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Usefulness of the Lang Stereotest with an Infant Population

by

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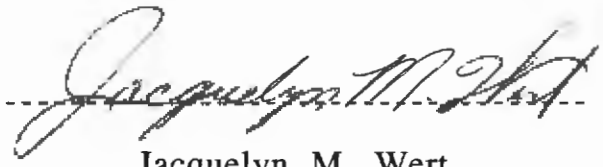
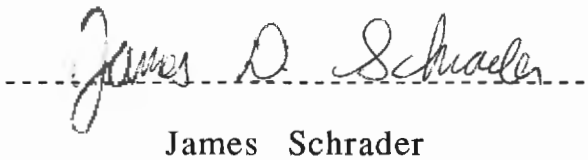


Jacquelyn M. Wert



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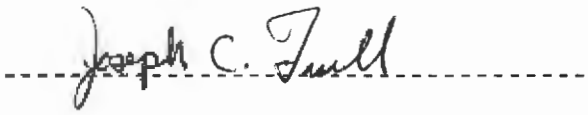

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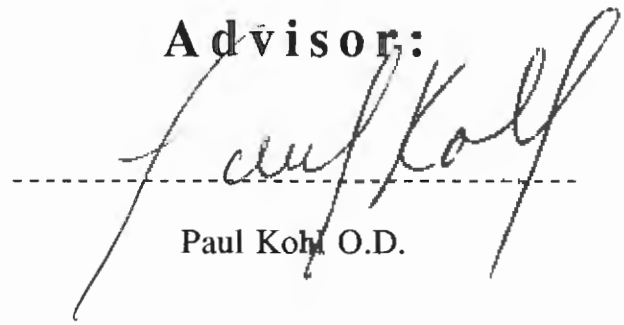

Paul Kohl O.D.

Autobiographies

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Jacquelyn attended North Dakota State University in Fargo, ND for the majority of her undergraduate studies. She received a Bachelors of Science Degree in Visual Science at Pacific University. Jacquelyn completed an internship at S.U.N.Y. and will receive her Doctor of Optometry from Pacufic University along with a Master in Education. She plans to enter private practice upon graduation with concentration on the areas of learning and reading disabilities.

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Abstract

Sixty-four healthy full term infants between 6 and 24 months of age were tested using the Lang Stereotest. A full vision examination including visual acuity assessment using the Teller acuity card preferential looking procedure, near point of convergence, Worth test for eccentric fixation, Hirschberg test, and monocular estimate method to measure accommodative posture was performed. Ocular health was also assessed to rule out pathology. Results showed that 90% of the 6.0 to 12.0 month age group, 100% of both the 12.0 to 18.0 and 18.0 to 24.0 month age groups were able to respond positively to at least one stereo image on the Lang Stereotest. Performance showed improvement with age.

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Introduction

A variety of techniques have been developed for measuring visual function in infants and young children. The primary clinical interest for these tests is to detect amblyopia, which may be associated with refractive error, strabismus, anisometropia, cataract, or nystagmus. Birch, Shimojo, and Held proposed that early detection of a visual abnormality will maximize the effectiveness of treatment.[1] Simons estimated that strabismus and/or amblyopia occurs in one of every 20 individuals.[2] It is possible to screen for amblyopia at an early age by measuring monocular visual acuities and testing for stereopsis. For normal stereopsis to occur, the optical, neural, and motor components of both eyes must be nearly equivalent and working together.

Testing visual functions with infants is not an easy task. Depending on their age, they do not talk, do not understand instructions, and do not read letters. Despite these problems, stereopsis can be measured in infants and young children. Behavioral and electrophysiological techniques have found that stereopsis usually develops between 2 and 4 months of age.[3] Fox *et al*[4] using a form of dynamic random-element stereogram, found that stereopsis emerges at 3.5 to 6 months of age. Birch, Gwiazda, and Held[5] demonstrated that infants aged 6 to 10 months were able to detect small disparities through 30 D base-in prism. This suggests that the development of accurate vergence is not the limiting factor for the development of accurate stereopsis.[5] The sensorineural

development occurring during the first 3 months of life is necessary for stereopsis to emerge. Cooper *et al* [6] studied young children using several tests of stereopsis and stated that "results indicated that stereoacuity scores improved with age and that performance variability decreased with age. Normal adult findings were achieved by age seven."

To achieve stereopsis and fine stereoacuity, one needs accuracy of oculomotor co-ordination and bi-foveal fixation. According to Banks,[7] there are sensitive periods for the development of binocularity where connections to binocular neurons are in a plastic phase and can be broken down and reformed. The sensitive period for the development of binocular vision starts a few months after birth, and peaks between 1 and 3 years of age. If binocular anomalies are not detected in this time, then treatment is more difficult and less effective. According to Ludlum;[8] however, strabismus and amblyopia can be successfully trained at any age.

Clinical tests used in examining the stereoacuity of infants includes the TNO Stereotest, the Frisby Stereotest, and the Lang Stereotest. The TNO Stereotest entails finding hidden anaglyphic shapes while wearing red/green glasses. The test includes screening plates, 3 quantitative plates and a suppression test. The TNO stereotest has a wide range of disparities and is excellent in testing the threshold of stereoacuity.

The Frisby Stereotest uses a random dot like pattern of blue triangular shapes. The 3 different test plates are square clear plastic plates varying in thickness, the thickest being 6 mm, the medium being 4 mm and finally the thinnest and most difficult being 1 mm thick. The test plates create an effect in which one of the four

squares contains an indented geometric shape. It is possible to reverse the test plate thereby causing a projected or floating image in one of the squares. The Frisby stereotest does not require filters, nor does the plate need to be presented in a specific "top" or "bottom" orientation. It is possible to vary the distance in a crude attempt to measure near threshold acuities. The thinner the plate and the greater the viewing distance the more difficult it becomes to identify the indented/projected image. The TNO Stereotest has been found to be useful with children ages 3 and above, while the Frisby Stereotest is useful with children age three and above but can be modified to be used with children as early as age one.[9]

The Lang stereotest card generates its stereo effect using cylinder gratings combined with a random dot picture showing three objects; namely a cat, a star, and a car. The Lang stereotest is easy to administer since no glasses are needed to produce the stereoscopic effect. The purpose of this study is to determine the usefulness of the Lang Stereotest with children 6 to 24 months of age.

Method

Sixty-four infants between the ages of 6 to 24 months were tested. The children were recruited from fellow optometry students, news paper advertisements, Head Start programs, and fliers placed in day care centers. Scheduling of the examinations was based on the postgestational age of the infants. The infants were separated into three age groups based on age: 6 to 12 months, 12 to 18 months, and 18 to 24 months. All testing was carried out in a single session

lasting approximately forty-five minutes per child. The following tests were administered to each infant.

Near Point of Convergence

The child was seated on the parents lap. The Lang fixation cube, provided with the card, was shown to acquaint the child with the characters on the Lang Stereotest. When the child gained fixation on the cube, the cube was advanced toward the child's nose. The objective distance at which the child's eyes broke fixation on the cube was recorded.

Lang Stereotest

After acquainting the child with objects appearing on the cube, the Lang stereotest card was presented directly in front of the child at a test distance of 40 cm. creating disparities of 1200" for the cat, 600" for the star, and 550" for the car.[10] The child was encouraged to fixate on the images appearing to float off the card. If old enough, the child was encouraged to point to, or touch, the images. This was viewed as a positive response. Definite fixation on an image was accepted as a positive response. For example, if the child repeatedly fixated at the same place on the card and upon turning the card vertically, the child then lost interest. When held vertically, the stereoscopic images are not perceived, therefore causing the child to lose interest. The test card was never held by the child as monocular clues could be obtained by flip-flop movements.[11]

Preferential Looking Visual Acuity

Preferential looking visual acuities using Teller preferential looking cards and the acuity card procedure was performed to assess the child's visual acuity. Monocular testing was attempted on all subjects using a Coverlet® eye patch for occlusion. When monocular testing was not possible, binocular testing was attempted. The testing distance was 38 cm resulting in Snellen equivalents for the square wave gratings of 20/400, 20/200, 20/80, 20/50, 20/30, and 20/20. Younger infants (under 1 year of age) were presented the stimulus in the "flying hold" position.[12] With older infants, the child was seated in the parent's lap, with head positioned at 38 cm and directed toward the acuity cards. The series of cards was presented starting with the 20/400 acuity. The right or left position of the acuity grating was determined by the subjective choice of the trained observer. Testing continued until the observer judged that the subject no longer fixated on the stripes.[13,14]

Worth Test for Eccentric Fixation

The Worth Test for eccentric fixation was performed to determine the angle kappa. The angle kappa of one eye was compared to the other eye. If a difference in angles existed, then eccentric fixation was suspect. The room lights were dimmed, and the patient was encouraged to monocularly fixate the transilluminator held at a distance of approximately 50 cm. With the examiner's sighting eye directly behind the light source, the position and distance of the light reflection in relation to the center of the pupil was observed and

estimated in millimeters. If the position of the light reflex was nasal, a positive angle kappa was recorded. If the light reflex was temporal, a negative angle kappa was recorded. Measurement of angle kappa was completed for both eyes at which time the two measurements were compared. They should be equal in both eyes. If not, further testing for eccentric fixation would be implemented.

Hirschberg Test

The Hirschberg test was performed to detect and/or quantify any strabismic angle. A transilluminator was directed onto both eyes of the infant and the patient was encouraged to fixate on the light held at approximately 50 cm along the midline. The examiner estimated the location of the corneal light reflections and a comparison was made between the two eyes. The position of the reflex in each eye should be approximately the same as when angle kappa was measured. If it is not the same, the difference in position of the corneal light reflex, when viewed monocularly and binocularly represents the magnitude of deviation. For each millimeter of displacement of the corneal light reflex in the deviating eye, relative to its location in the fixating eye, a deviation of 12 degrees or 22 prism diopters was used.[15]

Accommodative posture

Accommodative posture was determined using the monocular estimate method developed by Haynes.[16] Retinoscopy was performed at 40 cm. while the infant was encouraged to fixate on the

retinoscope light or on a toy held on the same plane as the retinoscope. The accommodative response was measured by briefly introducing lenses of known power in front of the fixating eye. By finding the lens that neutralized the retinoscopic motion it could be determined if the child's accommodation was leading in front, or lagging behind, the fixated target.

Ocular Health

Ophthalmoscopy was performed on all the infants. Tonometry was also attempted with all infants using the Keeler Pulsair® non-contact tonometer.

Results

All subjects were screened for eccentric fixation, strabismus, subnormal visual acuities, abnormal or unequal accommodative posture, subnormal convergence skills as well as abnormal ocular health. Two children were removed from the study, one an alternating exotrope and the other with significant abnormal general health.

Monocular visual acuities were attempted on all of the children; however, 16 of the children would not tolerate patching thus only binocular acuities were recorded for them. All visual acuities were within the normal range for their age group according to the norms provided with the Teller acuity test.[13] There was no strabismus nor eccentric fixation manifested by any subjects. Using the monocular estimate method, only one child was found to have unequal

accommodative posture between the two eyes. This child was still able to see all three of the Lang Stereotest images and was included in the results. Keeler Pulsair® non-contact tonometry was attempted on all of the children; however, it was only successful on 20 of the 64 subjects. If unsuccessful, digital tonometry was performed. All intra-ocular pressure findings were within the normal range for their age group.[17]

The responses to the Lang Stereotest were analyzed according to post-gestational age. The subjects were divided into three age groups and their responses to the Lang Stereotest were recorded. There were 20 patients (9 males and 11 females) in the 6.0 to 12.0 month age group (mean age = 8.2 months). Sixteen patients (10 males and 6 females) were in the 12.0 to 18.0 month age group (mean age = 15.9 months). The 18.0 to 24.0 month age group (mean age = 20.7 months) included 16 males and 12 females. Only the 12.0 to 18.0 month age group had a large difference between males and females (26%). Table one summarizes the age group data.

Table 1. Infant age groups.

Age range (months)	6.0-12	12-18	18-24
Mean age (months)	8.2	15.9	20.7
Number of subjects	20	16	28
number of males	9	10	16
number of females	11	6	12

The data was analyzed to determine the percentage of patients responding to one or more images on the Lang Stereotest (table 2).

Only two of the 64 patients did not respond positively to at least one of the images on the card (97% positive response). The two nonresponsive subjects were both in the 6.0 to 12.0 month age group.

Table 2. Positive response to one or more images on Lang Stereotest.

Age range	Positive responses
6.0-12.0	18/20 = 90%
12.0-18.0	16/16 = 100%
18.0-24.0	28/28 = 100%
Total	62/64 = 97%

In general, with increasing age there is an associated increase in ability to see more stereo images (table 3). In the 6.0 to 12.0 month age group, 10% of the children were unable to respond to any images on the card. Twenty-five percent (25%) responded to one image, 20% responded to two images, and the majority (45%) responded to all three images. In the 12.0 to 18.0 month age group, all subjects responded to at least one image. Thirty-one percent (31%) responded to one image only, 25% responded to two images, and 44% responded to all three images. The children in the 18.0 to 24.0 month age group demonstrated a similar response with all patients responding to at least one image. Eighteen percent (18%) responded to one image, 7% to two, and 75% to all three images. The total number of images seen was analyzed by age. Three percent (3%) of the children saw none of the images, 23% saw only one of the

images, and 16% of the children saw two of the images, while 58% saw all three stereo images.

Table 3. Response to the Lang Stereotest: Number of images seen by age as a percentage of positive responses.

	Number of Images Seen			
Age group	0	1	2	3
6.0-12.0	2/20 = 10%	5/20 = 25%	4/20 = 20%	9/20 = 45%
12.0-18.0	0/16 = 0%	5/16 = 31%	4/16 = 25%	7/16 =44%
18.0-24.0	0/28 = 0%	5/28 = 18%	2/28 = 7%	21/28 =75%
Total	2/64 = 3%	15/64 = 23%	10/64 = 16%	37/64 = 58%

Comparing the results of our study to that of Lang, Broadbent, and Shute, (table 4) we find that our results are much higher when using the criteria one out of three stereo images being seen by the child. Ninety percent (90%) of the children in the 6.0 to 12.0 month age group, and 100% of both the 12.0 to 18.0 month age group and the 18.0 to 24.0 month age group responded positively to at least one image. If a criteria for positive stereo response is set at 2 out of 3 images seen, then 65% of the 6.0 to 12.0 month age group, 69% of the 12.0 to 18.0 month age group, and 82% of the 18.0 to 24.0 month age group gave a positive response. If the most stringent criteria, 3 out of 3 images seen, is followed then 45% of the 6.0 to 12.0 month age group, 44% of the 12.0 to 18.0 month age group, and 75% of the children in the 18.0 to 24.0 month age group gave positive responses.

Table 4. Percentage of children passing the Lang stereotest: Lang,[10] Broadbent,[11] and Shute[18].

Age (months)	Lang	Broadbent	Shute	Wert, Schrader, Trull		
				1/3	2/3	3/3
6.0-12.0	42	50	39	90	65	45
12.0-18.0	75	72	74	100	69	44
Over 18.0	90	78	88	100	82	75

With respect to age and gender, responses to individual images were analyzed. Positive response to individual images varied within all age groups (table 5). In the 6.0 to 12.0 month age group, both males and females followed a logical trend (base on stereo disparity) with the cat having the highest percentage of positive responses and the car having the lowest percentage of positive responses. In the 12.0 to 18.0 month age group; however, the trend is not followed with females giving a mixed response. The car is seen 66% of the time while the star is seen only 50% of the time. For the males in the 6.0 to 12.0 month age group, the car is seen 80% of the time, followed by the cat 70%, and the star 60%. The 18.0 to 24.0 month age group follows the same pattern as the 12.0 to 18.0 month age group with females seeing the car 83% of the time, and the star 67%. For the males, the car is seen 94%, the cat 88%, and the star 81% of the time.

Table 5. Response to the Lang stereo test with respect to age and gender.

Age range	cat(1200")	star(600")	car(550")
Females:			
6.0-12.0	9/11 = 82%	8/11 = 73%	6/11 = 55%
12.0-18.0	6/6 = 100%	3/6 = 50%	4/6 = 66%
18.0-24.0	11/12 = 92%	8/12 = 67%	10/12 = 83%
Males:			
6.0-12.0	6/9 = 67%	6/9 = 67%	5/9 = 56%
12.0-18.0	7/10 = 70%	6/10 = 60%	8/10 = 80%
18.0-24.0	14/16 = 88%	13/16 = 81%	15/16 = 94%

Discussion

The results of this study indicate that the Lang stereotest is a useful test to assess stereopsis in infants 6.0 to 24.0 months of age. Previous stereo tests required the patient to wear Polaroid or red/green glasses to create the stereo affect. With infants, this can be very distracting. The Lang Stereotest does not require any glasses thus making it simple to administer with minimal distractions and easier comprehension. Since all of the children were screened for strabismus, amblyopia, and accommodative function, the results of this study can be used to indicate what can be expected from a visually healthy and normal child.

Our passing criteria required that the child see any one of the three images on the Lang Stereotest. If these results are compared with those of Lang, Broadbent, and Shute, our findings (see table 2) are much higher. This may be due to the fact that other researchers required a pointing response while we accepted fixation on the target as a positive response. Our reasoning is that it may be out of character for a child of such a young age to attempt to grasp at an image. Gross and fine motor skills involved in this movement may not yet be readily available at this age. To be certain that the child was actually fixating on the image, the examiner would turn the Lang Stereocard vertically causing the images to disappear and the child to lose fixation. This is strong evidence that the child could perceive the floating image and therefore was scored as a positive response.

One may argue that a single positive response is not positive enough proof of stereo ability. If 2 out of 3 positive responses are used as a passing criteria, then our data is closer to the findings of Lang, Broadbent, and Shute (table 4). If the more stringent 3 out of 3 criteria is used, our results are lower then those reported by Lang, Broadbent, and Shute especially for the 12.0 to 18.0 month age group. The lower data for the 12.0 to 18.0 month age group may be due to this age group being in a transitional stage of development from a visual response to a more verbal/tactile response. The 6.0 to 12.0 month age group gave a more visual response while the 18.0 to 24.0 month age group was able to give a more verbal/tactile response. The 12.0 to 18.0 month age group was more varied in the type of response given. This may be one explanation why our 12.0 to 18.0 month age group data was inconsistent with other researchers.

There may be a sexual bias for particular targets as male infants seemed to be more attracted to the car while the female infants were more attracted to the cat and neither seemed to be interested in the star until coaxed by the nursery song "Twinkle, Twinkle."

The cat was seen most frequently for all female age groups as expected. However, for the star and the car there is a mixed response. This may be related to the star and the car having only 50 seconds of arc disparity difference between the two and/or the fact that the car is much larger in area than the star and therefore may be more visually attractive to the child.

For the male age groups, the 6.0 to 12.0 month age group followed a logical trend with the cat being seen most frequently and the car being seen the least. The 12.0 to 18.0 and the 18.0 to 24.0 month age groups; however, showed the car being seen most frequently followed by the cat and star respectively. The 6.0 to 12.0 month age group showed a more logical trend (base on stereo disparity) with the highest percentage of the children seeing the image with the largest disparity, the cat, and the lowest percentage of children seeing the target with the least disparity, namely the car.

To ascertain whether the Lang Stereotest can be used to screen for strabismus or amblyopia known populations with these conditions must be tested to see if in fact they show reduced or different results from a healthy normal population such as ours. The large disparity used in the Lang Stereotest may make it easier for small angle strabismics to pass the test. Lang reported that no patients with large constant strabismus passed the test; however, patients with moderate anisometropia and intermittent exotropia

may pass the test.[19] Of 114 microtropes, 88.5% did not pass, 2.6% passed and 8.7% passed only partially. Of 23 patients with anisometropic amblyopia, 65.2% passed, 21.7% failed and 13% passed only partially.[10]

A problem with the Lang Stereotest is that all three objects are in close proximity to each other on the card making it difficult to determine if the child is actually pointing to an object or is just grabbing at the card. A possible improvement to the test would be to make a preferential looking test using the same cylinder grating principle but with decreasing stereo demands in a forced choice method. Thus one could determine the threshold of stereopsis giving valuable information about the functional ability of the visual system.

Although stereopsis may be demonstrated by some anisometropes and microtropes, a positive test of stereopsis helps rule out the presence of gross visual anomalies. A test of stereopsis, along with monocular visual acuities, is imperative in testing infants of all ages. This maximizes the probability that any abnormalities will be detected and treated as early as possible.

In terms of ease of testing and percentage testable, the Lang Stereotest is an appropriate screening tool for stereopsis in children between 6.0 and 24.0 months of age. Our conclusions from a population of healthy individuals may not be extended to individuals with poor binocularity. Further investigation to ascertain the sensitivity of the Lang Stereotest to screen for conditions which effect development of stereopsis should involve individuals that demonstrate known binocular anomalies or conditions which effect binocularity. These studies are being planned for the future.

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