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Abstract

Stereomobilization improves upon standard stereopsis measurements by utilizing temporal effects in the assessment of depth perception. Studies using optometry students have been performed to establish adult norms (Thompson and Yudcovitch, 1996 and Jahner and Moffit, 1998) and norms for jet fighter pilots (Brotherson, Rhoton, and Tipton, 1997). To create standard values for a younger population, 21 middle school students ages 10 to 12 were studied using the same protocol as the adult studies. The stereomobilization values for a disparity of 450" were not significantly different from these adult studies, but were superior in performance to the pilots studied. At 125 ms and faster, stereomobility was still operating above levels of chance or guessing.

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STEREOMOBILIZATION PERFORMANCE NORMS OF CHILDREN AGES 10 TO 12

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BIOGRAPHIES

Duc Nguyen

Duc received his Bachelor of Science degree in Biology from Georgetown University in Washington, D.C. He has been on two missions to Jamaica as a member of the volunteer eye care group Amigos. Currently a fourth year student at Pacific University, he is planning on establishing a private practice near his hometown of Annandale, Virginia specializing in functional binocular vision.

Murray Oshanyk

Murray attended the University of Alberta where he received his Bachelor of Science in Biological Sciences. He is currently a candidate for the Doctor of Optometry and Masters of Education in Visual Function and Learning degrees. Murray plans on returning to Canada to begin his career.

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ABSTRACT

Stereomobilization improves upon standard stereopsis measurements by utilizing temporal effects in the assessment of depth perception. Studies using optometry students have been performed to establish adult norms (Thompson and Yudcovitch, 1996 and Jahner and Moffit, 1998) and norms for jet fighter pilots (Brotherson, Rhoton, and Tipton, 1997). To create standard values for a younger population, 21 middle school students ages 10 to 12 were studied using the same protocol as the adult studies. The stereomobilization values for a disparity of 450" were not significantly different from these adult studies, but were superior in performance to the pilots studied. At 125 ms and faster, stereomobility was still operating above levels of chance or guessing.

Key Words

children, disparity, fusion, stereoacuity, stereomobilization, stereomobility, stereopsis

INTRODUCTION

Binocular function plays an important role in the schooling of today's youth. Grade schools rely heavily on visual information to teach children the foundations for higher learning. The concepts of the English alphabet and mathematics are taught at an early age. Kids are asked to read from the chalkboard, take notes at their desk, and copy from one page to another. The visual world of a typical grade-schooler is a very dynamic one, requiring the child to shift focus and eye posture at any time.

A typical assessment during a pediatric vision examination is the measurement of a patient's stereoacuity, which is measured in arc seconds of disparity. Stereoscopic depth perception is the highest level of binocular sensory fusion and gives information into the individual's binocular status. Stereoacuity, though, like Snellen acuity, is only a static measurement of the visual function of the patient. Static measurements in the exam lane give limited information to the dynamic world of most patients.

Under dynamic conditions, a person only has a limited amount of time to assess stereo-information. This amount of time is called stereomobilization. Stereomobilization not only measures whether a person is able to perceive depth, but also measures how quickly a person can fuse to perceive depth. Stereomobilization might be more useful in determining how a child uses binocular depth cues in real space and time.

Studies on stereomobilization thus far have focused on the adult population. There have been two normative studies on adults (Thompson and Yudcovitch, 1996 and Jahner and Moffit, 1998), a study using jet fighter pilots (Brotherson, Rhoton, and Tipton, 1997), and a study of anisometropic effects on stereomobilization (Chretien and Lindberg, 1997). No studies have as yet been performed on children.

With the limitations of stereoacuity testing, it would be ideal to make stereomobilization measurements a regular part of all pediatric exams. For this to be possible, norms must first be established. This pilot study will help establish these statistics of normalcy by probing the ability of children 10 to 12 years of age. In addition, it is hypothesized that the stereomobilization performance norms of children will be comparable to the norms of adults. Since it was found by Thompson et al (1996) that the values for a disparity of 450" from a normal population of adults differed significantly from jet fighter pilots, it is postulated that this study's subjects will be different as well.

METHODS

SUBJECTS

Subjects consisted of eight 5th grade students and thirteen 6th grade students (10 males, 11 females) ages 10 to 12 from Tom McCall Upper Elementary School in Forest Grove, Oregon. The subjects were recruited at a parent-teacher conference where the parents of each child gave written informed consent in accordance with Institutional Review Board approval. For participation in the study, each subject received a voucher for a free comprehensive vision examination at the College of Optometry, regardless of whether or not the subject made it to the testing phase of the study.

The criteria for entrance into the study consisted of 20/25 or better best-corrected Snellen acuity at 6 m, 20/20 visual acuity at 40 cm, and demonstration of at least 100 arc seconds stereoacuity on the Wirt Circle stereotest.

PROCEDURE

The stereomobilization program developed by Alan Leroy, O.D. and Paul Kohl, O.D. was used. This same program was used for all stereomobilization studies. The protocol by Thompson et al represents the backbone of this study. The program tachistoscopically presents four target rings simultaneously with one random target at a pre-programmed disparity. The rings are placed in a diamond configuration and a random number generator determines which of the four rings will give stereo information. Crossed-disparity depth is achieved by red-blue cancellation of the rings by red/blue glasses. The exposure times can be varied and a specific number of trials can be run. A fixation cross in the center of the screen helps to maintain maximum foveation and minimize eye and head movements. In this specific study, a target size of 29.9 arc minutes and a gross disparity of 450 arc seconds were used. Seven exposure times were evaluated: 1.0, 0.50, 0.25, 0.125, 0.0625, 0.031, and 0.015 seconds.

Each subject was seated one meter in front of a Macintosh 17" monitor while wearing red/blue glasses over their habitual correction (if any). Before actual testing began, each subject was familiarized with the program through a training session. This training session consisted of one trial at each of the exposure times and moved from the longest exposure duration to the shortest exposure duration. One presentation of the four rings consisted of the following sequence.

A one-second "READY" prompt told the subject to be prepared. Next, the fixation cross maintained the subjects' attention prior to flashing the rings. This lasted two seconds. A uniform pink screen then appeared for two seconds. The rings were then flashed for their predetermined exposure time followed by another two-second uniform pink screen. The selection screen, consisting of a larger display of the four rings and allowing an indefinite amount of time, now asked the subject to make a selection. Once training was complete, the computer moved on to the testing session.

The testing session consisted of ten trials at each exposure time. Ten trials of one exposure time were completed before the computer moved on to the next exposure time. This was done in the same sequence as the training session. After the completion of testing, the computer provided the results of both the training and testing sessions. These results were then transferred to a recording form.

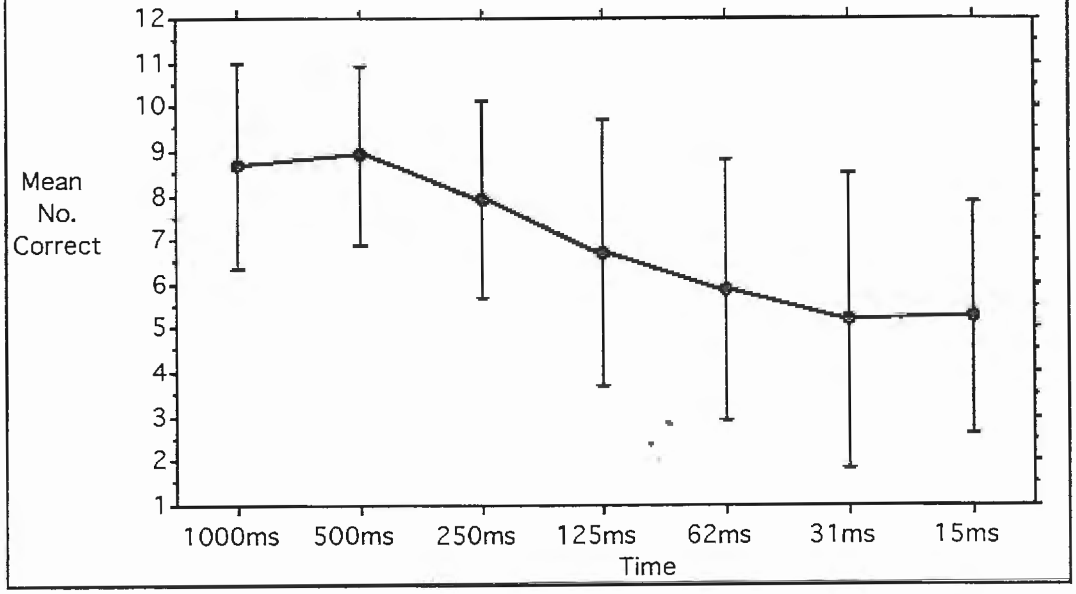
RESULTS

Table 1 shows the average correct responses and standard deviations for all 21 subjects for each exposure time. Figure 1 graphically displays these results.

Table 1: 450" stereomobilization values.

Exposure Time (ms)	Mean Number Correct +/- Std. Deviation	Percent Correct
1000	8.7 +/- 2.3	87
500	8.9 +/- 2.0	89
250	7.9 +/- 2.2	79
125	6.7 +/- 3.0	67
62.5.	5.9 +/- 2.9	59
31	5.2 +/- 3.3	52
15	5.2 +/- 2.6	52

Figure 1.Mean Number Correct for 450" Stereotarget vs Time



Analyzing the sixth-graders data summarized in Table 1 using an ANOVA (p=0.10) repeated measures with post-hoc Scheffé F-test, it is shown that statistical significance occurs when comparing 1000 ms and 500 ms ability to all stereomobilization ability at 125 ms and faster. Statistical significance is also shown when comparing 250 ms performance to 62.5 ms and faster stereomobilization abilities. There is no statistical significance when comparing 125 ms performance to abilities at 62.5 ms, 32 ms, and 15 ms, signifying a plateau in performance at about the 125 ms exposure time. Nevertheless, performance remained above the 25% level all the way down to the 15 ms exposure time signifying subjects can still perform better than chance even with 15 ms exposure of the stereo target. ANOVA results are shown in Table 2 comparing each time value to each other.

Table 2: ANOVA (post-hoc Scheffé F-test) measures of stereomobilization ability of children ages 10 to 12.

	1000ms	500ms	250ms	125ms	62.5ms	31ms	15ms
1000ms		0.04	0.405	2.658 *	5.504 *	8.426 *	8.197 *
500ms			0.697	3.346 *	6.477 *	9.62 *	9.375 *
250ms				0.988	2.924 *	5.137 *	4.959 *
125ms					0.512	1.619	1.52
62.5ms						0.31	0.267
31ms							0.002

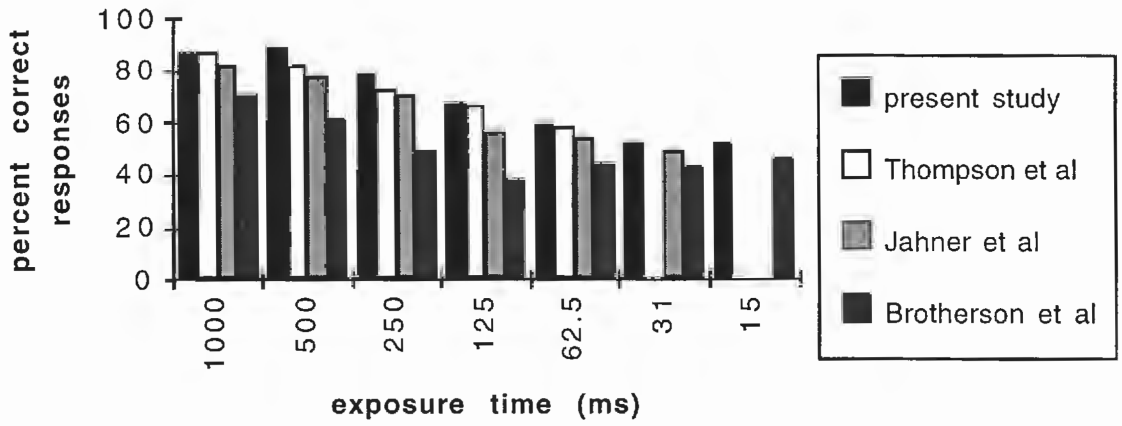
* denotes statistical significant value

Table 3 displays stereomobilization results from this study, the two previous studies utilizing adults (Thompson et al, 1996 and Jahner et al, 1998), and the one previous study with jet fighter pilots (Brotherson et al, 1997). Figure 2 shows these results in graphical form as compared to the results of this study.

Table 3: Results (mean percent correct) of all isometropic stereomobilization studies for 450" target.

	1000ms	500ms	250ms	125ms	62.5ms	31ms	15ms
present study	87	89	79	67	59	52	52
Thompson and Yudcovitch (1996)	87	82	73	66	58	no data	no data
Jahner and Moffit (1998)	82	78	71	56	54	49	no data
Brotherson, Rhoton, and Tipton (1997)	71	61	49	38	44	43	46

Figure 2: Comparison of stereomobility performance norms of all isometropic studies for 450" target disparity.



The previous study results were compared to the findings found in this study using a one group, two-tailed T-test (p=0.05) are shown in Table 4. No statistical significance was shown when comparing this study to the previous adult studies other than the 500ms value from the Moffit and Jahner study. Statistical significance was shown, however, when comparing the 1000, 500, 250,125, and 62.5 ms times to those obtained in the jet fighter pilot study.

Table 4: T-test results of children ages 10 to 12 vs. previous studies (shown in Table 3).

	1000ms	500ms	250ms	125ms	62.5ms	31ms	15ms
Thompson and Yudcovitch 1996	0.9479	0.126	0.2246	0.864	0.9299	no data	no data
Jahner and Moffit (1998)	0.3655	0.02 *	0.111	0.106	0.484	0.6945	no data
Brotherson, Rhoton and Tipton (1997)	0.005 *	0.0001 *	0.0001 *	0.0003 *	0.0342 *	0.2361	0.282

* denotes statistical significant value (p=0.05)

DISCUSSION

We can easily observe from analysis of Figure 1 that there is an almost linear performance decline from 500 ms to 31 ms, where it flattened to a steady state. Analysis of variance showed that the actual change in slope occurred statistically at 125 ms, for there was no statistical difference in performance for exposure speeds of 125 ms and faster. As mentioned earlier, even as this plateau occurred, performance was still greater than chance, which would be 25% correct for the four target multiple-choice format used in the study.

Comparison of adult stereomobility with the younger subjects used in this study satisfied our hypothesis of no performance difference between adults and 10-12 year old children. The only data point that differed from this hypothesis was that obtained in the Jahner et al study, where the 500 ms ability was significantly below that of this study. All other measures were not significantly different, however, between the two studies. It is believed that since stereopsis normally begins to develop at age 6 months, fast and efficient stereomobilization ability may also begin to develop soon thereafter. Our subjects' ages ranged from 10-12 years, much older than the age where stereopsis is still developing. Thus, results were as expected. In fact, as can be seen in Figure 2, the younger subjects performed better on average than the adult groups. The latest advances in video game technology which requires fast visual reflexes may be an explanation for this ability, in addition to the video game-like nature of the testing battery. It should be stressed that even though averages looked different, statistical analysis showed no difference between adults and children.

Interestingly, statistical differences were noted when this study was compared to the Brotherson et al study of jet fighter pilots. Only the fastest two times of 31 and 15 ms were not significantly different. The statistically non-significant result for these fast times reconfirms a leveling off in performance at the faster exposure times.

Why did the children perform better than the pilots? The previous studies with adults explained this effect to be due to the subjects used in the adult study. These subjects were optometry students, and it was believed that these subjects may have had a better understanding of what was to be expected when using 3-D testing paradigms. This explanation cannot be used when it comes to the youngsters, however, since they, like the jet pilots, probably have never seen the stereomobilization program. Since the youngsters performed on par with adults from two previous studies, it is clear that the performances found here and with the adults can be considered as the norm. It may be possible that there was glitch with the pilot study that was overlooked. Distractions such as noise, glare, and other problems that can deter concentration may have tainted the pilot's results. Another possible explanation is children's superb ability to attend to video, as mentioned earlier. Future pilot studies would provide more explanation to this phenomena of inferior performance.

Children performed at a level that is statistically comparable to adults. This study supports the fact that binocular vision is adult-like at an early age. Future studies will have to utilize larger samples and more uniform testing conditions to increase validity. It was also shown that there is no significance if the studies are performed with either five (Jahner et al) or ten (Thompson et al and the present study) trials, suggesting future studies would only have to run five trials at each exposure time. Quicker exposure times will establish a threshold level below chance and guessing. Finally, for stereomobilization to become a valid measurement to be used in optometric practice, a threshold age of ability must be established. What age does one acquire stereomobility? To answer this, future studies will have to use younger patients, possibly infants. This would obviously require a new computer program and objective oculomotor monitoring devices.

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