



# NIH Toolbox

Assessment of Neurological and Behavioral Function

## A new portable and cost-effective tool to screen vestibular function: Dynamic Visual Acuity for the NIH Toolbox

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**NIH Blueprint**

for Neuroscience Research



Tools, Resources and Training

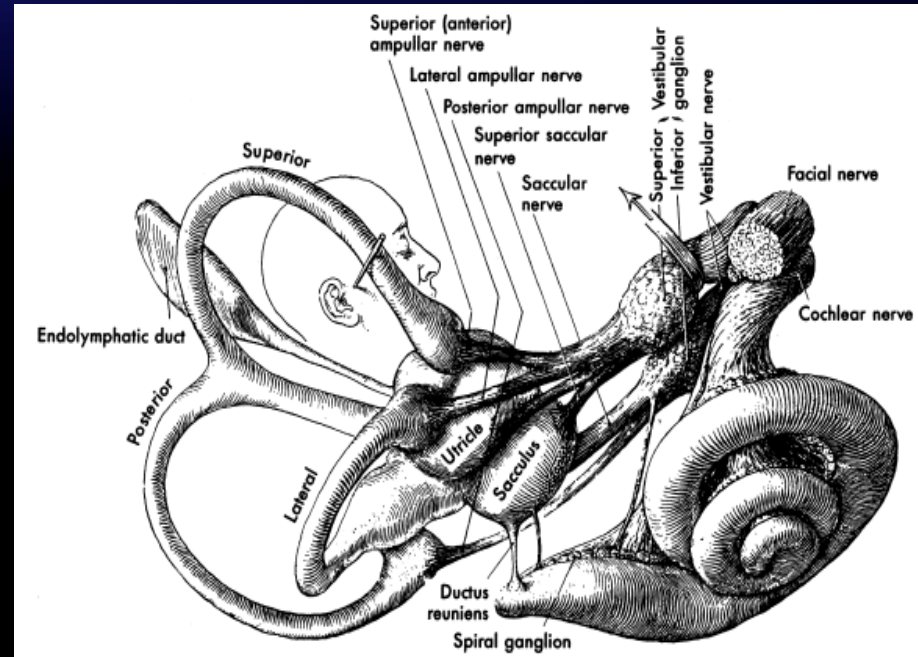
For more information, please visit [www.nihtoolbox.org](http://www.nihtoolbox.org)  
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# Normal Vestibular Function



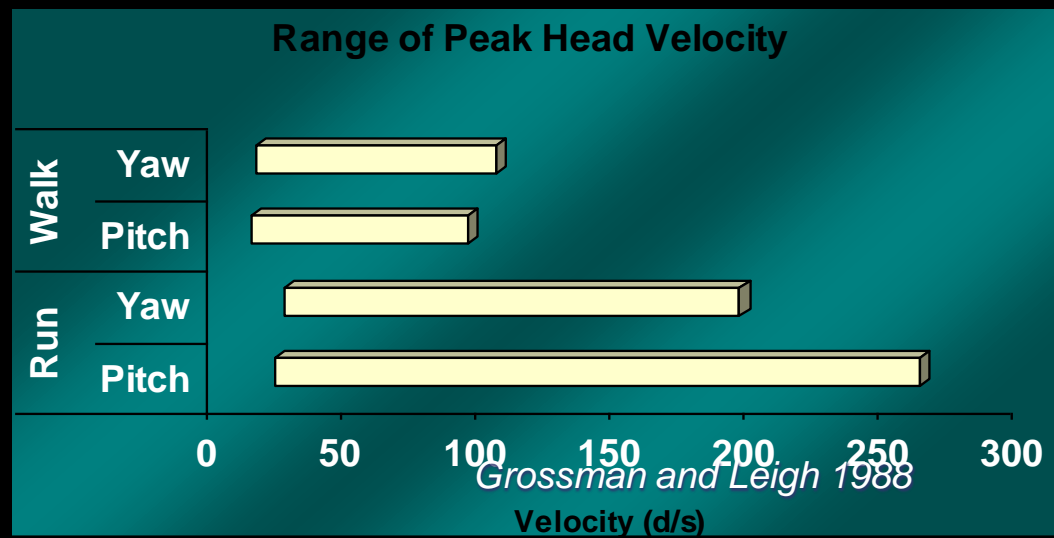
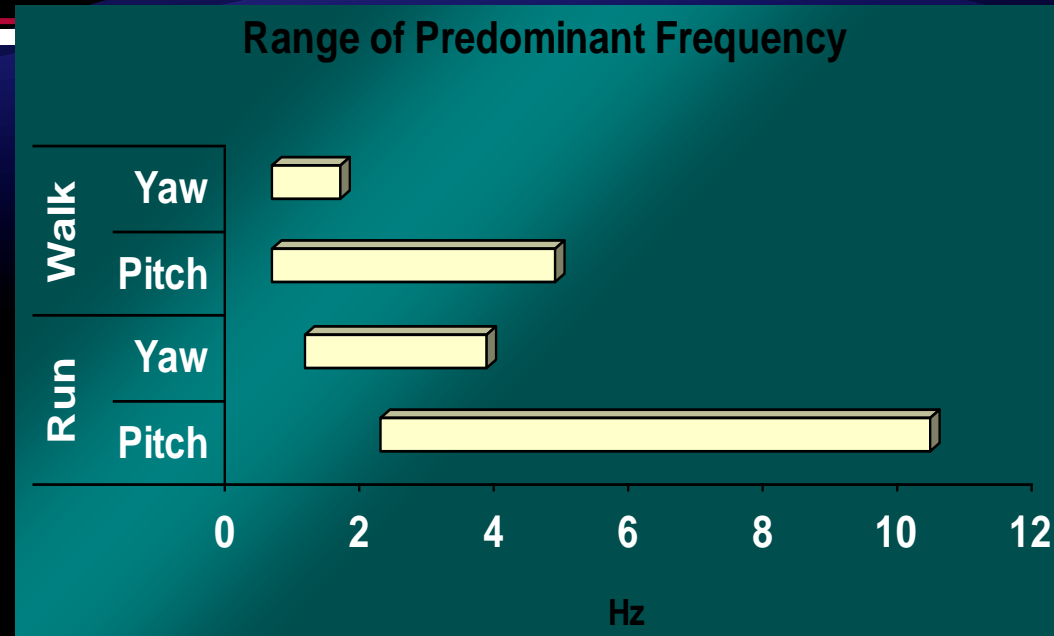
- ◆ Drive reflexes that maintain gaze and postural stability during head motion
  - ◆ Linear and angular accelerometers with output to spinal and ocular muscles



# Predominant Head Frequency and Peak Head Velocity in ADL's



- Normal activities of daily life (such as running) can have head velocities of up to  $550^\circ/s$ , head accelerations of up to  $6,000^\circ/s^2$ , and frequency content of head motion from 2 to 20 Hz

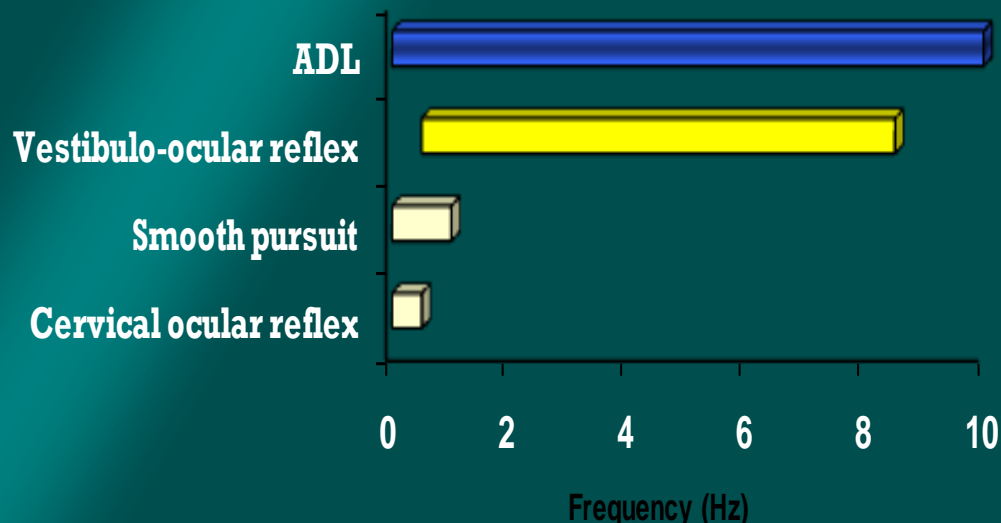


# Gaze Stability Mechanisms

## - Need for Speed



- ◆ Only the vestibular system can stabilize gaze and posture across the ADL we participate



# Introduction



## Purpose:

1. Develop an inexpensive, portable, and psychometrically sound measure of vision and 'vestibular' function
  - ♦ DVA was chosen as the tool to use for measuring vision with head still and during head motion as proxies of visual system and the vestibulo-ocular reflex
  - ♦ Current computerized DVA testing is valid and reliable, but has required professional training, costly equipment (~10K), is often not portable, can require  $\geq 25$  minutes to complete, and has no pediatric verification.

# Introduction



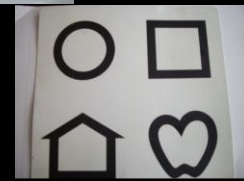
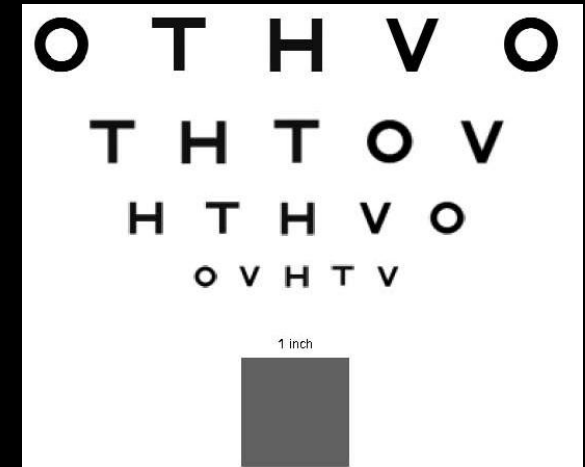
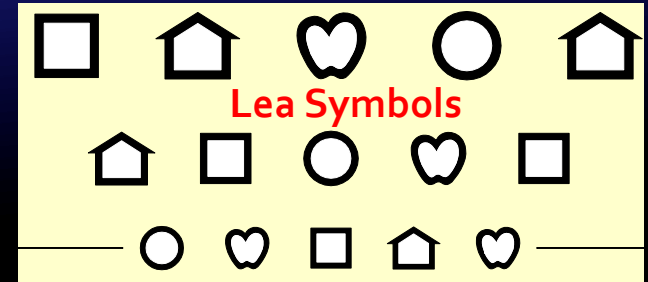
## Purpose

2. NIH required laptop and slave monitor interface
3. Determine best optotype for use in children
  - ◆ The test must be valid, reliable, inexpensive, available to pediatric and adult populations
  - ◆ Age ranges from 3-85 years

# Method

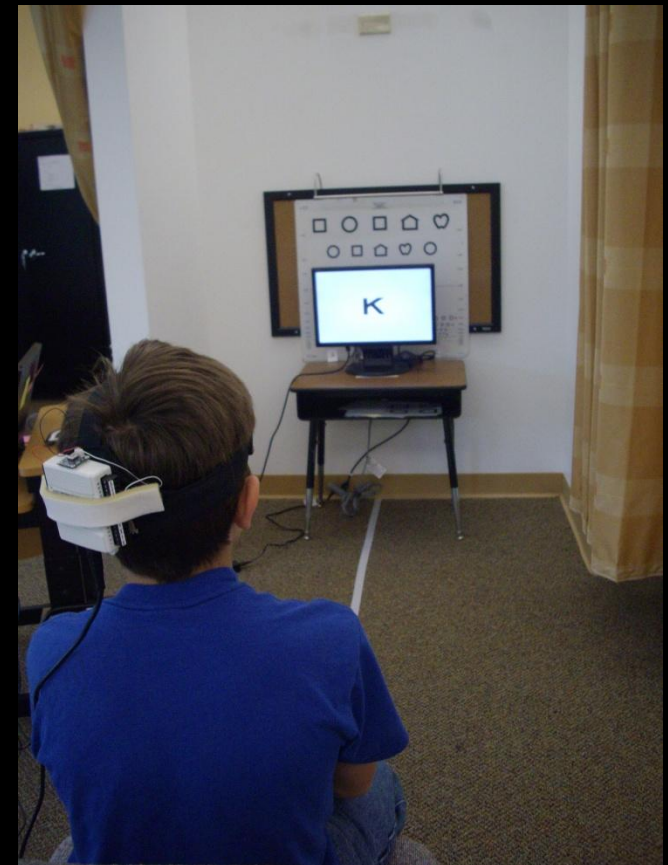
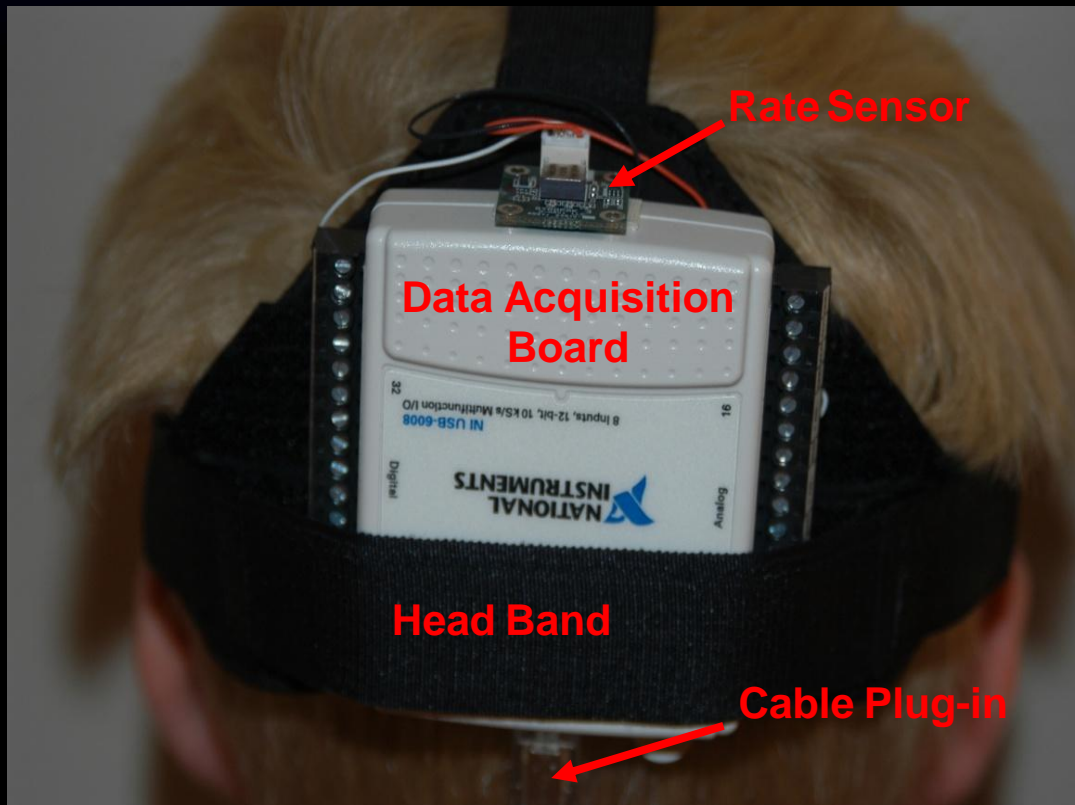


- ◆ Vision was tested by presenting computerized optotypes per acuity level of progressively smaller size
  - ◆ Lea, HOTV, ETDRS(CDHKNRSTVZO)
- ◆ Subjects then fit with headband and rate sensor allowing control for optotype presentation only at head velocities  $> 180$  d/s (same optotypes as static)

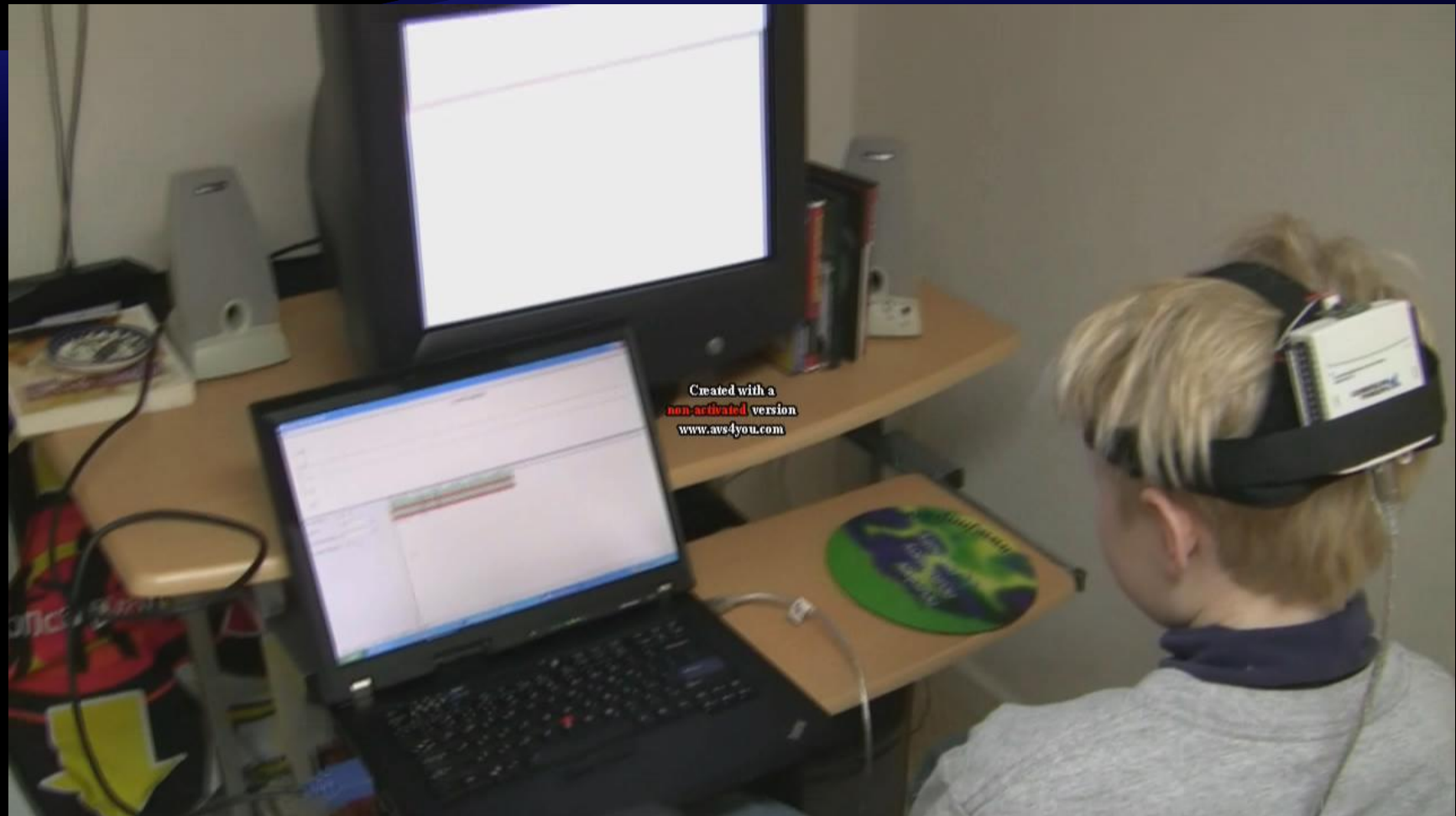


# Method and Materials

- ◆ Practice trials for adults and kids. Kids started only when practice trials were 80% accurate
- ◆ 12.5 Feet from monitor



# DVA Test



# Examiner's User Interface



## Dynamic Visual Acuity

File Tools

Character Set

Adult  HOTV  LEA

Head Direction

Left  Static  Right

Test Control

Begin Test

Response

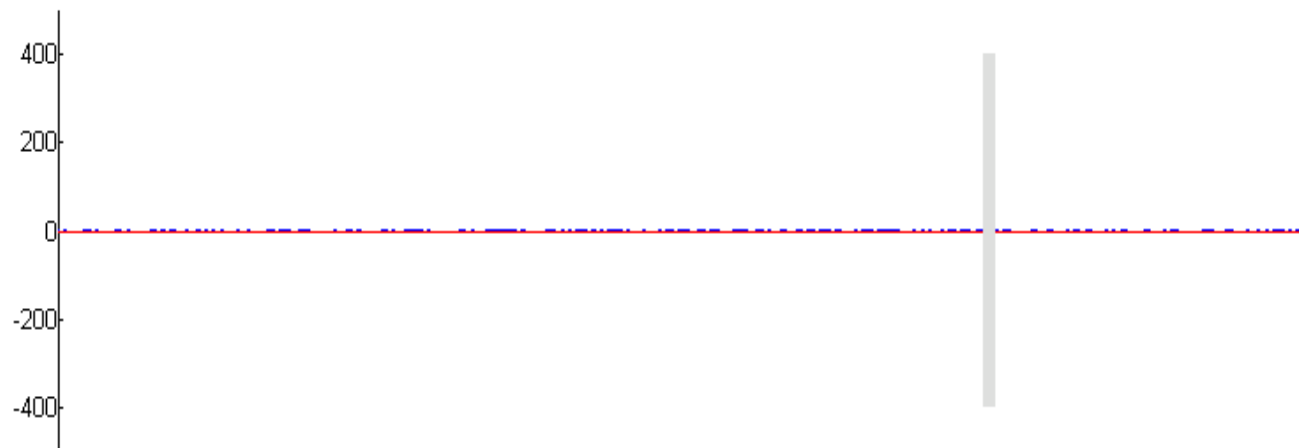
Change Last Response

Correct

No Response

H O T V

### Head Velocity



Trial Number	Size	Velocity	# Views	Optotype	Response	Phase	State
1	50	0	1	T	T	Screening	state_Start
2	40	0	1	O	O	Screening	state_DownBy1
3	32	0	1	H	-	Screening	state_DownBy1
4	40	0	1	V	V	Testing	Lg_40_5m_40_pool_5_corr_0_incor_0
5	40	0	1	H	H	Testing	Lg_40_5m_40_pool_4_corr_1_incor_0
6	40	0	1	O	O	Testing	Lg_40_5m_40_pool_3_corr_2_incor_0
7	40	0	1	H	H	Testing	Lg_40_5m_32_pool_7_corr_3_incor_0
8	40	0	1	T	-	Testing	Lg_40_5m_32_pool_6_corr_4_incor_0
9	50	0	1	O	-	Testing	Lg_50_5m_32_pool_10_corr_4_incor_1
Current Trial	64	0	1	T		Testing	Lg_64_5m_32_pool_14_corr_4_incor_2

# Scoring



- ◆ 20 acuity sizes from 20/800 down to 20/10. Test begins at 20/50 then uses adaptive software depending on response
- ◆ Static and dynamic test scored in LogMAR based on the formula:  $\text{LogMAR} = 1.7 - (0.02 \times \# \text{correct})$ .
  - ◆ DVA score = dynamic acuity – static acuity.
- ◆ Test ends when three optotypes at a given size were incorrect/missed or the subject completed the entire test.

# Statistical Analysis



- ◆ Descriptive statistics, histograms and boxplots were examined for outliers and age-related changes in scores.
- ◆ Test-retest reliability was evaluated using ICC and corresponding 95% confidence intervals.
- ◆ To aid the selection of the appropriate optotype in children, ICCs were used to describe the agreement between ETDRS, HOTV and LEA scores in children who were administered multiple optotypes.
- ◆ Criterion validity method using an existing computerized DVA test, rotary chair (peds), and ENG (adults)

# Subject Demographics



- ◆ N=299 normal subjects (no 'dizzy' complaints, screened for normal oculomotor fxn)
  - ◆ 3% Asian, 4% Black, 81% White, 9% unreported, 3% > 1 race
- ◆ N=17 pathologic subjects ('vestibular' complaints, abnormal ENG/Rotary Chair)
  - ◆ 53% White, 12% > 1 race, 36% unreported

Normal			Pathology		
Age	N	%	Age	N	%
3	21	7	3	0	0
4	35	12	4	0	0
5	21	7	5	0	0
6	22	8	6	1	6
7-12	130	43	7-12	8	46
13-17	22	7	13-17	2	12
18+	48	16	18+	6	36
	<b>299</b>	<b>100</b>		<b>17</b>	<b>100</b>

# Results - Subject Completion



Test	% Completion	
	Initial	Retest
Lea Static	73	58
Lea DVA	69	57
HOTV Static	73	58
HOTV DVA	68	56
ETDRS Static	65	56
ETDRS DVA	65	56

# RESULTS



## Reliability – Static (Vision)

- ◆ Static acuity measure reliable for adults and children (Overall ICC .94 – .95) with HOTV and ETDRS letters
  - ◆ Some reduced reliability values (ICC .31) for Lea objects at specific age groups

# Reliability



## Reliability - Dynamic Children

- ◆ **HOTV and ETDRS** dynamic acuity in children has some variability across ages (range .5 - .74).
- ◆ DVA with Lea objects (children) is less stable (.15 - .51)

## Adults

- ◆ ETDRS DVA for adults is reliable (.83 - .93)

# Validity



Compared with 'gold standard' VFT and cDVA.....

- ◆ Toolbox DVA effect sizes were moderate to very large, and significant – suggesting the Toolbox DVA is a valid measure of gaze stability and proxy of vestibular hypofunction

## Effect Sizes

ETDRS peds > 1.1

HOTV peds > .5

ETDRS Adults > 1.1

# Validity



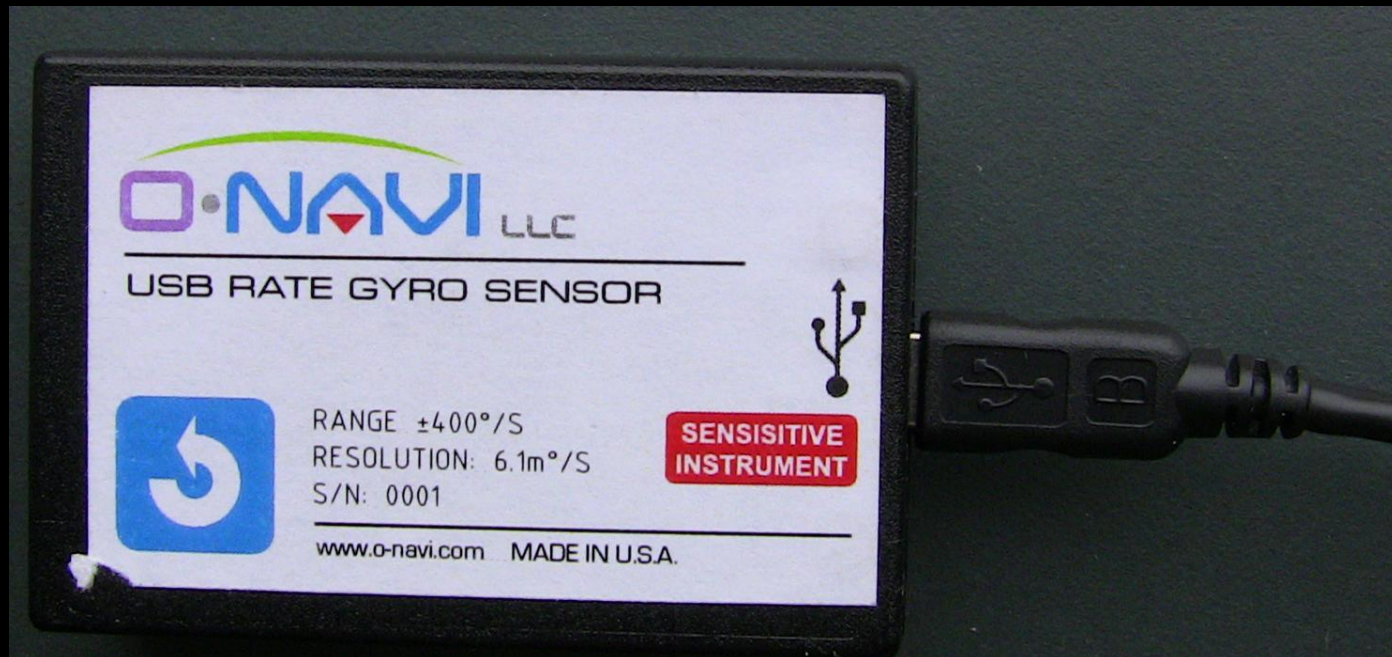
- ◆ Criterion validity comparing ETDRS eye charts with static visual acuity...
  - ◆ Moderate to good ICC
    - ◆ 7-12 y.o.                      0.81
    - ◆ 13-17 y.o.                      0.58
    - ◆ 18+ y.o                         0.62

# Results



## Operation

- ◆ Toolbox DVA will be of low cost (<\$500), require minimal training, is portable, and typically completed within 6 – 10 minutes



# CONCLUSIONS



- ◆ Data suggest the Toolbox DVA test is a reliable and valid measure of visual acuity during head still and gaze stability during head motion.
- ◆ It can identify individuals with uncompensated UVH and BVH in children and adults.
- ◆ Patients with compensated UVH (n=1) appear to display symmetrical DVA scores, as established in prior DVA studies.