An evaluation of infant visual acuity using Lea Grating paddles and Teller Acuity Cards

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Abstract

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Methods: Thirty-five subjects were recruited with parent/guardian consent. Subjects were comprised of newborns and infants ranging in age from 5 days to 17 months. The assessment of infant visual acuity was performed using the Lea Grating Paddles and the Teller Acuity Cards. Procedural manuals for both techniques were used as reference guidelines. Testing was performed in a standard examination room with normal room illumination. One tester presented the gratings to the infant and determined which direction the infant was looking, while another tester documented acuity levels based on the first tester’s observations. Binocular testing followed by monocular testing was conducted. Testing took approximately 15 minutes to complete per child.

Results: T-testing showed no significant difference between the Lea Paddles and TAC binocular means for each four-month interval age group. ANOVA binocular testing for the Lea Paddles and TAC indicated an asymptotic increase in acuity with age, leveling-off starting at four months and older. ANOVA monocular results for both procedures suggested a sigmoidal increase in acuity with age, leveling-off between 4-12 months of age. According to the scatter plot, a strong correlation was found for both procedures when means were calculated for the four interval age groups. Correlation coefficient between the Lea Paddles and TAC for binocular and monocular findings were 0.9930 and 0.9910 respectively.

Conclusion: In summary, it was found that any benefit of the Lea Grating Paddles over the TAC is primarily for the clinician. It was easier to obtain the attention of the infants with the Lea Grating Paddles. In addition, the lower cost and increased portability of the Lea Grating Paddles are desirable features for the clinician. While values in this study corresponded with the norms set by the Lea manual, future studies may be useful to establish a larger base of normative data.

Degree Type

Thesis

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An Evaluation of Infant Visual Acuity Using Lea Grating Paddles and Teller Acuity Cards

BY

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Jennifer Maeda
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A thesis submitted to the faculty of the
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Advisor:

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Project Title: An Evaluation of Infant Visual Acuity Using Lea Grating Paddles and Teller Acuity Cards

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Thirty-five subjects were recruited with parent/guardian consent. Subjects were comprised of newborns and infants ranging in age from 5 days to 17 months. The assessment of infant visual acuity was performed using the Lea Grating Paddles and the Teller Acuity Cards. Procedural manuals for both techniques were used as reference guidelines. Testing was performed in a standard examination room with normal room illumination. One tester presented the gratings to the infant and determined which direction the infant was looking, while another tester documented acuity levels based on the first tester's observations. Binocular testing followed by monocular testing was conducted. Testing took approximately 15 minutes to complete per child.

Results:
T-testing showed no significant difference between the Lea Paddles and TAC binocular means for each four-month interval age group. ANOVA binocular testing for the Lea Paddles and TAC indicated an asymptotic increase in acuity with age, leveling-off starting at four months and older. ANOVA monocular results for both procedures suggested a sigmoidal increase in acuity with age, leveling-off between 4-12 months of age. According to the scatter plot, a strong correlation was found for both procedures when means were calculated for the four interval age groups. Correlation coefficient between the Lea Paddles and TAC for binocular and monocular findings were 0.9930 and 0.9910 respectively.

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In summary, it was found that any benefit of the Lea Grating Paddles over the TAC is primarily for the clinician. It was easier to obtain the attention of the infants with the Lea Grating Paddles. In addition, the lower cost and increased portability of the Lea Grating Paddles are desirable features for the clinician. While values in this study corresponded with the norms set by the Lea manual, future studies may be useful to establish a larger base of normative data.
Introduction

Pediatric vision care has undergone an increase in attention by various health care professions in the United States during the last few years. The AOA recommends regular eye exams for all children beginning at 6 months of age or sooner if significant risk factors are present. The American Academy of Pediatrics called for pediatricians to check a child’s eyes at each well visit from birth on. Confident assessment of visual acuity cannot routinely be carried out with standard clinical tools for children under three years of age due to their variable cooperation and comprehension levels. Therefore, several studies have limited their evaluations of 1 to 3 year-old children to gross estimations based on their ability to fixate a light source, follow a moving stimulus, or reach for a small toy.

With the development of tools that quantify behavioral responses, such as preferential looking, it has become relatively easy to complete an accurate and rapid assessment of even the youngest infant. Preferential looking, pioneered by the experimental psychologist Fantz in the 1960’s is based on the principle that infants tend to look at the most interesting stimuli presented in their field of view. Clinical use of preferential looking acuity is generally very successful. The Teller Acuity Card (TAC) procedure was developed in the mid 1980s and is used in clinical practice to assess non-verbal patients, including infants and young children. Since the 1980s, the modified version of the TAC procedure has become widely accepted as an important and effective diagnostic tool. This is reinforced by a study conducted by Spierer et al. (1999) who found that while the modified TAC procedure was associated with a high rate of false positive results, it has proven to be a useful clinical tool for conducting vision screenings in preverbal children.
More recently, the Lea Grating system of preferential looking tests have been developed, using hand-held paddles with printed grating lines to assess visual acuity in infants and young children.\textsuperscript{10, 11}

Basic research to determine clinical validity of the Lea Grating paddles has not yet been conducted.\textsuperscript{12} This study involves the evaluation of infant (0 to 17 months) grating acuity.
with the Lea Grating Paddles and Teller Acuity Cards in a clinical setting. The purpose of this study is to compare the acuity measure obtained with both methods, and to establish age-related acuity norms for the newer Lea Grating system.

Methods

Visual acuity testing was conducted on 35 infant and toddler subjects, two of which were born pre-term. Subjects included two sets of fraternal twins; both of which were born full-term. Of the 35 subjects, two of the subjects’ parents had significant pregnancy histories (one with pre-eclampsia and one with gestational diabetes); however, all subjects were born without any significant complications. Only one of the 35 subjects was currently on non-prescription medication for a mild cold. Subject ages ranged from 5 days to 17 months.

<table>
<thead>
<tr>
<th>Table 1: Subject Age/Gender Demographics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Range (months)</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Males</td>
</tr>
<tr>
<td>Females</td>
</tr>
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</table>

Testing began in September 2000 and ended in February 2001. Subject recruitment included the local newspaper, university newsletter and a local community network. The Northeast WIC (Women Infant Child) program in Portland, Oregon was also a valuable resource for obtaining subjects. Testing was conducted at both the Pacific University Family Vision Center in Forest Grove, Oregon and the Pacific University Northeast Vision Clinic in Northeast Portland, Oregon. All testing was conducted during the afternoon from 1:00-5:30 p.m. and took approximately 15 minutes per subject to
Parents were asked to fill out a questionnaire, informed consent and a photo release form prior to testing, and were given a Comprehensive Vision Exam Certificate for their time at the end of testing.

The assessment of infant visual acuity was performed using the Lea Grating Paddles and the Teller Acuity Card Procedure. Procedural manuals for both techniques were primarily used as reference guidelines. Testers wore neutral or solid color clothing during testing to prevent directing the subject’s attention away from the test. Binocular and monocular testing was conducted using both techniques with binocular testing performed first. Pediatric opaque eye-patches were used for the monocular portion of the test; however, using an occluder or having the parent cover the infant’s eye with his/her hand was also necessary when patching was not successful. Bottles, pacifiers and a variety of toys were incorporated into the testing in order to help gain and maintain the subject’s attention.

The Lea Paddles consisted of one gray control paddle and three grating paddles with gratings on both sides (Figure 2). Presentation with the Lea Paddles were done by holding the striped paddle behind the control paddle and quickly moving them apart at subject’s eye level side by side (Figure 3). Unlike the TAC, the tester began by presenting the paddle near the subject’s expected acuity and increased the distance when 20/75 or 8cpcm was reached.
Figure 3. Testing Protocol Example for the Lea System

Testing with the TAC was performed beginning with one octave interval or greater above the age expected acuity, to arouse the subject’s attention (Figure 4). Testing protocol was conducted in this manner after the testers encountered subjects having difficulty understanding the test. In order to obtain the best grating acuity, bracketing was only performed on the TAC procedure. Cards were presented in descending order in one octave steps and then in half octave intervals. The cards were held at eye level and presented once if an immediate eye movement was observed by the tester and verified by the assistant. Two presentations were given when subject hesitation or uncertainty of the eye movements by the tester was noted.
Both the Teller Acuity Cards (TAC) and the Lea Grating Paddles were tested at a distance of 57 cm. There were two instances when testing was performed at 29 cm and acuities were modified accordingly for both tests. Testing with the Lea Grating Paddles required measuring beyond the 57 cm testing distance in order to acquire acuities better than 20/75. Markers were placed at the following distances: 86 cm, 114 cm, 143 cm, and 171 cm (20/25). Subjects were tested sitting on their parent’s lap facing the tester. However, exceptions were made for the 5 day-old and 3 week-old infants, who were cradled in their parents’ arms facing the tester.

Testing with the Lea Grating Paddles and the TAC were presented randomly for each subject. Monocular testing was also done in this manner with the first tested eye being randomly chosen. Blind testing was incorporated into the testing regimen for both procedures. The tester was given a card without knowing the position of the grating or the acuity being measured. Observations on whether the subject’s eye movements were
accurate was based on the observer/assistant and reinforced with the tester's judgement.

Figure 5. Monocular Testing with Pediatric Opaque Eye Patch

Standard room illumination was measured with a photopic illuminance probe at 0.913 X 100 lm/m (Tektronix J16, Beaverton, Oregon). The contrast \( \frac{L_{\text{max}} - L_{\text{min}}}{L_{\text{max}} + L_{\text{min}}} \) of gratings (between dark and light stripes) was measured with a photopic luminance probe and calculated at 83% for the Lea Grating Paddles and 41% for the TAC. Statistical analysis was done using StatView 5.0.1 for Macintosh (SAS Institute Inc., North Carolina).

Results

Two-tailed T-testing (see Appendix A) showed no significant difference \( p=0.7516 \) between the Lea and the TAC binocular acuity means for each 4-month interval age group (Group 1=0-4 months, Group 2=4-8 months, Group 3=8-12 months, Group 4=12-16 months, with one 17 month-old included). Significant difference between the Lea and the TAC, however, was seen for subject matched OD \( p=0.0436 \) and OS \( p=0.0859 \) acuity means (see Appendix A: T-test Data).
Figure 6 shows the binocular mean acuity values for the TAC and the Lea at 4-month intervals, respectively. Mean binocular acuity increased from approximately 4.0 cpd at 0-4 months to 9.3 cpd at 12-16 months of age for the TAC. Mean binocular acuity for the Lea test increased from 3.8 cpd at 0-4 months to 10.2 cpd at 12-16 months of age.

ANOVA Post hoc Shaffé testing for the TAC binocular means showed no significant difference between means of each group, except for age 0-4 months compared to age 8-12 months and age 0-4 months compared to age 12-16 months. ANOVA Post-hoc Shaffé testing for Lea binocular means showed no significant difference between means of each group, except for age 0-4 months compared to age 12-16 months. This suggests an asymptotic increase in acuity with age, leveling off starting at 4 months and older.

![Figure 6. Binocular Mean Acuity Values for TAC and Lea](image)

Figure 7 shows the mean monocular acuity values for the TAC and the Lea at 4-month intervals, respectively. Mean monocular acuity for the TAC increased from approximately 2.8 cpd at 0-4 months to 7.6 cpd at 12-16 months of age. Mean monocular
acuity for the Lea test increased from 2.7 cpd at 0-4 months to 10.4 cpd at 12-16 months of age. ANOVA with Post-hoc Shaffé testing for the TAC monocular means showed significant difference between means of each group, except for age 4-8 months compared to age 8-12 months, age 4-8 months compared to age 12-16 months and age 8-12 months compared to age 12-16 months. ANOVA with Post-hoc Shaffé testing for the Lea monocular means showed significant difference between means of each group, except for age 0-4 months compared to age 4-8 months, age 4-8 months compared to age 8-12 months and age 8-12 months compared to age 12-16 months. This suggests a sigmoidal increase in acuity with age, leveling off between 4-12 months of age.

Figure 7. Monocular Mean Acuity Values for TAC and Lea

Scattergrams for the TAC and the Lea binocular and monocular acuity means at 4-month age intervals are shown in Figures 8 and 9 respectively. Strong correlation was found ($r = 0.993$ for binocular, $r = 0.991$ for monocular) between each test from 0-17 months. In contrast, intra-subject correlation between the TAC and the Lea tests were low for
binocular ($r = 0.505$) and monocular ($r = 0.615$) acuity readings. Standard errors for Lea tend to be larger than those for TAC. (See Appendix B: Cell Charts)

\[
\text{Mean Lea (cpd) = -.825 + 1.151 \times \text{Mean TAC (cpd)}; \ R = .993}
\]

**Figure 8.** Scattergram for TAC and Lea Binocular Acuity Means

\[
\text{Mean Lea (cpd) = -2.821 + 1.717 \times \text{Mean TAC (cpd)}; \ R = .991}
\]

**Figure 9.** Scattergram for TAC and Lea Monocular Acuity Means
The following table gives a general overview of the observations made during the data-gathering phase for both the Lea and TAC systems.

Table 2. Subjective examiner observations for the Lea Paddles and TAC

<table>
<thead>
<tr>
<th>General Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neither the TAC nor Lea Paddles held any sustaining attention benefit for any age group tested.</td>
</tr>
<tr>
<td>Monocular testing was difficult for both tests; however, results were found more quickly and easily with the Lea Grating Paddles.</td>
</tr>
<tr>
<td>Sound and movement with Lea Paddles made it easier to gain the child’s attention to the task.</td>
</tr>
<tr>
<td>Fanning with the TAC was helpful in keeping the baby’s attention.</td>
</tr>
</tbody>
</table>

Discussion

The testers found working with the Lea System to be an easy and simple tool in assessing visual acuity for the different age groups. Unlike the TAC, the Lea Paddles are lightweight, inexpensive, and were easily portable between testing sites. With regards to the two procedures, we found that blind testing could not be accurately done with the Lea Paddles. Due to the limited number of paddles and the design of having gratings on both sides of the paddles, the tester knew which acuity was presented at all times. One of the larger concerns we had with the Lea Paddles was the issue of whether the subject was actually seeing the gratings or just noticing a darker contrast target at a further distance.

During the data gathering phase of the study, observations were noted concerning subject interest in the test, difficulties with administering the test and any concerns the testers had with either procedure. Testing was conducted in a standard pediatric clinic room; however, stimuli such as posters or hanging mobiles were distracting, and the testers
found it difficult to keep the older subjects on task. A study conducted by Kohl et al. (1986) stated that as children approach 12 months of age, they become less interested in the relatively boring grid stimulus and become more interested in the holder, the observer, the device and everything else in their field. The testers also encountered difficulties in maintaining attention with the other age groups as well. Spierer et al. (1999) found that in general, the younger the infants, the more difficult it is to attract their attention and keep them interested in the test, prolonging the duration of the test and lessening its reliability. This observation was equally noted for both procedures.

Subjects were more prone to look at the tester's eye on the Teller Acuity Cards and tester's face during the Lea Paddle presentations. This behavior was mainly seen in the 7 to 12-month age group, who have a tendency to play the "peek-a-boo" game at this stage of their development.

With regards to monocular acuity testing, patching was a universal problem with each age group and for both procedures. According to a study conducted by Atkinson et al (1982), infants were in an overall calmer state when they were not wearing a patch. Of the 35 subjects tested, monocular results could not be obtained for 12 subjects. Subjects became fussy or uncooperative once the patch was placed over their eye and the testers found that the older age groups were more likely to successfully pull the patch off on their own.

As the results indicated, Teller acuities corresponded with values from prior studies. The present study showed an increase in visual acuity with increasing age both binocularly and monocularly. In addition, mean monocular and binocular findings showed a leveling off of acuity starting at 4 months and older. Similarly, a pilot study conducted by Kohl et
al (1986) found that the PL visual acuity improves rapidly from 2 to 6 months and levels off at near 20/100 at 10 to 12 months of age. He further stated that a plateau occurs between the sixth and eighth month and similarly between the tenth and twelfth month. This trend was also found in previous FPL (Forced Preferential Looking) studies, according to Kohl et al.

Salamao and Ventura’s (1995) study on population norms for the first three years of life using the TAC further reinforces this point. The study found that a steep increase in binocular and monocular VA is observed from birth to approximately 6 months, followed by a shallow growth thereafter. Interestingly, a study using the OPL (Operant Preferential Looking) method found similar results to those mentioned previously using the FPL technique. Mayer and Dobson (1982) found that across ages, there was a tendency for acuity to increase with age. Furthermore, they stated that while no changes in acuity were found between 5 and 12 months, a steady improvement was seen from 12 to 60 months.

Objectively, it was found that like the Teller Acuity Cards the Lea Grating Paddles can be considered a useful clinical tool in assessing visual acuity. The benefit of the Lea Paddles is primarily for the clinician. The authors found it to be more convenient, especially when working with inattentive or fussy infants during monocular testing. Not only did testing move quickly and smoothly, but subjects were attentive to the sound and movement of the separating paddles.
Conclusion

To summarize, both the Lea and TAC preferential looking systems provide consistent and efficient behavioral measures of infant acuity in the clinical setting. In general, a slightly finer cpd acuity “trend” can be expected for the Lea System versus the TAC system for each age range above 4 months. Variability in acuities between the tests for each patient can be expected by the clinician; however, the testing showed that infant population means are strongly correlated between the TAC and Lea. This allows the practitioner a basis of comparison of their patient’s results to the age-expected norm.
Appendix A: T-test data

**Paired t-test between TAC (OU) and Lea (OU)**

<table>
<thead>
<tr>
<th>Hypothesized Difference = 0</th>
<th>Mean Diff.</th>
<th>DF</th>
<th>t-Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>OU-TAC (cpd), OU-Lea (cpd)</td>
<td>-.239</td>
<td>34</td>
<td>-.319</td>
<td>.7516</td>
</tr>
</tbody>
</table>

**Paired t-test between TAC (OD) and Lea (OD)**

<table>
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<th>Hypothesized Difference = 0</th>
<th>Mean Diff.</th>
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<th>t-Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAC-OD, Lea-OD</td>
<td>-1.455</td>
<td>21</td>
<td>-2.147</td>
<td>.0436</td>
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</tbody>
</table>

**Paired t-test between TAC (OS) and Lea (OS)**

<table>
<thead>
<tr>
<th>Hypothesized Difference = 0</th>
<th>Mean Diff.</th>
<th>DF</th>
<th>t-Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAC-OS, Lea-OS</td>
<td>-1.957</td>
<td>21</td>
<td>-1.802</td>
<td>.0859</td>
</tr>
</tbody>
</table>
Appendix B: Cell Charts

Binocular Cell Point Chart for TAC and Lea
Split By: Test
Error Bars: ± 1 Standard Error(s)

Monocular Cell Point Chart for TAC and Lea
Split By: Test
Error Bars: ± 1 Standard Error(s)
### Appendix C: Raw Data

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<tr>
<th>Subject</th>
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<th>1st test</th>
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<th>TAC OU</th>
<th>TAC OD</th>
<th>TAC OS</th>
<th>TAO OU (cpd)</th>
<th>TAC OD (cpd)</th>
<th>TAC OS (cpd)</th>
<th>Lea OU (cpm)</th>
<th>Lea OD</th>
<th>Lea OS</th>
<th>Lea OU (Sn)</th>
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**Legend:**
- T: TAC
- L: Lea
- NT: unable to get test result
References


7. Vistech Consultants, Inc. 1372 North Fairfield Road, Dayton, Ohio 45432. (513) 426-4822.


11. Lea Gratings™, Test Instructions for Precision Vision™ Products, Precision Vision™, La Salle.

12. Personal communication with Dr. Lea Hyvarinen, M.D. via e-mail on April 20, 1999.


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Author Biographies

M. Emily Linden was born in Hsinchu, Taiwan. She attended National Sun Yat-Sen University in Kaohsiung, Taiwan and received her B.A. in 1988. She then came to the U.S. and was awarded a M.S. from Claremont Graduate School in Claremont, California in 1991. Emily is currently a 4th-year Optometry student at Pacific University College of Optometry in Forest Grove, Oregon. Emily is a member of the Beta Sigma Kappa International Optometric Honor Society. She has participated in various Amigo vision screenings. After graduation, Emily hopes to specialize in pediatric optometry.

Jennifer Maeda was born and raised in Hilo, Hawaii. She attended Western Michigan University in Kalamazoo, Michigan and received her B.A. in Elementary Education, with minors in English and Mathematics in 1996. She is presently a 4th-year Optometry Student at Pacific University College of Optometry in Forest Grove, Oregon. Aside from her studies, Jennifer has participated in a variety of local vision screenings. Following graduation, Jennifer plans to return to Hilo to continue the family practice. She also plans to return to the educational arena to promote community awareness on the importance of vision care.

Neeru Verma was born in England and raised in Saskatchewan, Canada. She attended the University of British Columbia in Vancouver, B.C. and received her B.Sc. in Ecology and Environmental Science in 1995. She is currently a 3rd year student at Pacific University College of Optometry in Forest Grove, Oregon. Neeru is a member of the Beta Sigma Kappa International Optometric Honor Society and participates in a variety of local and international vision screenings. After graduation she hopes to practice full scope optometry in the northwest.