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Preliminary normative data for a new device to measure dynamic visual acuity

Abstract

PURPOSE: Historically, dynamic visual acuity (OVA) measurement relied on instruments that presented a moving target at a high velocity that was gradually slowed until the subject could correctly identify it (head stable, target moving). This type of testing, however, bears little resemblance to typical OVA stimuli encountered in daily life. The purpose of this project is to introduce preliminary normative data for a new device using a stationary stimulus viewed during calibrated head movements to measure OVA. This condition is much more representative of the OVA tasks encountered in everyday life.

METHODS: Fifty-four subjects aged 23-57 years were evaluated using the inVision™ system (NeuroCom® International, Inc.). The PC-based instrument presents a tumbling E stimulus when the subject achieves a given head movement velocity as monitored by a head-borne accelerometer. Subjects are instructed to move the head to and fro (as if to say "no") at differing velocities. When the target head velocity is reached, a tumbling E is presented on the computer monitor and the subject must make a forced choice regarding the orientation of the stimulus. Data were obtained for two protocols: OVA (head velocity is held constant and the stimulus size is gradually reduced) and gaze stabilization (stimulus size is held constant and head velocity is increased).

RESULTS: The inVision™ system demonstrated excellent testability, all fifty-four subjects were able to complete both test protocols. With increasing age, there appears to be a trend toward decreasing performance, but no statistical significant differences were found. Further testing involving older subjects is needed to uncover more definite trends with age. When the data were analyzed by refractive category, high myopes (>4.000) performed significantly poorer on the OVA test. There were no differences in this group based on static visual acuity, age, or type of correction.

CONCLUSION: While the inVision™ system is currently being used mostly in vestibular/ENT clinical settings, it offers intriguing potential for utilization in optometric science. Previous studies have shown that OVA performance cannot be predicted by other tests commonly used in optometric patient evaluations, and our results suggest the same. Hence, this instrument may provide a unique new assessment tool to aid the clinician in the diagnosis and management of visual conditions that cannot be quantified using static methods of visual assessment.

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PRELIMINARY NORMATIVE DATA FOR A NEW DEVICE TO MEASURE
DYNAMIC VISUAL ACUITY

By

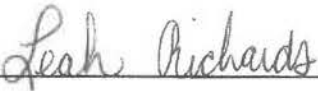
LEAH RICHARDS
SARAH OLMSCHENK

A thesis submitted to the faculty of the
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for the degree of
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Advisor:
Bradley Coffey, O.D., FAAO

PRELIMINARY NORMATIVE DATA FOR A NEW DEVICE TO MEASURE
DYNAMIC VISUAL ACUITY

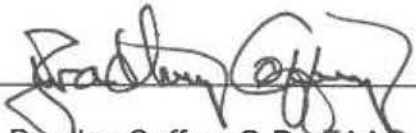
Signatures



Leah Richards, B.S.



Sarah Olmschenk, B.A.



Bradley Coffey, O.D., FAAO
Advisor

Biographies

Leah Richards, B.S.

Leah was born and raised in Seattle, Washington where she attended high school at Holy Names Academy. She was always interested in the sciences and selected a major of biology at Linfield College in McMinnville, Oregon. Leah had the opportunity to participate in a student research project during one summer while at college. In this project, she and her partner attempted to prove that suppressor T cells can be found in the spleen tissue of Syrian hamsters. After completing her Bachelor of Science degree at Linfield, she enrolled in the optometry program at Pacific University. Following graduation next spring, Leah hopes to complete a one-year residency program at a VA hospital in Washington or Oregon, then she plans to live and work in Vancouver, Washington. Leah enjoyed working on this project with Sarah and Dr. Coffey. She would like to thank her research partners as well as her friends and family for their unyielding love and support.

Sarah Olschenk, B.A.

Sarah grew up in a farming community of central Minnesota and attended high school at Melrose Area Public. She discovered early in her academic career that she was interested in optometry, thus attended University of Minnesota Moorhead to major in biology to complete the prerequisites of optometry school. While at MSUM, Sarah partook in a mentorship program that emphasized in cellular signaling, determining the signaling pathways of the sodium-hydrogen exchanger in Chinese Hamster Lung cells. Sarah was also fortunate enough to study abroad at Oxford University in Great Britain for a semester and participate in a three week exploratory course throughout China. After completing her Bachelor's degree, Sarah enrolled in the optometry program at Pacific University. She was very excited to work on this thesis project with such a wonderful partner and superb mentor. Following graduation next May, Sarah will begin her career as an optometrist, hopefully practicing somewhere in the Midwest. She would like to thank Leah, Dr. Coffey, her family and friends for allowing her to be where she is today.

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Abstract

PURPOSE: Historically, dynamic visual acuity (DVA) measurement relied on instruments that presented a moving target at a high velocity that was gradually slowed until the subject could correctly identify it (head stable, target moving). This type of testing, however, bears little resemblance to typical DVA stimuli encountered in daily life. The purpose of this project is to introduce preliminary normative data for a new device using a stationary stimulus viewed during calibrated head movements to measure DVA. This condition is much more representative of the DVA tasks encountered in everyday life.

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Acknowledgements

The authors would like to thank NeuroCom® International, Inc. for its generous support of this project through donated equipment. In particular, we would like to extend our thanks to Dr. Lew Nashner and Dr. Jon Peters for their support and constant communication.

INTRODUCTION

Dynamic visual acuity (DVA) is typically defined as the visual resolution during relative motion of either target or observer.¹ The history of DVA research can be traced back to the 1940s, and many established facts are still accepted today. These include: as target velocity increases, an observer's acuity decreases markedly; observers with identical static acuity can differ greatly in their DVA; DVA is sensitive to changes in target energy, even at levels for which static acuity has plateaued; DVA appears to be more closely related to real-world tasks (i.e. driving or flying) than are traditional visual acuity (VA) measures.² Burg, in 1966, established that DVA shows a striking age-related decline in performance, with those over forty showing a marked decline for the high target velocities.³ A significant illuminance effect was established by Long in 1990, demonstrating vastly improved performance with high illumination levels.² Considering these illuminance data, Long suggested the cause of age-related DVA loss to be optical in nature (thickening of the lens and pupillary miosis), rather than attributing the loss to neuromuscular or post-retinal changes with age. Gender seems to play no role in DVA performance.²

DVA is not currently evaluated as standard protocol in examinations of the eyes and visual system. It has been proposed that DVA should be evaluated for a variety of reasons. One area where information regarding functional DVA would be extremely useful is in the evaluation of elderly drivers. Elderly drivers have higher accident rates than all other drivers in the US (besides those 25

years of age and younger).⁴ Also, vestibulo-ocular reflex (VOR) performance.^{5,6,7,8,9,10} and indications of vestibular pathology^{11,12,13,14} can be inferred by measuring DVA. The VOR causes fast eye movement in the opposite direction of head movement for the purpose of maintaining fixation on a target of interest. In normals, the VOR helps to maintain visual acuity while fixating a stationary target during head movement. In certain disorders, however, the VOR may be compromised, leading to a dramatic decrease in visual acuity as the velocity of head movement increases. Studies have shown that in subjects with unilateral vestibular dysfunction, the decrease in DVA is much worse with ipsilesional head rotation than with contralesional rotation.¹⁵ This finding was associated with significantly decreased VOR gain with ipsilesional head rotation but normal VOR gain with contralesional rotation. The decreased VOR gain could be the primary explanation for the greater DVA loss in only one direction. This and similar studies suggest another possible application for the measurement of DVA: diagnosing and monitoring patients with unilateral vestibular dysfunction.

Pursuit tracking ability can be indirectly assessed via DVA performance.¹⁶ DVA has been found to be significantly better among athletes than their non-athletic peers.¹⁷ Better DVA can also be indicative of better rehabilitative success in patients utilizing telescopic spectacles as low-vision devices.¹⁸ For these and numerous additional purposes, the importance of DVA testing is apparent.

Some previous inadequacies in theory and protocol have prompted a new approach to DVA testing. Historical measurement methods usually used instrumentation that involved a moving target (often circular movement) with a stationary observer.¹⁹ Not only is this instrumentation no longer available, but it provided an incomplete assessment of DVA since there was no movement of the subject. For previous methods that involved movement of the subject, a disadvantage to head-on-torso rotation was the inability to maintain control and isolate head rotation (versus whole body rotation).¹⁵ Also, previous testing involved extrapolating from eye movement records to the subject's performance regarding resolution of moving targets.² Very limited testing has been done requiring subjects to move their heads, as opposed to pursuing a moving target. Other design deficiencies, cited by Demer, include: velocity and frequency characteristics of imposed head motion have been poorly controlled and often have been unmonitored; optotypes have been presented continuously, even during low or even zero head velocity periods; the variation in letter size from line to line in the optotype charts has been non-uniform, making reliability poor and acuity resolution uncertain; and measures have not been taken to prevent memorization of the contents of the charts.¹² Herdman also noted some experimental design problems, including: uncontrolled periods in which head movement slowed so that pursuits or fixations could be utilized instead of the true VOR; no computerized system has examined test reliability; no computerized system has examined the effect of age on visual acuity during head movement;

and no study has determined the sensitivity and specificity of computerized DVA in identifying subjects with vestibular deficits.¹³

With the aforementioned problems in mind, NeuroCom® International, Inc. developed a computer-based protocol for measuring DVA. The company was founded in 1984, and is headquartered in Clackamas, OR. Their *inVision*™ instrument was developed as a complement to their full line of clinical vestibular diagnostic and treatment instrumentation. The *inVision*™ device was developed in 2003 and approximately 50 units are in use around the world. NeuroCom pioneered the development of Computerized Dynamic Posturography (CDP), a testing protocol that has become a worldwide diagnostic standard for assessment of balance and postural control. Initially, CDP was developed for the purpose of evaluating the effects of space flight on vestibular function and balance control and was funded by grants from NASA. The National Institutes of Health have sponsored research using CDP to study the effects of disease on balance and mobility functions. Since CDP provides a measure of visual-vestibular interaction related to otolith function, the *inVision*™ instrument is a useful companion device since it provides information about visual-vestibular interaction related to semicircular canal function and the VOR. These instruments are used in both clinical and academic settings to study a great diversity of acute and chronic disorders. The technology developed by NeuroCom® has been used in a variety of medical disciplines including otolaryngology, neurology, geriatrics, sports medicine, and physiatry.²⁰

Measuring DVA with *inVision*[™] involves rotation of the head on the stationary torso, while fixating a stationary target. This variation of movement mimics a more natural mode of head motion commonly encountered in everyday life. With this mode of testing, other motor mechanisms in addition to the VOR can be evaluated. Using a similar computerized method to assess DVA, a significant relationship was reported between age and DVA scores with older subjects exhibiting poorer DVA.¹³ We hypothesized similar results utilizing the *inVision*[™] device.

METHODS

Fifty-four adult volunteers participated in this study, ranging in age from 23-57 years. There were 23 men and 31 women. Each volunteer gave written informed consent (See Appendix 1) to participate in the protocol as approved by the Institutional Review Board at Pacific University. All subjects filled out a personal and family health history form used for routine patient care at the Pacific University Family Vision Center in Forest Grove, OR (See Appendix 2). Questions pertained to personal and family history of diabetes, high blood pressure, heart problems, thyroid problems, cancer, glaucoma, cataracts, macular degeneration, crossed eyes, amblyopia, reading problems, or high cholesterol. The subjects also answered personal questions regarding problems with breathing, liver, stomach, kidney, sinuses, nerves, and HIV/AIDS. In addition, subjects responded negatively to a set of questions orally administered that ruled out any vestibular dysfunction, ear problems, or head injuries. Subjects were also questioned about their highest education level, current medications, any current optical prescription (type and power), preferred hand, and preferred foot.

Subjects then underwent pre-testing which included 6 meter monocular visual acuity using a logMAR chart, cover test at distance and near, ocular sighting preference, and 40 cm stereoacuity. Ocular sighting preference was determined using the following protocol: one hand was placed on top of the other, forming a small triangular window. Keeping both eyes open, the subject

was asked to fixate the examiner's right eye then raise the hands until they could view the examiner's eye through the "window". Then the subject was asked to lower the hands, fixate the examiner's left eye, and repeat the procedure. The subject was instructed to switch the orientation of the hands so that the opposite hand was on top and repeat the procedure for each of the examiner's eyes, as before. In this way, four trials for sighting preference were performed and it was noted which eye was preferred and how strongly it was preferred (50%, 75%, or 100%). Stereoacuity was determined using the Randot nearpoint stereo test (available from Bernell Corp. at www.bernell.com) with stimuli as fine as 20 sec arc. All tests were performed in the same room with ambient lighting of approximately 110 lux measured at the subject's forehead.

The *inVision*[™] instrumentation developed by NeuroCom[®] and used in this experiment is composed of a standard desktop PC with flat LCD screen, the appropriate software to run the experiments, a posturography platform, and an inertia cube (a headborne accelerometer). The instrument was specifically designed for the measurement of DVA using a stationary target with head-on-torso rotation. DVA can be measured for yaw, pitch, and roll rotation axes; only yaw rotation was investigated in this study.

Each subject first performed a modified Clinical Test of Sensory Interaction and Balance (CTSIB)^{21,22,23} to ensure adequate baseline vestibular function and balance (see Figure 1). During this test, the subject removed the shoes and attempted to stand straight and still, with arms at the sides, on a hard

surface, first with eyes open for three trials (10 seconds each) then with eyes closed for three trials (10 seconds each). This was immediately followed by the subject standing on a soft foam surface, with eyes open and then eyes closed, in the same manner as the hard surface. The purpose of administering this

Figure 1. Subject standing on the posturography platform used for CTSIB (foam pad in place).



screening test was to insure that each subject's postural sway in each of the four conditions was within normal limits. After performing this test successfully, the subject was permitted to move on to the next section.

The subject was seated on a padded non-rolling, back-supported chair at a distance of 10 feet from the computer screen. The inertia cube was placed on the subject's head and properly adjusted so that it would not slide with head movement. The subject's static visual acuity was then re-measured using the *inVision*[™] protocol involving a black tumbling E stimulus in one of four orientations: left, right, up, or down in the center of a white LCD screen. The subject made a four-alternative forced choice to identify the orientation of the

tumbling E. The program continued presenting smaller stimuli in staircase fashion until threshold was reached (3/5 incorrect).

One of two tests was performed next. The order of the two tests was assigned to each subject in an alternating fashion. One test was Dynamic Visual Acuity (DVA) and the other was the Gaze Stabilization Test (GST). For the DVA test, the subject was instructed to move the head back and forth about the yaw axis (as if saying "no") while keeping their eyes on the screen. During the practice period, a practice screen appeared that provided feedback about how fast the head was moving. The subject was encouraged to move the head in a large, sweeping motion rather than rapidly jiggling the head back and forth with a small angle of motion. The first 14 subjects tested were asked to reach a minimum head velocity of 120 deg/sec in order to elicit stimulus presentation. However, this velocity was difficult for some subjects to achieve, so the protocol was changed to require a minimum head velocity of 85 deg/sec, for the remaining 40 subjects. The actual head velocity during stimulus presentation was recorded. When the subject felt comfortable moving the head at the appropriate speed, the test began. During the test, the screen was white except for a large thin black circle in the center of the screen.

When the subject's head reached a velocity of at least 85 deg/sec, a tumbling E stimulus was presented for 75 msec in the center of the circle on the screen (see Figure 2). Immediately following the stimulus, subjects made a four-alternative forced-choice decision about the orientation of the E. The test continued with stimuli presented in a descending staircase until the subject

reached a threshold for dynamic visual acuity (3 of 5 trials incorrect). If during any trial the subject failed to reach the desired head velocity within a few

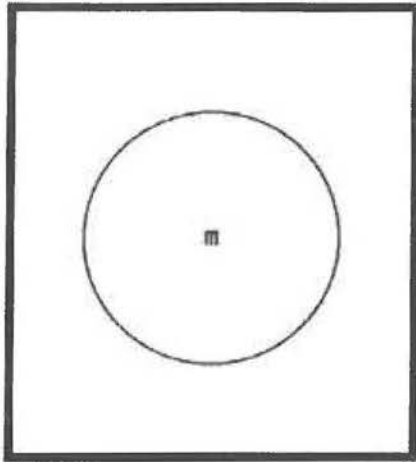


Figure 2. Cartoon portrayal of stimulus screen viewed by subjects. Diameter of circle: 9 cm for viewing distance of 10 ft.

seconds, the practice screen reappeared and the subject was instructed to again practice the appropriate head movement. The threshold acuity was recorded for rightward and leftward head movement separately in order to note any discrepancies between the two directions. The protocol yielded a DVA measure and a terminal head velocity measure for both rightward and leftward movement. Subjects' terminal head velocity (the actual head velocity when the DVA threshold was measured) was typically slightly faster than the minimum required velocity. The program also calculates "DVA Loss," the difference between the subject's static visual acuity and the threshold DVA value in each direction.

The GST was performed in a similar manner, either before or after the DVA test as assigned. However, for GST the size of the stimulus was held constant at 0.2 logMAR larger than the subject's static threshold (but never smaller than 0.0 logMAR) and the subject moved the head progressively faster to trigger the stimulus. The test began with a minimum head movement velocity of

80 deg/sec to trigger the stimulus. As the subject responded correctly, the minimum velocity was increased in steps of 10 deg/sec until threshold (3/5 incorrect) was reached. As with DVA, the instrument recorded the threshold velocity for rightward and leftward head movement separately. Results of the GST testing were presented as the threshold velocity the subject was able to reach, in deg/sec, while maintaining a visual acuity of 0.2 logMAR larger than the static acuity threshold.

After performing both the DVA and GST tests, subjects performed the modified CTSIB test again to demonstrate whether or not performing the tests had an effect, either positive or negative, on their balance or vestibular functioning. The entire testing sequence lasted about 25 minutes. The *inVision™* test protocols, CTSIB, DVA, and GST, were completed in about 10-15 minutes.

Results

Dynamic measures from *inVision*® were analyzed using one-way ANOVA for independent groups based on different categorical grouping variables. Acceptable probability was set at $p < 0.05$. The final dataset consisted of 54 subjects. Grouping categories included type of Rx (specs, CL's, none), refractive condition category (low myopia, high myopia, emmetropia), heterophoria category, preferred sighting eye, education level, and age by decade. Each category was analyzed to detect differences in left DVA, right DVA, left DVA loss, right DVA loss, left terminal head velocity during DVA, right terminal head velocity during DVA, left GST, and right GST.

Several of our tested categories showed no difference in performance in any of the above variables. Regarding gender, no differences were found between the performance of males and females. Education level also showed no differences whether the subject completed high school, bachelor's degree, or graduate level. There were no differences whether the subject completed the DVA or GST test first. Phoria at distance also showed no difference, in any degree of eso or exo phoria. No differences were found between right and left ocular sighting preference, whether the preference was 100%, 75%, or 50%. Regarding hand preference, valid analyses could not be run, due to the imbalance between right- and left-handedness; only three subjects were left-handed. Type of optical prescription (spectacles, contact lenses, or none) used was not associated with any consistent difference in the dynamic measures.

Refractive category was analyzed for three groups: emmetropes, high myopes (4 diopters or greater), and low myopes. High myopes performed significantly poorer on left DVA, right DVA, left DVA loss, and right DVA loss. These refractive categories were also analyzed for differences regarding static visual acuity, age, or type of prescription, but no significant differences were found. Therefore, the reason for high myopes performing poorer cannot be attributed to the aforementioned variables.

The dependent variables mentioned above were also analyzed for differences between the following age groups: 20s, 30s, 40s, and 50s. There were 27 subjects in the 20's decade and 9 each in the 30's, 40's, and 50's. With increasing age, there appears to be a trend toward decreasing performance, but no significant differences were found. An apparent age-related difference in DVA terminal velocity was found (see figure 3), although this result is confounded by a difference in testing protocol. Most of the older subjects were tested using a slower initial DVA velocity than were most of the younger subjects.

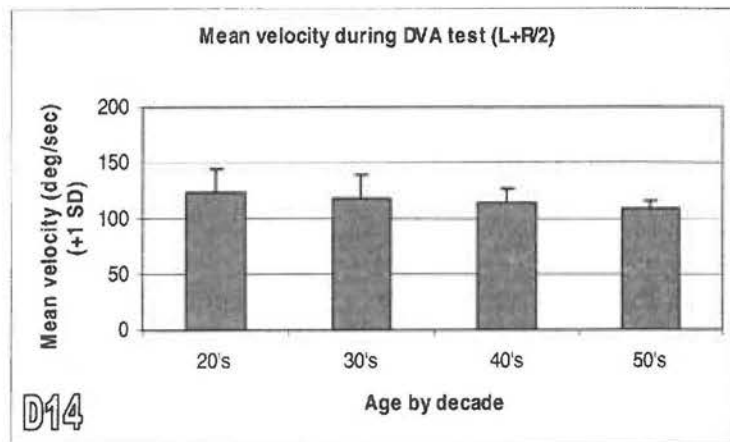


Figure 3. Average DVA terminal velocity for the four age groups, demonstrating a decrease in DVA velocity for older subjects.

Regarding GST velocity, no age-related decrease in terminal velocity was found (see figure 4).

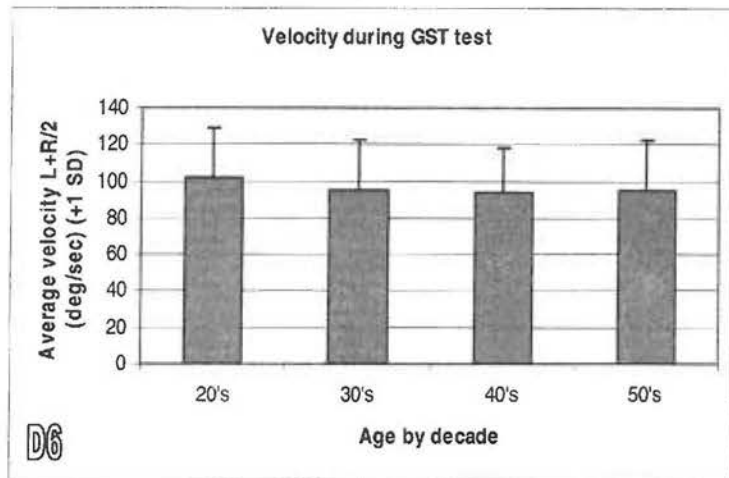


Figure 4. Average GST terminal velocity for the four age groups, demonstrating no apparent change in GST velocity for any age group.

Average DVA was also compared for each of the four age groups; no differences were found.

DVA loss, the difference between a subject's static and dynamic VA thresholds, was also analyzed between age groups and no differences were found. Average DVA loss for all groups was approximately 0.2 logMAR units. (See figure 5).

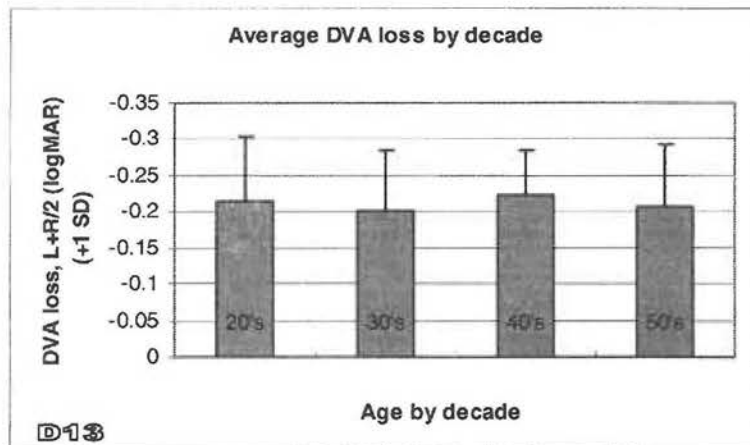


Figure 5. DVA loss by age group showing no differences by decade of age.

Data were tabulated and grouped by age (see Table 1) and refractive category (see Table 2). All variables that showed a significant difference at 95% confidence are marked with an asterisk (*).

Table 1. Variables grouped by age.

Variable	20's			30's			40's			50's		
	value	std dev	n	value	std dev	n	value	std dev	n	value	std dev	n
Var 1: SVA (logMAR)	-0.18	0.03	27	-0.14	0.13	9	-0.15	0.04	9	-0.12	0.11	9
Var 2: LFGST	104.44	32.85	27	94.44	32.05	9	92.22	22.79	9	103.33	30.41	9
Var 3: RBGST	98.14	26.89	27	96.66	25.49	9	96.66	32.01	9	87.77	25.87	9
Var 4: LFGST (logMAR)	0.01	0.03	27	0.05	0.13	9	0.04	0.04	9	0.07	0.11	9
Var 5: RBGST (logMAR)	0.01	0.03	27	0.05	0.13	9	0.04	0.04	9	0.07	0.11	9
Var 6: GST vel L+R/2	101.29	27.61	27	95.55	26.74	9	94.44	23.51	9	95.55	27.20	9
Var 7: LDVA	0.011	0.10	27	0.04	0.14	9	0.07	0.09	9	0.07	0.12	9
Var 8: RDVA	0.05	0.13	27	0.07	0.14	9	0.05	0.10	9	0.08	0.16	9
*Var 9: L Vel	123.92	23.25	27	120.33	22.58	9	116.66	15.62	9	108	8.10	9
*Var 10: R Vel	123.11	19.63	27	114	21.58	9	112.11	14.87	9	107.55	9.47	9
Var 11: Left loss	-0.19	0.09	27	-0.18	0.11	9	-0.23	0.06	9	-0.2	0.07	9
Var 12: Right loss	-0.23	0.12	27	-0.21	0.05	9	-0.21	0.07	9	-0.21	0.11	9
Var 13: L+R/2 loss	-0.21	0.09	27	-0.20	0.08	9	-0.22	0.06	9	-0.20	0.08	9
*Var 14: DVA vel L+R/2	123.85	20.80	27	117.55	22.11	9	114.66	12.64	9	108.11	7.20	9

* significant at 95%

Table 2. Variables grouped by refractive category.

Variable	Emmetropes			Low myopes			High myopes		
	value	std dev	n	value	std dev	n	value	std dev	n
Var 1: SVA (logMAR)	-0.16	0.09	21	-0.17	0.03	20	-0.13	0.10	10
*Var 7: L DVA	0.02	0.11	21	0.01	0.10	20	0.13	0.09	10
*Var 8: R DVA	0.02	0.13	21	0.03	0.10	20	0.17	0.13	10
*Var 11: Left loss	-0.18	0.08	21	-0.18	0.08	20	-0.26	0.09	10
*Var 12: Right loss	-0.18	0.09	21	-0.21	0.09	20	-0.31	0.10	10
*Var 13: L+R/2 loss	-0.18	0.07	21	-0.2	0.07	20	-0.28	0.08	10
Var 15: age	35.23	11.32	21	33.1	10.64	20	34.4	12.58	10

* Significant at 95%

*Significant at 95%

**Significant at 95% but confounded by change in protocol

DISCUSSION

The results presented here represent early findings of an ongoing study to generate normative data for the *inVision*® device. Because we continue to acquire data, especially for older subjects, any conclusion based on the current data set must be considered preliminary.

The authors looked for any differences in DVA performance based on age by decade, refractive condition, type of optical prescription worn, preferred hand, ocular sighting preference, heterophoria, education level, and gender.

The current study found no significant effect of aging on DVA, DVA terminal velocity, or DVA loss. However, previous studies have found a significant loss only for subjects over age 65.¹³ This study included subjects up to age 57. Further studies using this device are planned which will include older subjects and larger numbers of middle-aged subjects that may result in a more conclusive understanding of the relationship between age and DVA loss using the *inVision*™ device.

Our results indicate that individuals with myopia of 4.0 D or greater, regardless of type of optical prescription, demonstrate poorer DVA than do individuals with lesser myopia or emmetropia. These subjects did not differ on any other measured variable. This finding is interesting and suggests that dynamic visual acuity may be compromised associated with higher amounts of myopia. A larger sample size is necessary to establish whether this finding is repeatable.

Other laboratories using *inVision*® have reported anecdotal concerns that patients wearing progressive addition lenses (PAL's) seem to have greater difficulty with DVA and GST assessment than do patients with other types of prescription eyewear. It might be expected to find poorer DVA performance in subjects wearing PAL's due to the distortion present in the periphery of the lenses and the necessity to view the stimulus through this portion of the lens at times during head rotation. We found no difference in performance that could be attributed to PAL's, however our sample (n=7) of PAL wearers was very small. A larger sample of these subjects is needed for clarification of whether an effect of PAL's on DVA exists.

Regarding preferred hand, ocular sighting preference, heterophoria, education level, and gender, we found no differences in DVA or GST associated with these variables. Additionally, correlations between the static vision measurements (VA, refraction, phoria, stereo acuity) and the *inVision*® dynamic measures were uniformly low, suggesting that *inVision*® may be measuring aspects of visual function that have heretofore been ignored in routine visual function testing.

When comparing DVA loss for rightward versus leftward head movement, there was no significant difference between the two directions. This is an important finding to note in the current study of normal subjects because previous studies have shown a significant difference between leftward and rightward motion in DVA loss for patients with unilateral vestibular loss.^{13,15} These researchers have proposed computerized DVA assessment protocols,

similar to that used in the current study, as a possible mode of diagnosing vestibular disorders and monitoring patient progress in rehabilitation.

In addition to the potential this device holds for vestibular dysfunction patients, we believe the *inVision*® device has numerous applications in optometry as well. It has been shown that DVA cannot be predicted by other measures commonly used in the optometric test battery, such as static visual acuity,² and our results suggest that the device measures aspects of visual performance that are distinct from the static measures that are part of routine vision assessment. As such, it is possible that clinical measurement of DVA and or GST may yield insights for patients who express concern about motion-related visual function. We are also interested in the potential application of the device in high-demand visual tasks such as sport activities. We are currently testing college athletes and hope to present those data soon. It has been suggested that DVA can be trained,²⁴ hence the *inVision*® device could be used either to assist in training or to monitor improvement with training.

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Appendix 1

Pacific University
Informed Consent to Act as a Research Participant

Dynamic Visual Acuity Normative Data

Investigator(s) Contact Information

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1. Introduction & Background Information

You are invited to be in a research study of normative data for a new method of measuring dynamic visual acuity. You were selected as a possible participant because you signed up on the interest sheet. Please read this form carefully and ask any questions you may have before agreeing to be in this study. This study is being conducted by Dr. Bradley Coffey. The purpose of this study is to obtain normative data for various age groups for a new method of measuring dynamic visual acuity.

2. Procedures

If you agree to be in this study, we will ask you to do the following things: You will wear a measurement device on your head and complete three tasks: computerized posturography, gaze stabilization, and dynamic visual acuity. The first task involves attempting to stand still on both a firm surface and a foam pad, both with eyes open and with eyes closed. For the gaze stabilization test, you will sit in a chair ten feet from a computer screen wearing lightweight headgear while swinging your head back and forth horizontally. When your head is moving fast enough, a Snellen tumbling "E" will appear on the screen and you will be asked to identify the correct orientation verbally. If you identify the orientation correctly, the rate of head movement is incrementally increased until you are unable to correctly identify the stimulus of constant size. The dynamic visual acuity test consists of the same setup as the gaze stabilization test. For this test, the rate of head movement remains constant while the size of the stimulus letter is incrementally decreased until you can no longer correctly identify it. You will spend about 30-40 minutes for the testing and will not need to return.

3. Risks & Benefits

None of the procedures conducted during the dynamic visual acuity study should pose any significant risks. During head rotation, there is a small risk that you may experience symptoms of dizziness, nausea, and/or motion sickness. There is also a small risk of neck injury due to head rotation. You will be in full control of your head movement during the entire testing procedure and may report these symptoms at any time to the experimenters and/or request to discontinue the testing. If you are experiencing these symptoms, you should not drive a motor vehicle until the symptoms subside. Possible benefits include further knowledge gained about dynamic visual acuity and particularly this method of measuring it. The data from this study will be used as comparative data for NASA astronauts who have completed the same testing protocol.

4. Alternatives Advantageous to Participants

Not applicable

5. Participant Payment

You will not receive payment or compensation for your participation

6. Promise of Privacy

The records of this study will be kept private. The individual data will be kept on the computer in the research lab which remains locked at all times. If the results of this study are to be presented or published, we will not include any information that will make it possible to identify a participant. Research records will be stored securely and only researchers will have access to the records.

7. Voluntary Nature of the Study

Your decision whether or not to participate will not affect your current or future relations with Pacific University. If you decide to participate, you are free to not answer any question or withdraw at any time without prejudice or negative consequences.

8. Compensation and Medical Care

During your participation in this project you are not a Pacific University clinic patient or client, nor will you be receiving complete care as a result of your participation in this study. If you are injured during your participation in this study and it is not the fault of Pacific University, the experimenters, or any organization associated with the experiment, you should not expect to receive compensation or medical care from Pacific University, the experimenters, or any organization associated with the study.

9. Contacts and Questions

The experimenters will be happy to answer any questions you may have at any time during the course of the study. The experimenter can be reached at 503.352.2880 or by email at coffeyb@pacificu.edu. If you are not satisfied with the answers you receive, please call the Institutional Review Board Chair, Dr. Karl Citek, at (503) 352 – 2126 to discuss your questions or concerns further. Although Dr. Citek will ask your name, all complaints will be kept in confidence.

10. Statement of Consent

I have read and understand the above. All my questions have been answered. I am 18 years of age or older. I have been given a copy of this form to keep for my records.

Participant's Signature _____ Date _____

Participant's printed name _____

Investigator's Signature _____ Date _____

Appendix Z

10/98

* = parts completed by subjects VISION AND GENERAL HEALTH PRELIMINARY HISTORY FORM



* Patient Name _____

* Date _____ Date of Birth _____

Thank you for taking the time to carefully complete this form. Your answers to these questions help us to develop a clear picture of your visual and general health conditions. All of your responses are kept confidential.

REASON FOR VISIT

What is the primary reason for your visit to our clinic today? _____

I may be interested in (circle all that apply):

- | | | | |
|------------------------|--------------------------|-----------------------------|---------------------|
| Reading Glasses | Contact Lenses | Vision Therapy | Refractive Surgery |
| No-Line Bifocals | Colored Contact Lenses | Rehabilitative Vision Care | Low Vision Services |
| Computer Eyewear | Contacts for Astigmatism | Crossed Eye Treatment | Lazy Eye Treatment |
| Sunglasses | Bifocal Contacts | Nearsightedness Control | Sports Vision Care |
| Polaroid Lenses | UV Protection | Thinner-Lighter Lenses | Anti-glare Coatings |
| Sports-Related Eyewear | Lenses that Change Color | Occupational Safety Eyewear | |

EYE HEALTH AND VISION INFORMATION

Do you currently wear glasses?..... Yes No Yes, but not all the time

Do you currently wear contact lenses?..... Yes No Yes, but not all the time

Do you have vision problems using a computer?.... Yes No Yes, but not all the time

When was your last vision examination? _____ Clinic or Doctor's name? _____

Do you have (or have you ever had) any of the following eye or vision problems? (circle any or all that apply)

- | | | | | |
|----------------|-----------|----------------|-----------------------|---------------------------|
| Blurred vision | Dizziness | Eye injuries | Poor night vision | Crossed or "lazy" eye |
| Double vision | Red eyes | Eye infections | Poor depth perception | Tired or irritated eyes |
| Headaches | Dry eyes | Eye surgeries | Flashes of light | Low reading comprehension |
| | | | Motion sickness | Floater in vision |

Other eye or vision problems: _____

HOW DO YOU USE YOUR EYES?

What is your occupation (or grade level if you are a student)? _____

Please circle any of the following tasks and activities in which you participate.

- | | | | | | |
|------------|-------------|-----------|-------------|------------|----------------------------|
| Reading | Gardening | Carpentry | Tennis | Swimming | Computer use |
| Music | Driving | Logging | Skiing | Homemaking | Public speaking |
| Sewing | Office work | Golf | Fishing | Football | Hunting/Shooting |
| Television | Teaching | Welding | Bowling | Baseball | Arts and crafts |
| Sales | Mechanic | Boating | Racquetball | Basketball | Activities in the sunshine |

Other occupations, hobbies, etc.... _____

Please turn this page over and complete the other side

MEDICAL INFORMATION

Do you currently take any medications (prescription or "Over the Counter")?..... Yes No

Please list: _____

Do you have allergies to any medications?..... Yes No

Please list: _____

Do you have any other allergies?..... Yes No

Please list: _____

Are you currently pregnant or nursing?..... Yes No

When was your last medical examination? _____ Clinic or Doctor's name? _____

PERSONAL and FAMILY HISTORY

Many vision and general health problems tend to run in families. Please indicate below if you or your family members have any of the following problems.

	<u>Do you have?</u>	<u>Family member has?</u>	<u>Relationship to you?</u>
Diabetes	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____
High blood pressure	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____
Heart problems	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____
Thyroid problems	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____
Cancer	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____
Glaucoma	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____
Cataracts	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____
Macular degeneration	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____
Crossed eyes (strabismus)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____
Amblyopia (lazy eye)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____
Reading prob.(dyslexia)	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____
High cholesterol	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____
Breathing problems	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown		
Liver problems	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	Other Conditions <input type="checkbox"/> Yes <input type="checkbox"/> No	
Stomach problems	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	(Please Describe) _____	
Kidney problems	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____	
Nerve problems	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____	
Sinus problems	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____	
HIV/AIDS	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	_____	

Patient Signature _____ Date _____

Attending Doctor Signature _____ Date _____

Please turn this page over and complete the other side