Comparison of the new Cardiff Acuity Test with the Teller Acuity Test in toddlers 12 to 36 months of age

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Abstract
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Both acuity tests yielded a nearly 100% patients testable level. Only one subject was unwilling/unable to complete both acuity tests in one sitting.

We suggest that the Teller Acuity Test be performed on infants from birth to 1 2 months old. The Cardiff Acuity Test proved to be easier to use for the 1 2-36 month olds who are pre-verbal and easily distracted.

Degree Type
Thesis

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COMPARISON OF THE NEW CARDIFF ACUITY TEST WITH THE TELLER ACUITY TEST IN TODDLERS 12 TO 36 MONTHS OF AGE

BY

EDITH G. BOWMAN
PAUL S. PRESTON

A THESIS SUBMITTED TO THE FACULTY OF THE
COLLEGE OF OPTOMETRY
PACIFIC UNIVERSITY
FOREST GROVE, OREGON
FOR THE DEGREE OF
DOCTOR OF OPTOMETRY
APRIL 1995

Adviser:
Paul Kohl, O.D.
SIGNATURE PAGE

EDITH G. BOWMAN, 4TH YEAR STUDENT

PAUL S. PRESTON, 4TH YEAR STUDENT

PAUL KOHL, O.D. FACULTY ADVISOR
Edith G. Bowman:

Affectionately known as “Edie B.” and “Fast Edie Bowman” around school; first pursued a career in ophthalmic and obstetrical nursing that spanned fifteen years from 1969 until 1984. Career highlights include pre and post-op patient education, surgical assisting, contact lens fitting and adjustments, optical dispensing and school, community and health fair screenings.

In 1982, I received my F.A.A. commercial pilot lighter-than-air free balloon rating, and hit the skies of Colorado and Utah working as a pilot for three different hot air ballooning operations for six years.

In the fall of 1991 I had completed all under graduate course requirements at Colorado State University, and was accepted into the optometry program here at Pacific University. Two years later I received my Bachelor of Science degree in visual science.

My initial career interests were in contact lenses and pediatrics. Following an intensive physical therapy and vision therapy program set up for my husband after his recent stroke, I became more interested in an interdisciplinary approach to vision therapy, that includes working with physical and occupational therapists towards a combined goal of patient recovery.

I find delight in traveling anywhere and everywhere with my husband while seeking out creative and evocative art, sculpture, and jewelry as well as staying home and creating some of our own.

Paul S. Preston:

Pre-optometry course work included a B.A. cum laude from Macalester College in Saint Paul, Minnesota where Paul was a National Merit Scholar and National Presbyterian Scholar, varsity cross country runner, alto sax player, actor in three theatrical productions and editor of the Macalester literary magazine. He majored in English with a concentration in Creative Writing.

Father of two active young girls ages 4.5 and 2, both of whom can say “fundus photo.” In a former life (read “former career”) he was a teacher of English as a Foreign Language in Taipei, Taiwan, Republic of China (ROC) for seven years. Taught students of nearly all ages, from private tutoring of eight year old boys (not recommended) to teaching in a private school to children in all grades from 5th to 12th. Also taught at Cheng-Chi University, both freshman English in the day university and English conversation in the adult education branch (night school). Together with his wife Kristi, he also taught in the ROC Ministry of Finance’s Public Finance Training Institute for seven years. There they created specialized curriculums and tests (both written and oral) for Customs officials and Public Finance Ministry personnel, as well as teaching these courses. Also was Assistant Coordinator and teacher of English at the Language Training and Testing Center, located on the campus of Tai-Da (Taiwan National University).

Other sideline adventures in Taiwan included being chosen along with Kristi to be MC’s for a nationally televised talent contest for non-Chinese people to perform, sing, do Kung Fu, etc., all in Mandarin Chinese. They were dressed as Chinese aristocratic scholars from the Ching Dynasty. They also appeared in a cameo performance of a Chinese soap opera on television.

Paul has great interest in practicing full-scope optometry including taking on post-trauma and post-stroke patients, and challenging patients such as autistic, ADHD, & ADD patients. He’s also interested in the normal potpourri of contact lenses, vision therapy, low vision, primary care, pre-and post-op co-management, strab and amblyopia, and so on ad infinitum. His big dream currently is to try to go on charitable optometric missions to both Africa and Mainland China (The People’s Republic of China) and to teach optometric continuing education courses in Asia, Europe, or any of the other continents.
Abstract

This paper presents clinical data comparing visual acuity test findings in 12-36 month olds. Visual acuity tests performed were with the Teller Acuity Test, and a new visual acuity test for toddlers, the Cardiff Acuity Test. Both tests use preferential looking cards, but the Cardiff test cards contain vanishing optotypes of easily recognizable pictures. We found this age group to be more attentive to, more at ease with, and better able to understand the Cardiff Acuity test.

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Both acuity tests yielded a nearly 100% patients testable level. Only one subject was unwilling/unable to complete both acuity tests in one sitting.

We suggest that the Teller Acuity Test be performed on infants from birth to 12 months old. The Cardiff Acuity Test proved to be easier to use for the 12-36 month olds who are pre-verbal and easily distracted.

Key words:
Teller Acuity Test, Cardiff Acuity Test, Non-verbal acuity tests, Toddler acuity tests, visual acuity pictures, pre-verbal toddlers, 12-36 mo. olds.
Acknowledgements

The student authors would like to thank Keeler Instruments Inc. for the loan of the Cardiff Acuity Cards to Pacific University for our study. We also would like to thank Beta Sigma Kappa for their generous grant that will go towards purchasing a set of the Cardiff Acuity Cards for our Family Vision Clinic in Forest Grove, OR.

Thank you very much Paul Kohl, O.D. from both of us, for your guidance and expertise in pediatric optometry that you shared with us during our project. You deserve a weekend in the J. Garcia Suite in the Triton Hotel.

Last but not least our thanks goes out to our families and loved ones for their patience and understanding while we were away working on this project and studying.
Introduction

Research and development of infant and toddler visual acuity testing procedures began with Robert Fantz in the late 1950's and early 1960's. Forced-Choice Preferential Looking methods of assessing infant visual acuity were clinically adapted from Fantz's earlier research. Modification and refinement of laboratory testing procedures continued through the 1970's, 80's and 90's. Preferential looking techniques for assessment of visual acuity has become a standard in optometric and ophthalmologic research and clinical practice. Reliability of preferential looking visual acuity results has been established through comparison to Snellen acuity, and other acuity card procedures. One of the best considered modified techniques of preferential looking was established by Teller et. al. in the 1970's. Today this test is commonly known as the Teller Acuity Card Test (hereafter referred to as the TAT).

Teller acuity cards are large rectangular cards that have a homogeneous grey background with a section to the left side or the right side that consists of black and white square-wave gratings. In the center of the rectangular card is a peep hole through which the examiner looks to observe an infant's preference to looking at a patterned stimulus as compared with the plain homogeneous luminance-matched field. The examiner subjectively makes a decision that the infant fixated the grating based on eye movement, head turn, or pointing towards the side of the card with the grating. When the examiner no longer can observe the infants preference to look to the side of the card with the grating, then it is decided that the previous card is equivalent to the highest spatial frequency that the infant is able to resolve. Testing is conducted at a near distance of 55cm. or 37 cm. from the infant's face. Visual acuities tested range from 20/1600 to 20/15. Results are recorded in cycles per degree. This resolution acuity can be compared to recognition acuity i.e., the Snellen acuity, although some believe it is an unequal comparison and can be misleading to future examiners, because resolution acuity is often better than recognition acuity. The measure of resolution acuity may be an incomplete indicator of total visual function. Resolution acuity can be converted into Snellen equivalents by using the following formula:

\[
\text{Snellen Denominator} = 20 \times \left[\frac{30}{(\text{cpd})}\right] \\
\text{or} \\
\text{Cycles per degree} = \left(\frac{20}{\text{Snellen denominator}}\right) \times 30. \\
\text{(cf. footnote 4)}
\]
Over the years of clinical use, preferential looking procedures have been proven to be quick and reliable, easily portable, and easy to learn how to administer. However, preferential looking procedures have shown difficulties in obtaining accurate assessment of visual acuities in certain age groups.

Kohl states that acuity card procedures are more difficult with children at 12 to 24 months of age. McDonald also states that the acuities of 15-36 month olds are difficult to measure. Dobson et al describe 18-24 month olds as often being difficult to test. Adoh, Woodhouse and Oduwaiye also describe problems as well as limitations encountered while testing 12 to 36 month old toddlers. Jaworski’s opinion is that although the preferential looking test is accurate, some patients do not have enough target interest to view the stripes. The following is a list of some of these difficulties in testability that occur in these age groups as cited in the above literature;

1.) They are usually pre or non-verbal at this age.
2.) They are too young to understand instructions.
3.) They lack motoric responses such as the ability to point.
4.) They are fearful of strangers and less apt to cooperate.
5.) They find their surroundings more interesting than the stripes.
6.) They are more attracted to the peep hole.
7.) They tend to pull off their patches during monocular testing.
8.) They become bored quickly due to short attention spans.

In 1992 Optometry and Vision Science Vol 69 #6 pp 427-432, Adoh, Woodhouse and Oduwaiye, form the Department of Optometry, University of Wales College of Cardiff, Cardiff, United Kingdom, describe their new test for visual acuity measurement designed for this hard to test group of toddlers. The Cardiff Visual Acuity Test (hereafter referred to as the CAT) incorporates preferential looking techniques with vanishing optotypes.

Cardiff visual acuity cards are smaller square cards that contain a homogeneous grey background with easily recognizable pictures at the top or bottom of the card. Kay’s study shows that amongst the pictures tested those of a fish, car, train, house, dog and duck had the highest percentage rate of recognition in 2-3 year olds. These same pictures have been incorporated into the Cardiff acuity cards to hold the interest and attention of difficult to test 12 to 36 month olds. Each stimulus picture can be used as a resolution target as well as a recognition target and is calibrated in cycles per degree. Converting to Snellen equivalent is carried out the same as in the Teller acuity test. There is no peep hole
in the center to distract the child. Testing is conducted at a distance of 50cm. for acuities of 20/400 to 20/40 and can be extended to 1m. in order to increase the range of acuities to 20/20.12 13

The entire set of Cardiff Acuity Cards consists of eleven sets of three cards, one set of three for each spatial frequency (and therefore visual acuity) level. The sets are labelled A through K, with A being the largest target. The examiner is blind to the direction of the optotype because the three cards at each visual acuity level are shuffled before presenting it to the toddler.12 14 The examiner makes a subjective decision that the child or toddler has seen the target based on up or down eye movements, head turn, or ability to point to the target. When the examiner concludes that the toddler has seen two of the three presentations at each acuity level, a next higher spatial frequency demand is then presented. When two positive responses are no longer elicited, the examiner then shows the previous set of cards, where an endpoint of two of the three cards is consistently seen.12 14

In the present study we present data comparing visual acuity findings of the Teller acuity test with the new Cardiff acuity test in the difficult to test toddler groups of 12 to 36 month olds. Data were also gathered on the percent testable.

It is hoped that our study will guide the optometrist and ophthalmologist in choosing and purchasing the most age appropriate visual acuity tests for their clinical use.
Methods

Subjects
Our subjects, ages 12 to 36 months, were recruited by placing flyers in the class rooms of our optometry school, sending notices to local churches and day care centers, and putting want ads in the newspaper. The twenty-nine toddlers tested were selected randomly on the basis of their age only. They were divided into two age groups, 12-24 months and 25-36 months. Two subjects were dropped from the study because of crying and being unable to cooperate.

Testing procedure
The examiners were two third year optometry students both trained in administering the Teller acuity test and the Cardiff acuity test.

Both tests were performed on the subjects in the same exam room location, under the same lighting conditions, while sitting in their parent’s lap. The parent was sitting in the exam chair, and both subject and parent faced the examiner who was sitting at the eye level of the toddler.

One of the two examiners presented the Teller acuity cards, starting with one octave above normal expecteds for that age, at a distance of 55cm. The examiner then observed through the peep hole for binocular eye movements, head turns or pointing to either the right or left side grating stripes of the Teller acuity card. The examiner then checked the card to ascertain the correct position was fixated. Continued presentation of progressively higher spatial frequency cards resumed until the examiner decided that the subject was no longer fixating the grating stripes. A binocular visual acuity score was recorded and the examiner left the room with their findings.

The other examiner then entered the exam room and presented the Cardiff acuity cards to the subject, at a distance of 50cm., starting with a larger than expected acuity card so the subject could understand and feel at ease with the test. Testing was started at least one octave above the age-expected norm for the given subject. The subject’s up or down responses in eye movements, head turns, pointing or sounds that mimicked the animal picture on two consecutive cards out of three were considered valid fixations of the target as were eye movements alone. Continued binocular presentation of the cards resumed until the subject reached the last card or did not respond to two of three presentations at any acuity level. At the testing distance of 50cm., the last card was equivalent to 20/40 Snellen acuity. At this point the examiner would move to a one meter testing distance and repeat presentation of the last few cards to
measure visual acuities up to a maximum of a 20/20 Snellen equivalent. After binocular acuity was recorded, the examiner placed a coverlet patch, a pirate patch, a hand held occluder, or possibly just Mom or Dad's cupped hand over the subject's left eye for monocular testing. The left eye was also tested in the same manner. The subject was given a 'sticker' for good performance and allowed to leave the exam room with his/her parent. Binocular and monocular recordings of visual findings were kept separately by each examiner and not compared until all data were collected. Depending on circumstances, at times the Cardiff Acuity Cards were presented first.
Results

All PL-VA data, in cycles per degree, were converted to log MAR units (Minimum Angle of Resolution) for statistical analysis. A paired t-Test (1 tail) using the standard criteria of probability < 0.05 being significant was used to analyze the data for the twelve subjects from Group A (ages 12 to 20 months) and for the fifteen subjects in Group B (ages 25-35 months). In both groups, there was no statistical significance between the VA findings for the Cardiff Acuity Test (CAT) and the Teller Acuity Test (TAT). Table 1 shows the data for Group A and Table 2 contains the data for Group B. As would be expected there was a generalized trend towards an overall improvement in OU acuities with increasing age. Table 3 illustrates an interesting difference between Groups A and B, i.e. for subjects in Group A, the younger group, there was an almost equal number of subjects who scored higher VA scores with the CAT and the TAT. But for the subjects in the older group, Group B, six out of fifteen subjects scored a higher acuity score (better visual acuity) on the CAT, whereas only two out of fifteen scored better on the TAT. Almost half of the subjects (seven out of fifteen) scored equal VA’s with both the CAT and the TAT in this age group. Appendix A shows Conversions to Snellen equivalents for both the CAT and the TAT.

The percent of patients testable was nearly 100% for each test. In only two cases were we unable to get data from both tests. In one case the subject was not cooperating for the second test and his mother informed us he had been sick recently and that the testing time was also near his nap time.
### Table 1. Visual Acuity Data for Group A (12-24 months)

<table>
<thead>
<tr>
<th>Subject Number</th>
<th>Age in mos.</th>
<th>Cardiff VA's OU Log Mar values</th>
<th>Teller VA's OU Log Mar values</th>
<th>Cardiff Snellen VA's</th>
<th>Teller Snellen VA's</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>0.4</td>
<td>0.4</td>
<td>20/50</td>
<td>20/50</td>
</tr>
<tr>
<td>2</td>
<td>13</td>
<td>0.5</td>
<td>0.3</td>
<td>20/40</td>
<td>20/64</td>
</tr>
<tr>
<td>3</td>
<td>14</td>
<td>0.4</td>
<td>0.4</td>
<td>20/50</td>
<td>20/50</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>0.1</td>
<td>0.6</td>
<td>20/25</td>
<td>20/80</td>
</tr>
<tr>
<td>5</td>
<td>14</td>
<td>0.6</td>
<td>0.2</td>
<td>20/80</td>
<td>20/32</td>
</tr>
<tr>
<td>6</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>20/20</td>
<td>20/20</td>
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<tr>
<td>7</td>
<td>16</td>
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<td>0.3</td>
<td>20/50</td>
<td>20/40</td>
</tr>
<tr>
<td>8</td>
<td>18</td>
<td>0.4</td>
<td>0.3</td>
<td>20/50</td>
<td>20/40</td>
</tr>
<tr>
<td>9</td>
<td>18</td>
<td>0.4</td>
<td>0.6</td>
<td>20/50</td>
<td>20/80</td>
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<tr>
<td>10</td>
<td>20</td>
<td>0</td>
<td>0.4</td>
<td>20/20</td>
<td>20/50</td>
</tr>
<tr>
<td>11</td>
<td>20</td>
<td>0.1</td>
<td>0.3</td>
<td>20/25</td>
<td>20/40</td>
</tr>
<tr>
<td>12</td>
<td>20</td>
<td>0.4</td>
<td>0.3</td>
<td>20/50</td>
<td>20/40</td>
</tr>
<tr>
<td>Subject Number</td>
<td>Age in mos.</td>
<td>Cardiff VA’s OU Log Mar values</td>
<td>Teller VA’s OU Log Mar values</td>
<td>Cardiff Snellen VA’s</td>
<td>Teller Snellen VA’s</td>
</tr>
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</tr>
<tr>
<td>1</td>
<td>25</td>
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<td>0.2</td>
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<td>3</td>
<td>27</td>
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<td>0.2</td>
<td>20/20</td>
<td>20/32</td>
</tr>
<tr>
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<td>28</td>
<td>0.2</td>
<td>0.4</td>
<td>20/32</td>
<td>20/50</td>
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<td>20/50</td>
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<td>29</td>
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<td>0</td>
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<td>0</td>
<td>20/20</td>
<td>20/20</td>
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<tr>
<td>11</td>
<td>32</td>
<td>0</td>
<td>0.2</td>
<td>20/20</td>
<td>20/32</td>
</tr>
<tr>
<td>12</td>
<td>32</td>
<td>0</td>
<td>0.3</td>
<td>20/20</td>
<td>20/40</td>
</tr>
<tr>
<td>13</td>
<td>31</td>
<td>0.1</td>
<td>0</td>
<td>20/25</td>
<td>20/20</td>
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<tr>
<td>14</td>
<td>34</td>
<td>0.2</td>
<td>0</td>
<td>20/32</td>
<td>20/20</td>
</tr>
<tr>
<td>15</td>
<td>35</td>
<td>0</td>
<td>0</td>
<td>20/20</td>
<td>20/20</td>
</tr>
</tbody>
</table>
Table 3. Frequency Distribution of Subjects with Cardiff Acuity Scores Higher Than, Equal to, and Lower Than Corresponding Teller Acuity Scores

<table>
<thead>
<tr>
<th>Percent of subjects with higher UA’s on both</th>
<th>Percent of subjects with lower UA’s on both</th>
<th>Percent of subjects with same UA’s on both</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiff Acuity Test (n)</td>
<td>Cardiff Acuity Test (n)</td>
<td>Cardiff Acuity Test (n)</td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33.33% (4)</td>
<td>41.67% (5)</td>
<td>25% (3)</td>
<td>100% (12)</td>
</tr>
<tr>
<td>Group B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40% (6)</td>
<td>13.33% (2)</td>
<td>46.67% (7)</td>
<td>100% (15)</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37% (10)</td>
<td>25.93% (7)</td>
<td>37.84% (10)</td>
<td>100% (27)</td>
</tr>
</tbody>
</table>
Discussion

The Cardiff acuity test fills a gap in accurately assessing the visual acuities in a difficult age group of 12-36 month olds. This age group has been described as pre or non-verbal, too young to understand testing instruction, fearful of strangers and less apt to cooperate. They have also been described as becoming quickly bored, having short attention spans and being more interested in their surroundings than in the testing. We found that it was easier for the toddlers to ‘play’ picture games with us than to look at stripes in front of their faces. We found too that some of the older ones actually enjoyed peeping back at us through the Teller card peep hole and weren’t even interested in the grating stripes but would continue on testing with the Cardiff picture cards. Although we didn’t test them with out their parents they seemed more at ease sitting in Mom or Dad’s lap, especially when it came time for patching and testing monocular acuities.

The possible implication of the data in Table 3 is that in the pediatric optometric population, the 2 to 3 year old patients may well attend better to the visually attractive and captivating vanishing optotypes employed by the Cardiff Acuity Test than to the grating stripes of the Teller Acuity Test. That was the two clinicians’ subjective impression, and these data suggest that for clinical purposes, the Cardiff Acuity Test may possibly yield better results for the two to three year old patient. This may be an area for further research in the optometric and visual science communities.

We found that both the Teller acuity test and the Cardiff acuity test are easily administered, transportable and both are quick methods of assessing visual acuity in infants and toddlers when compared to the forced-choice-preferential-looking theater apparatus (which still remains a very useful setup for infants from newborns to 12 months old). The Teller acuity card set runs almost $1,000.00 at present while the approximate cost of the Cardiff cards is $600.00.

We suggest that optometrists and ophthalmologists whose clinical practices include a volume of children ages 12-36 months old might be better able to assess the visual acuities of these patients by using the Cardiff acuity test cards.
References

Appendix A. CPD and log MAR Conversions to Snellen Equivalents for Teller and Cardiff Tests.

<table>
<thead>
<tr>
<th>Cycles/degree for Teller cards</th>
<th>Approx. Snellen Equiv. at 55 cm</th>
<th>Cardiff card letter</th>
<th>Log Mar values for Cardiff cards</th>
<th>Approx. Snellen Equiv. at 50 cm (or 1.0 m with *)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3</td>
<td>29/400</td>
<td>A</td>
<td>1.3</td>
<td>20/400</td>
</tr>
<tr>
<td>2.4</td>
<td>20/200</td>
<td>D</td>
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<td>20/200</td>
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