the direction of the "C" as described in the Methods section under point 3. The Landolt C chart was able to measure to a maximum acuity of 20/20. Since this chart was able to measure to the level of the standard Snellen chart an accurate statistical analysis was calculated (n=651). The correlation coefficient was r=.84 (n=651). This suggests a significant correlation between the Landolt C acuity and the Snellen acuity. In the majority of the instances where there was a discrepancy between the two acuities, the Landolt C acuity was less than that of the Snellen acuity. Therefore, one can be reasonably confident to assume that the subject's acuity is <u>at least</u> that which is determined by the Landolt C near acuity chart.

The Snellen chart is a valid and reliable measurement of visual acuity. The chart is designed using the characters in the alphabet.

The advantage of this chart is that once the subjects are familiar with the characters no pre-test instruction in necessary. Also, the letters do maintain Donder's ratio. This test is easy to administer and accurate.

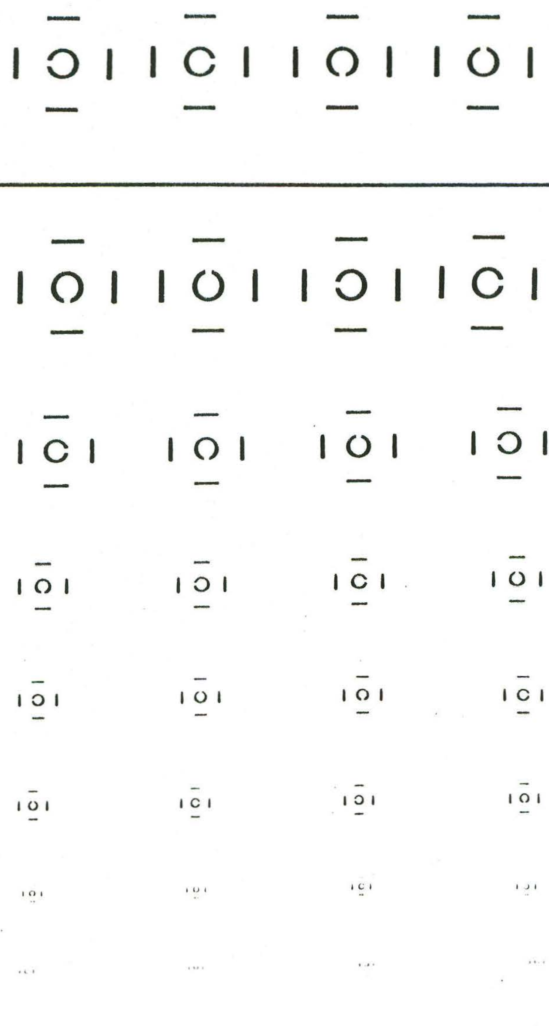
One disadvantage is that this test cannot be used on young children and illiterate adults. Also, this chart does not avoid interaction effects. Yet, in spite of the disadvantages, the Snellen acuity chart is the standard by which other acuity charts are judged.

CONCLUSION

When choosing a pediatric near acuity chart one needs to consider whether it meets the objectives for a good pediatric acuity chart. In addition, the near acuity test must be reliable and valid with respect to the measured Snellen acuity. The above discussion was not meant to be a point by point critique of each of the test, but an overview of the performances of the test charts encountered while administering them to a pediatric sample. Thus, each test must be judged upon its own merit in regards to reliability, validity and ease of use.

NEAR VA TEST

TEST DISTANCE 13 INCHES



SAMPLE

20/200

20/150

20/100

20/80

20/60

20/40

20/30

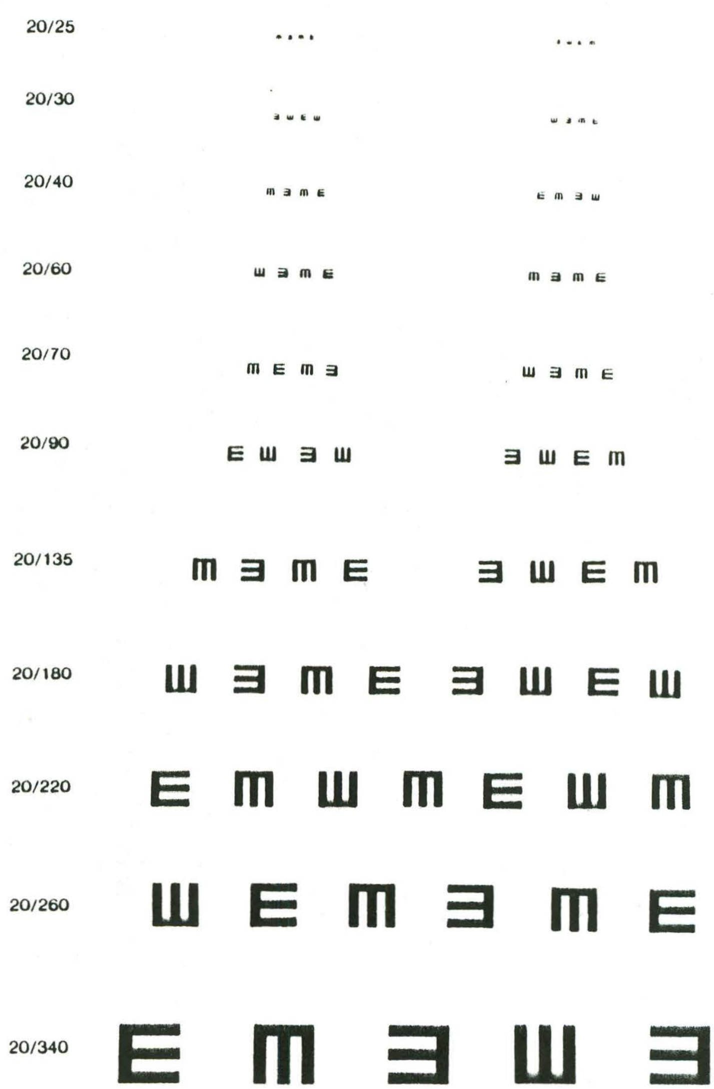
20/25

20/20

Ferris State University

BIG RAPIDS, MICHIGAN

APPROX. SNELLEN
EQUIVALENT AT 16"



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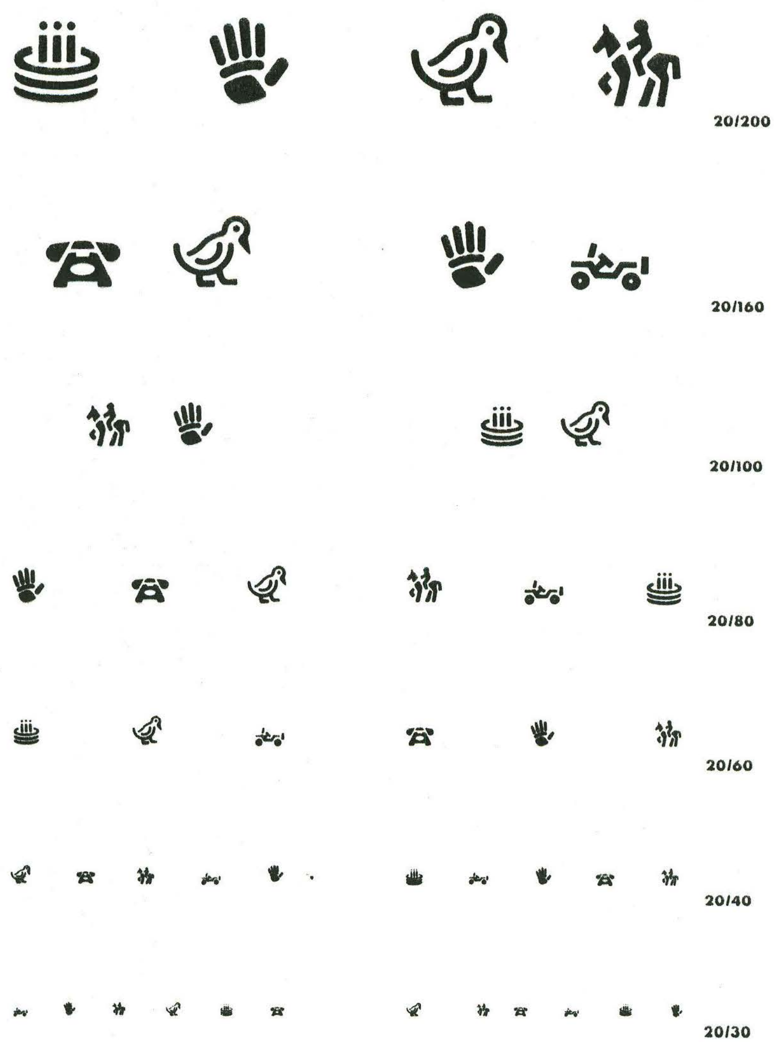
TEST DISTANCE 13 INCHES



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REFERENCES

1. Kohl, P., Rolen, R., Bedford, A., Samék, M., Stern, N., "Refractive error and preferential looking visual acuity in human infants: a pilot study", Journal of American Optometric Association; 57, 4, 290.

2.

3. Shlear,S., "The relationship between visual acuity and illumination," Journal of General Physiology, 21,165.

4. Moses, R., Hart, W., Adlers Physiology of the eye (Mosby, Missouri, 1981) pp. 420-428.

5. Leibowitz, H., "The effect of pupil size on visual acuity for photometrically equated test fields at various levels of luminances", Journal of Opt. Soc. Am., 42, 416.

6. Davison, H., The physiology of the eye (Academic Press New York, 1976) pp.236-247

7. Manny, R.E., Fern, K. Loshin, D., "Contour interaction function in the preschool child", AM. J. of Opt and Phys. Optics; 64, 9, 686.

8. Flom, M., Weymouth, F., Kahneman, D., "Visual resolution and contour interaction", J. Opt. Soc. Am., 53, 1026

9. Richman, J., Petito, G., Cron, M., "Broken wheel acuity test : a new and valid test for preschool and exceptional children", J. of Am. Opt. Assoc., 55, 8, 561.

10. Griffin, J., Binocular Anomalies, Procedures for Vision Therapy,(Fairchild, New YOrk, 1988) pp. 76-82.

11. Fern, K., Manny, R.; "Visual acuity of the preschool child; a review" AM. J. of Opt. & Phys. Optics; 63,5,319