

A New Portable and Cost-Effective Tool to Screen Vestibular Function: DVA for the NIH Toolbox

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Introduction

The goal of the NIH toolbox initiative is to develop a valid set of instruments that measure motor, sensory, cognitive, & emotive functions. Computerized dynamic visual acuity testing (cDVA)^{1,2} was chosen as a proxy for vestibular function. Current versions of cDVA are expensive, require expertise & have no pediatric correlate. We have attempted to develop a cDVA that is time efficient, inexpensive, portable, requires minimal training, and valid for individuals aged 3-85 years. Specific objectives - to determine the cDVA:

- Test/retest reliability
- Validity for testing visual acuity and vestibular function
- Optimal optotype (Lea, HOTV, ETDRS; Figure 1) for use with children (3-17 years)

Methods

Subjects: 318 subjects (164 female, 154 male) grouped by status and age participated (Table 1). Vestibular hypofunction (VH) was confirmed by ENG or rotational chair tests. Screening confirmed exclusion criteria were met: preexisting CNS disorder, cervical spine pathology, oculomotor impairment.

Instrumentation: IBM ThinkPad and custom software (C programming) were used to measure static acuity and cDVA. A single axis rate sensor mounted to a flexible bike-light strap detected head velocity (Figures 2 & 3). Static visual acuity was also measured using ETDRS charts mounted in a light-box (subjects aged 12 years and older).³

Data Collection

Static and cDVA:

- Acuity was measured with the head still and during sinusoidal head rotations in the yaw plane. An optotype flashed only during a left- or rightward rotation ≥ 180 deg/sec .
- Training trials were discarded, but used to control for learning effect.¹
- Young children responded verbally or by pointing, and pre-test training was done to 80% correct identification criterion.
- 100 optotypes representing acuity levels 20/10 - 20/800 were available in each optotype set. Five optotypes at each level were presented individually, progressing to smaller sizes until the subject identified all (20/10 acuity) or missed 3/5 optotypes at a particular acuity level. Scores were calculated:

$$\text{Acuity (logMAR)} = 1.7 - (.02 * \#\text{correct viewed optotypes})$$

$$\text{cDVA} = \text{dynamic acuity} - \text{static acuity}$$

- Repeat testing was done in 299 subjects.
- Children (3-12 years) were tested using multiple optotype sets with sequence of set presentation in a random block design.

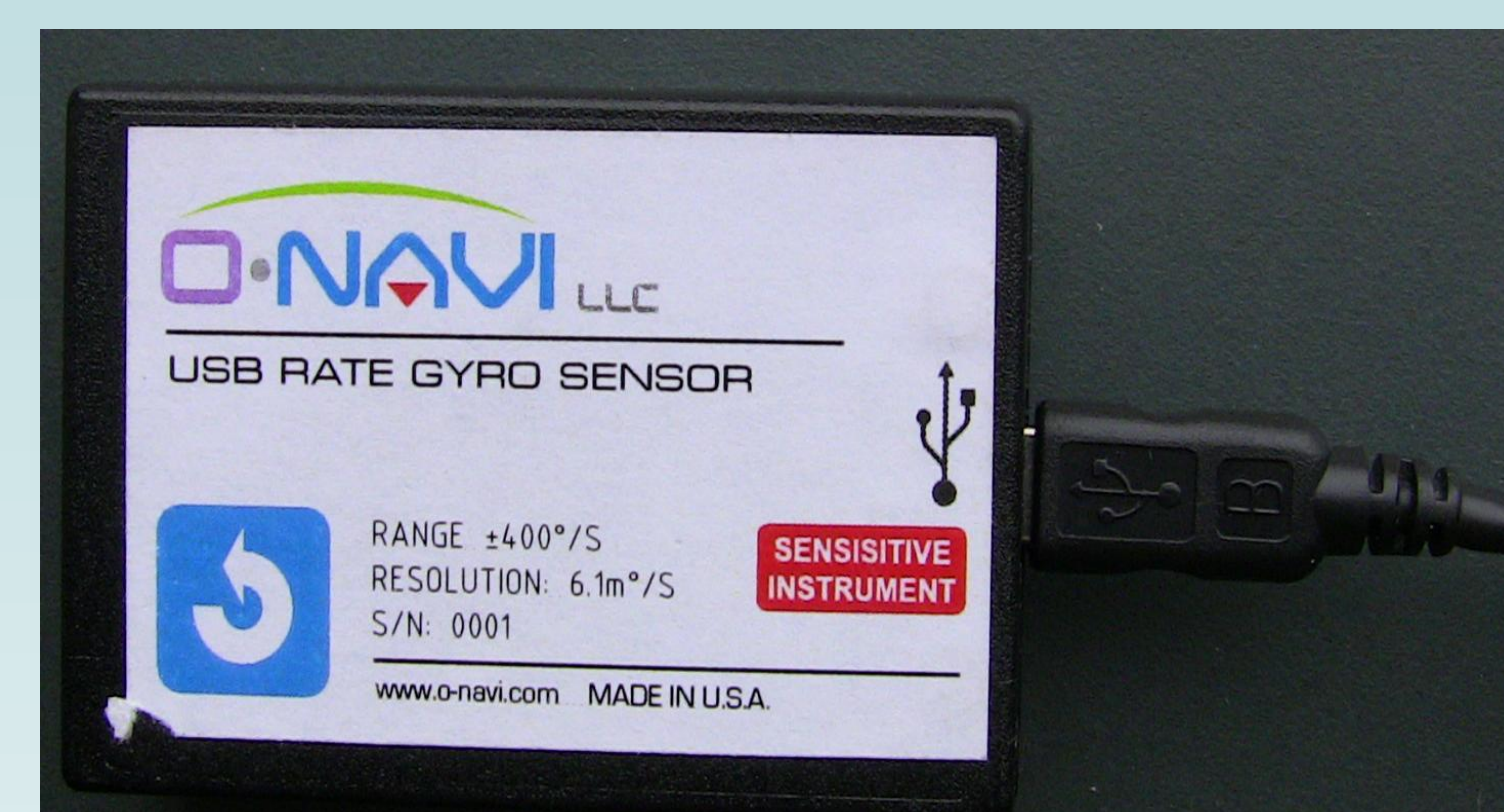
ETDRS Light Box Acuity testing:

Subjects were asked to read each letter on the chart 13 feet away, backlit with a light box. Test was complete when subject missed 3/5 or read the entire chart.³ The static acuity score was the logMAR of the line just above this.

Figure 1: Optotype sets



Figures 2 and 3



Rate sensor



Rate sensor on headband

Tables

Table 1: Subjects by Age and Status

Age	N	Status	Optotype set			
			VH	Norm	LEA	HOTV
3-7	129	3	126	+	+	-
8-12	111	6	105	+	+	+
13-17	24	2	22	-	-	+
18+	54	6	48	-	-	+

Table 2: Sensitivity & Specificity (ETDRS)

cDVA	Pathology		Total
	NO	YES	
Pass	135	4	139
fail	60	11	71
total	195	15	210

Sensitivity 73%, Specificity 69%, NPV 97%, PPV 16%

Table 3: Success Rates by Age and Optotype Set

Age:	Static		Dynamic	
	LEA	HOTV	LEA	HOTV
3 yrs	81%	76%	70%	40%
4 yrs	94%	86%	85%	50%

Results

Reliability of static acuity testing was good to excellent (ICC = .962, .955, .856 for Lea, HOTV, ETDRS respectively), and for cDVA - dependent on the optotype (ICC = .396, .748, .869 for Lea, HOTV and ETDRS respectively).

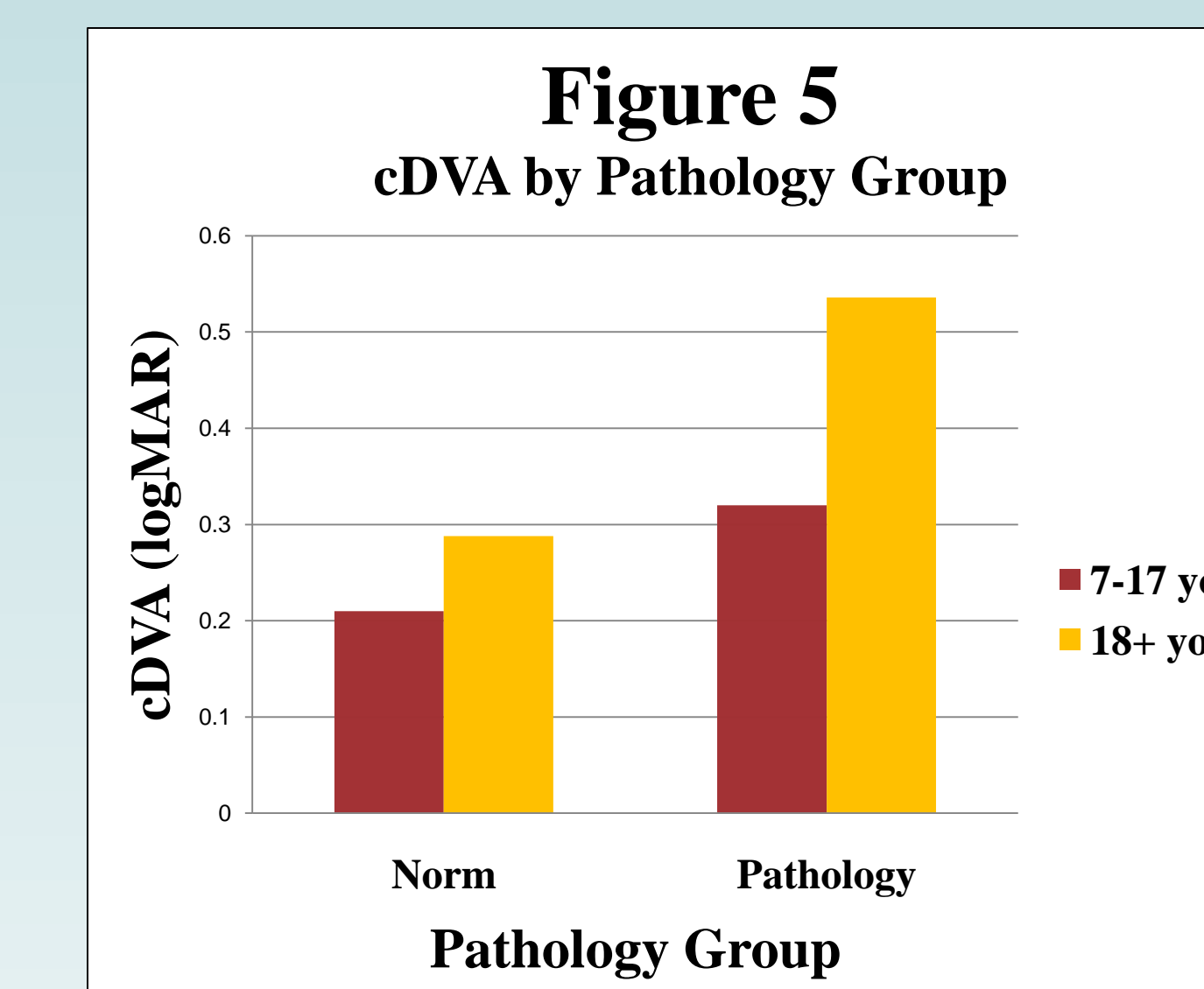
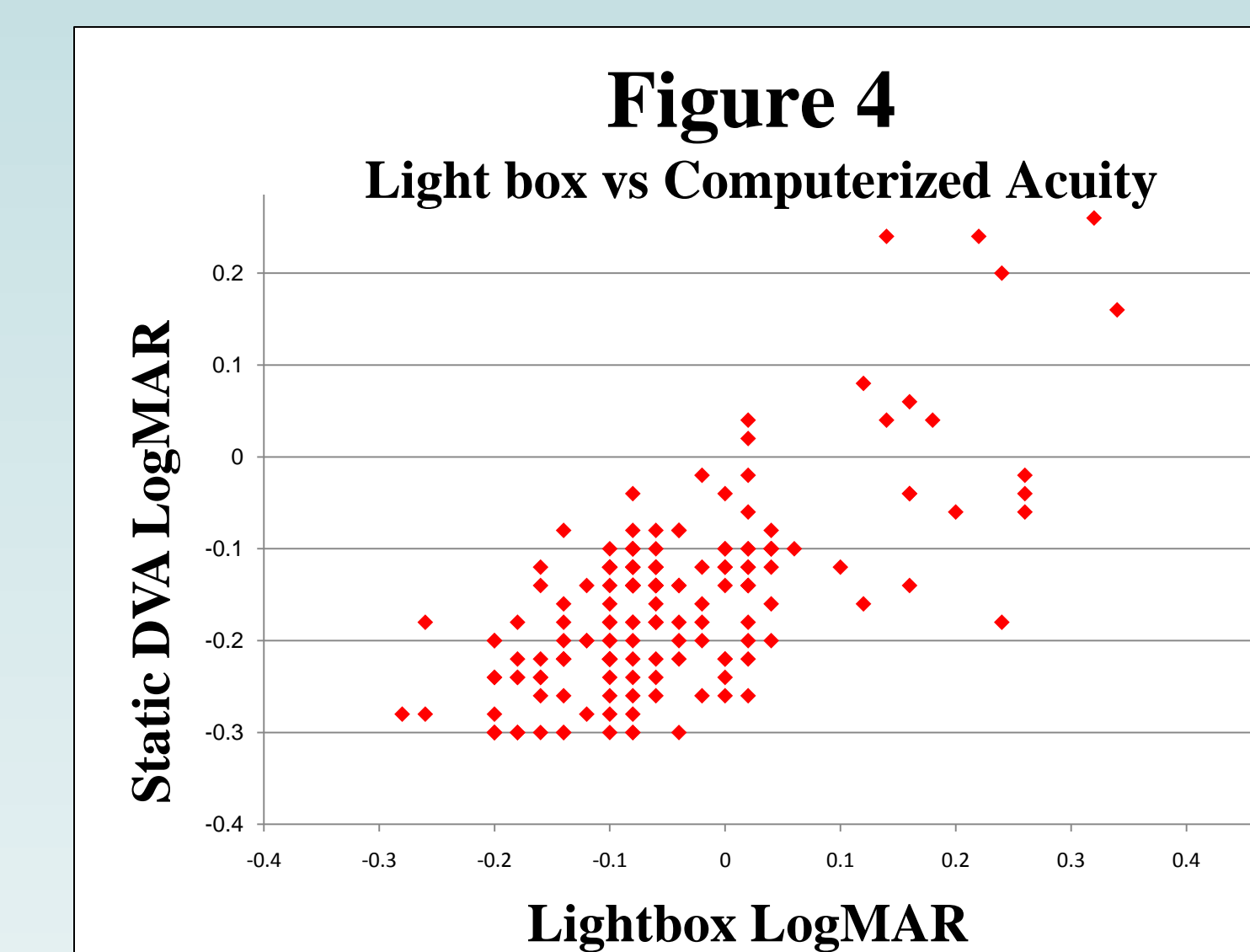
Correlation of cDVA and light box static acuity scores was excellent ($r=.795$, $p \leq 0.001$; Figure 4).

Validity : cDVA scores differed between groups, and sensitivity and specificity was fair to excellent ($p < .03$; Figure 5; Table 2).

Completion rates differed in the youngest group (Table 3).

Correlation of static acuity scores between optotype sets: Lea and HOTV moderate to excellent ($r=.58-.98$; overall $r=.88$); Lea and ETDRS fair to excellent ($r=.41 - .96$; overall $r=.92$), HOTV and ETDRS good to excellent ($r=.72 -.97$; overall $r=.93$).

Figures 4 and 5



Discussion & Conclusion

The cDVA tool created for NIH Toolbox Initiative is a valid tool for measuring static visual acuity and to screen for vestibular hypofunction. Reliability of cDVA is moderate when using the ETDRS optotype set, and fair when using Lea and HOTV sets. This might be due to minimal variation in scores (most with pathology used only ETDRS). Results presented here suggest that the ideal optotype set for children aged ≤ 6 yr is HOTV for static but Lea for cDVA. This tool will be an accurate measure of vestibular function for use with individuals three to 75 years of age. Further research is needed to establish normative data and further examine the validity of the test.

References

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