Remote Visual Field Testing: Tablets, Virtual Reality Headsets and Secure Internet Web Sites

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Disclosure: CAJ is a consultant for M&S Technologies

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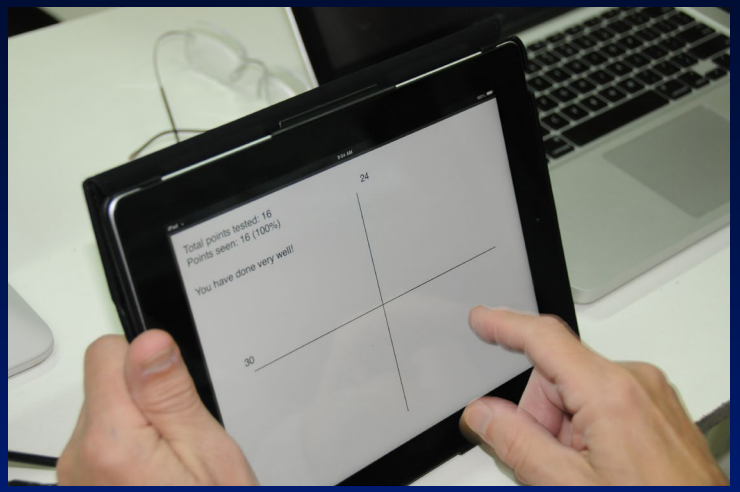
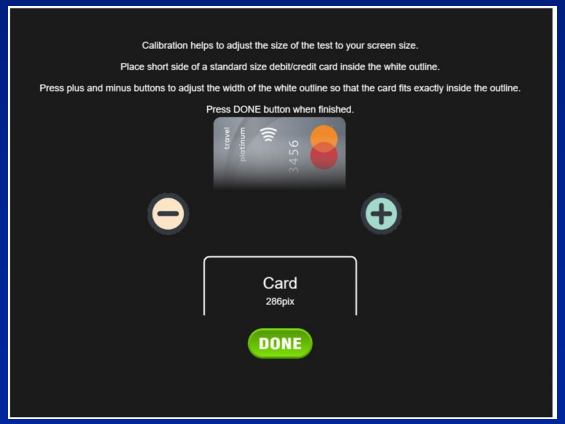
Smartphones and Tablets



Secure Internet Web Sites



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Screening for Glaucoma

- Controversial – Cost-benefit ratio is not favorable for general screening.
- However, can target "at risk" populations (persons of African descent, hispanic latinos, elderly, persons with limited or no access to traditional eye and health care)
- The purpose of this study was to perform visual field screening in Nepal using a low-cost program available on the iPad tablet and a modified tablet based test in comparison to the 24-2 SITA Standard procedure on the Humphrey Field Analyzer.

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Johnson, Thapa, Kong, Robin –
American Journal of Ophthalmology,
2017, 147-154.

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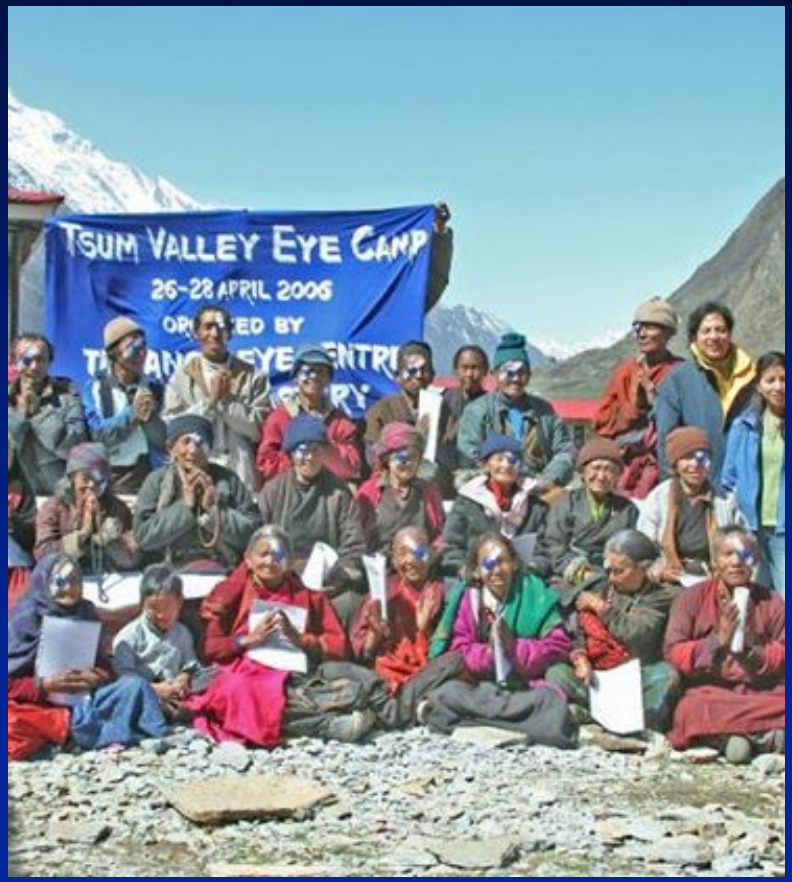
Remote Locations



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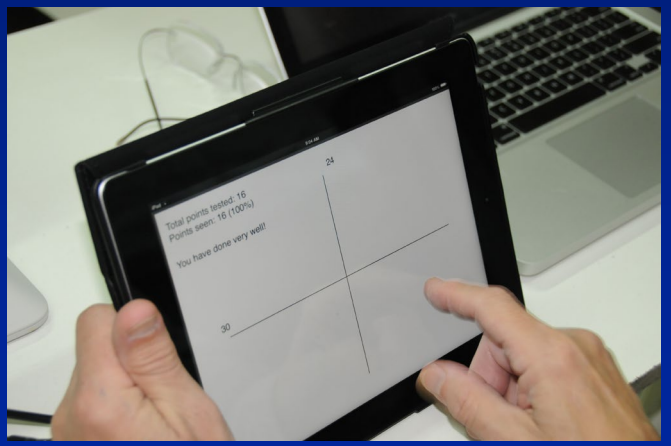
The Perimeter



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Background luminance is 31.5 asb (10 cd/m2)

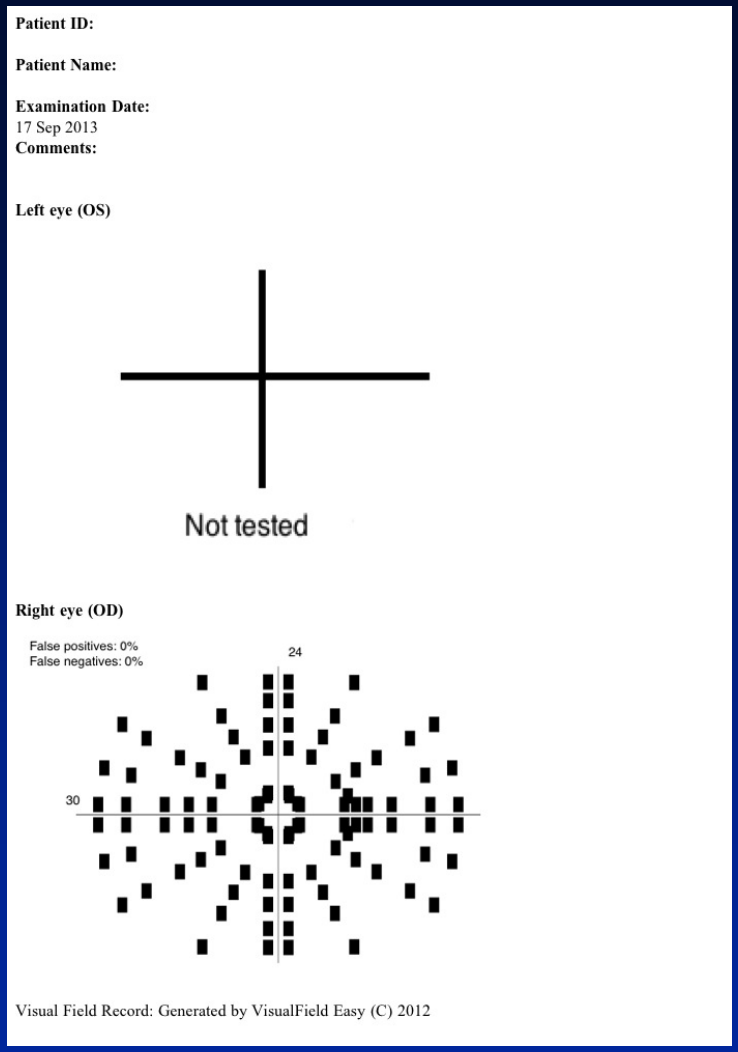
96 test locations (right eye format is shown to the right) – the left eye is a mirror image of the right eye format.

Target size is a Goldmann Size V (1.73 deg diameter)

Target luminance is 250 asb, 80 cd/m2, or 16 dB.

Each quadrant is tested one at a time (upper right, upper Left, lower left, lower right).

A red fixation point moves from one corner of the display to another.



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Participants

- Inclusion Criteria:
  - Complete Eye Exam (anterior segment biomicroscopy, ophthalmoscopy of the optic nerve head, retinal nerve fiber layer and macula, 20/60 or better visual acuity, fundus photography, no other ocular, neurologic or systemic diseases other than glaucoma or diabetic retinopathy.
- More than 400 eyes evaluated with Visual Fields Easy. Most participants also underwent Humphrey Field Analyzer 24-2 SITA Standard tests for comparison purposes.
  - 210 Normal Control Eyes, 198 with HFA results
  - 183 Glaucoma Eyes, 160 with HFA results
  - 18 Diabetic Retinopathy Eyes, 15 with HFA results

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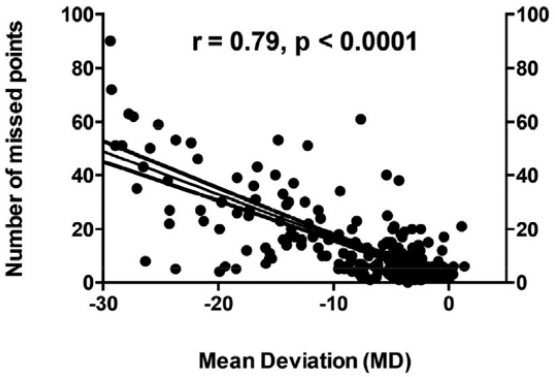
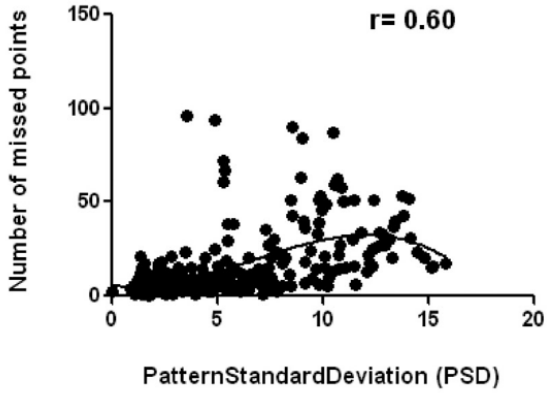
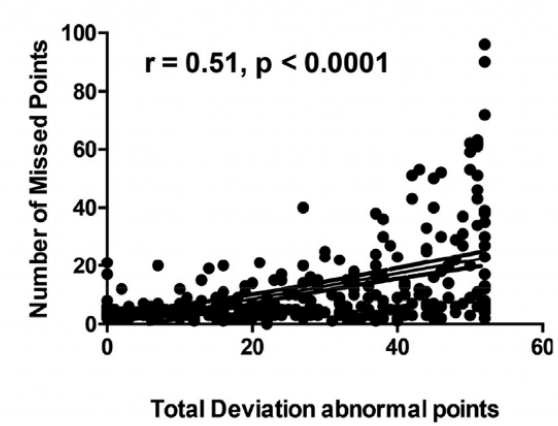
TABLE. Descriptive Statistics of Visual Field Loss Severity

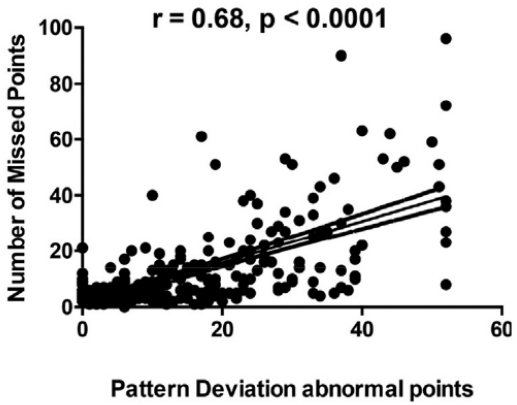
Group	Average Age (Standard Deviation, Range)	Visual Field Loss[a] (% of Cases)		
		Mild	Moderate	Advanced
Normal	42.42 (15, 18–78)	84.3%	10.1%	5.6%
Glaucoma	54.7 (14.7, 18–82)	52.3%	36.8%	21.9%
Diabetic retinopathy	54.3 (5.6, 45–64)	73.4%	20.2%	6.6%

[a]Visual field loss quantified with the Humphrey Field Analyzer SITA Standard 24-2 program. Mild: mean deviation (MD) no worse than −6 dB; moderate: MD between −6 and 0–21 dB; advanced: MD worse than −12 dB.









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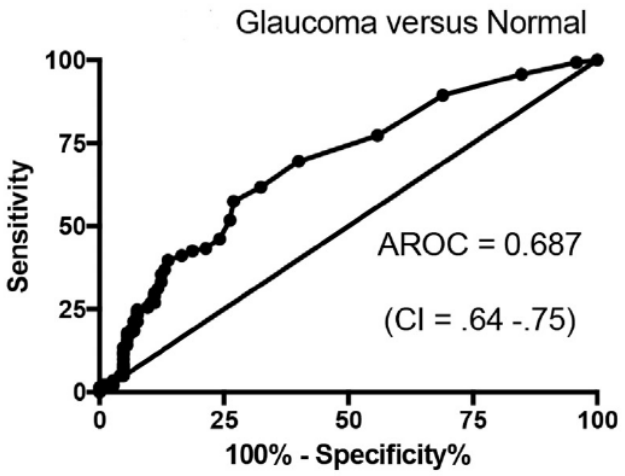

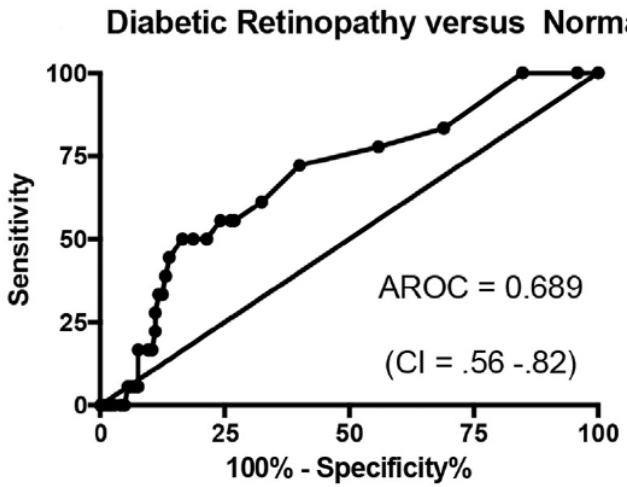

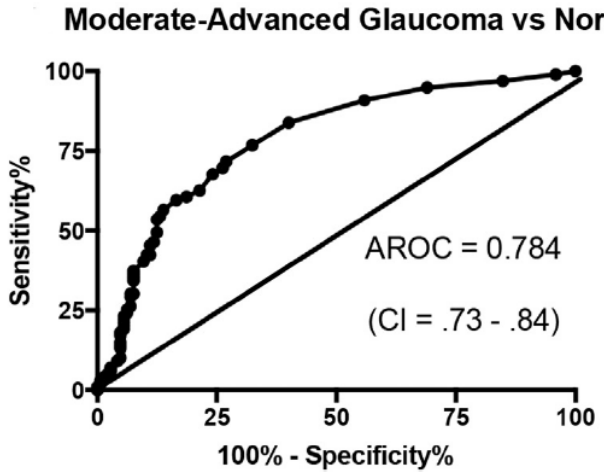

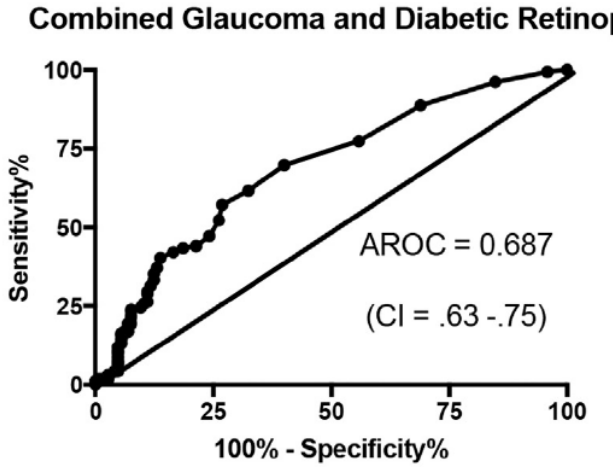

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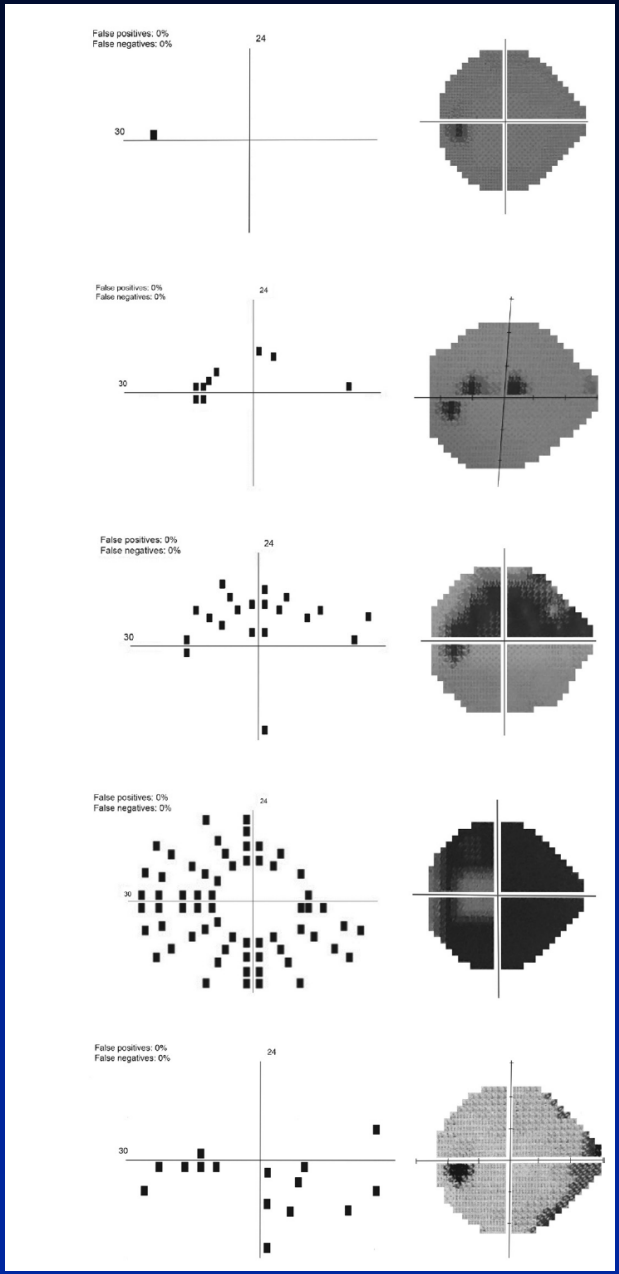

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PURPOSE

To determine the relationship between tablet-based and internet web site-based versions of the Melbourne Rapid Fields (MRF) visual field procedure and to assess the test-retest reliability of both procedures in a group of healthy participants with normal visual function. Comparison with the 24-2 SITA Standard test (Humphrey Field Analyzer) were also performed.

METHODS

- Forty healthy normal participants (33 female, 7 male; average age = 24)
- Melbourne Rapid Fields (MRF)
  - Zippy Estimation of Sequential Thresholds (ZEST, a Bayesian Test strategy)
  - Background luminance of 16 apostilbs (5 candelas per meter squared)
  - Target size increased as a function of greater eccentricities, resulting in a flat sensitivity visual field profile (a "mesa" of vision, rather than a hill of vision)
- Testing at 33 cm for tablet and internet web site. Standard distance refractive correction used for all tests.
- Microsoft Surface used for tablet testing.
- Internet web site used clinic computer (test) and participant's display system at home (retest)

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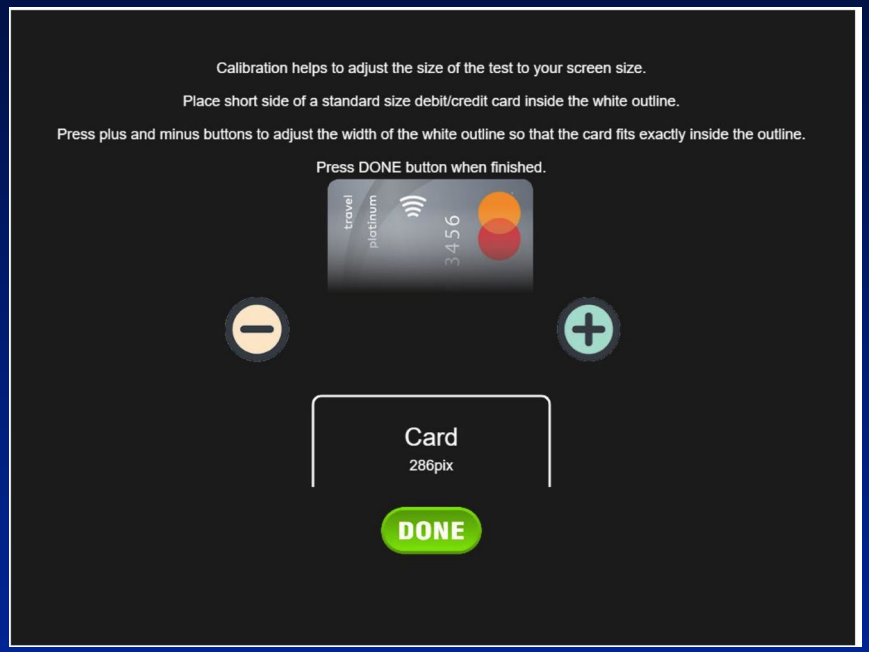

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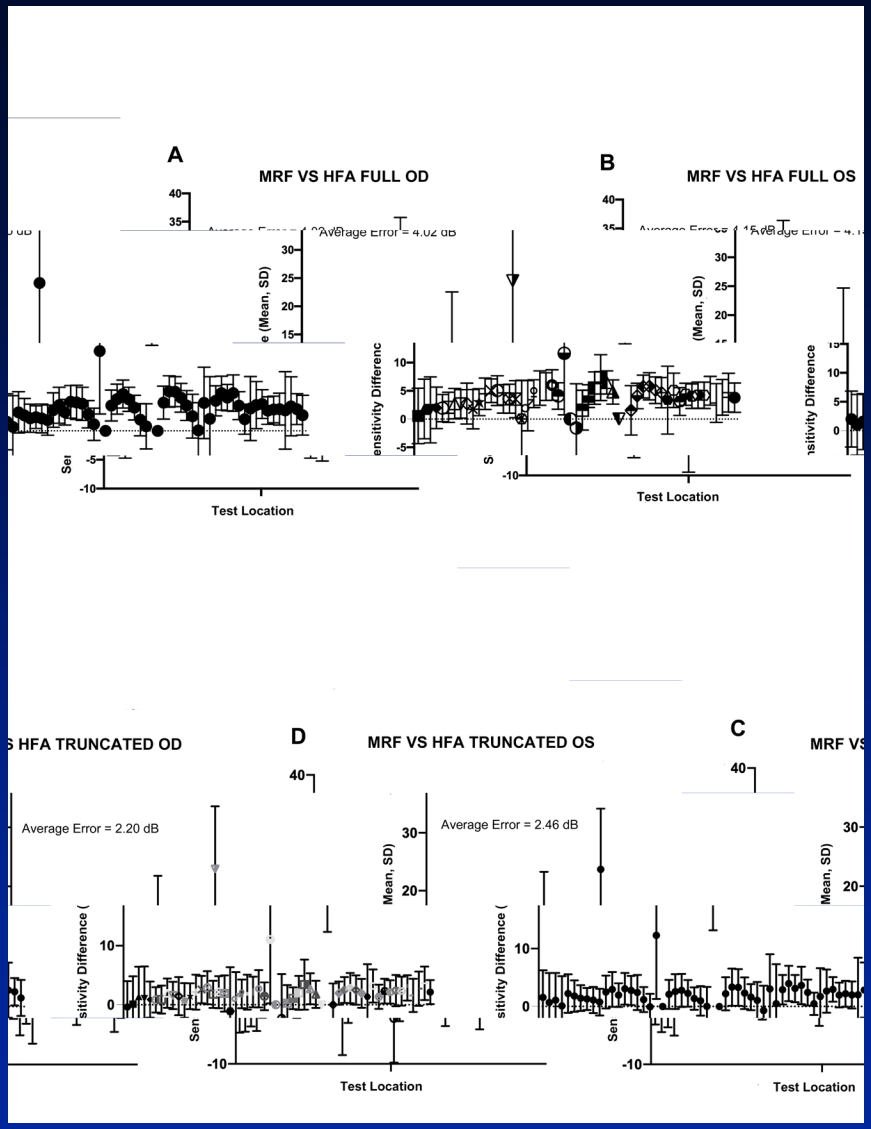

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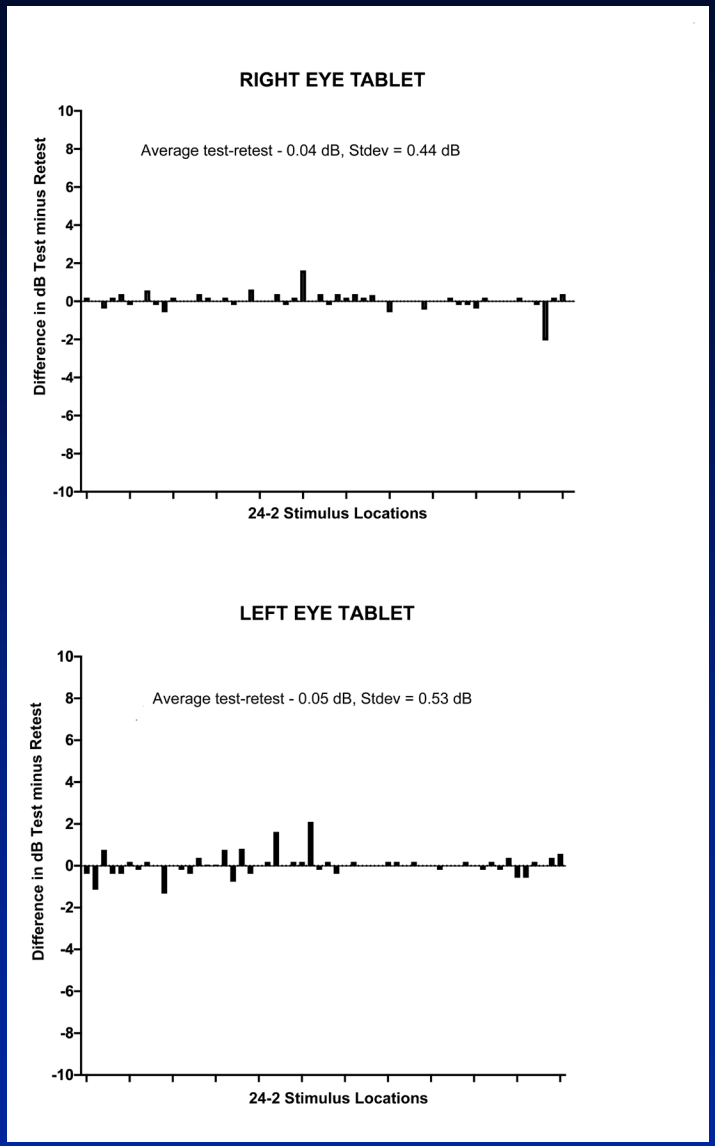

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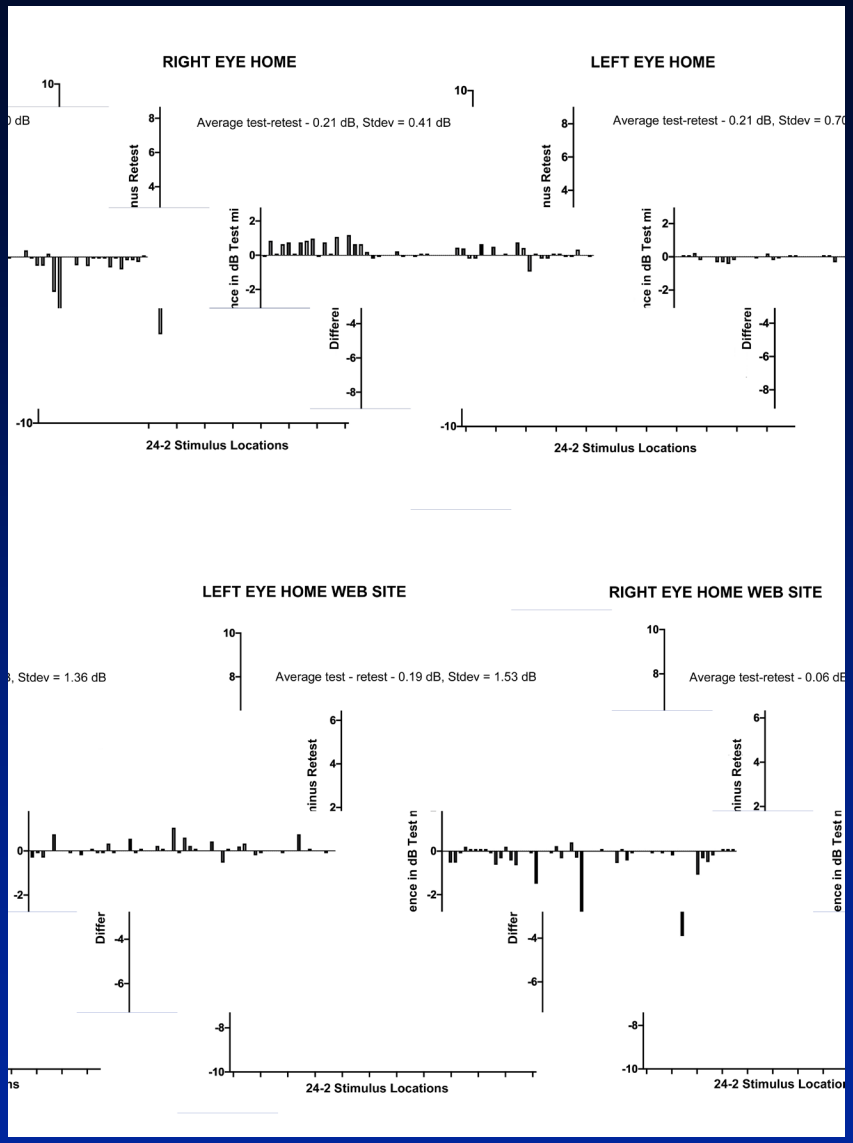

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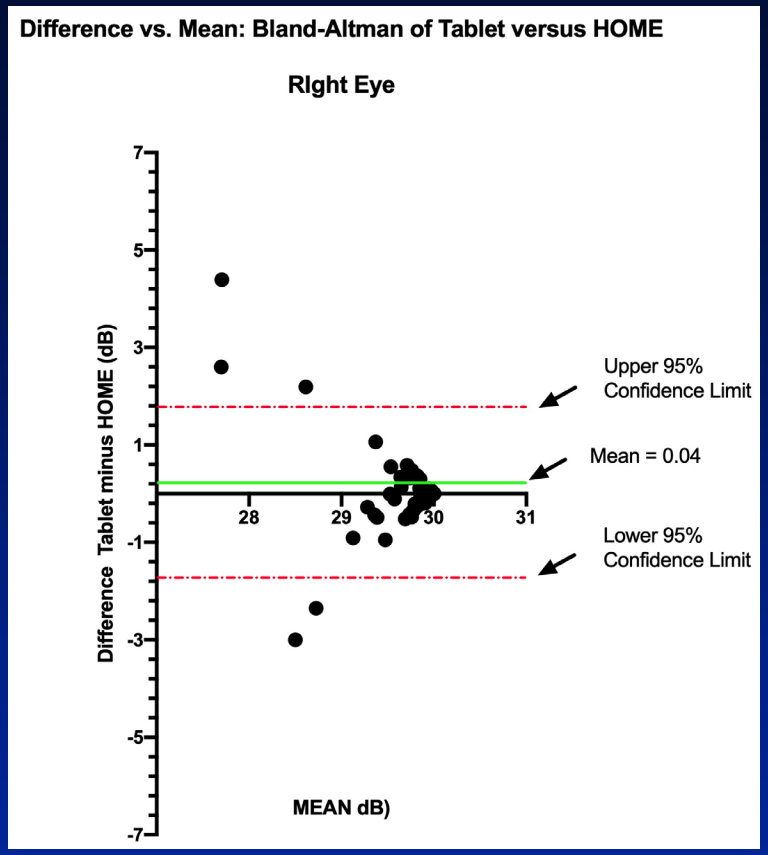

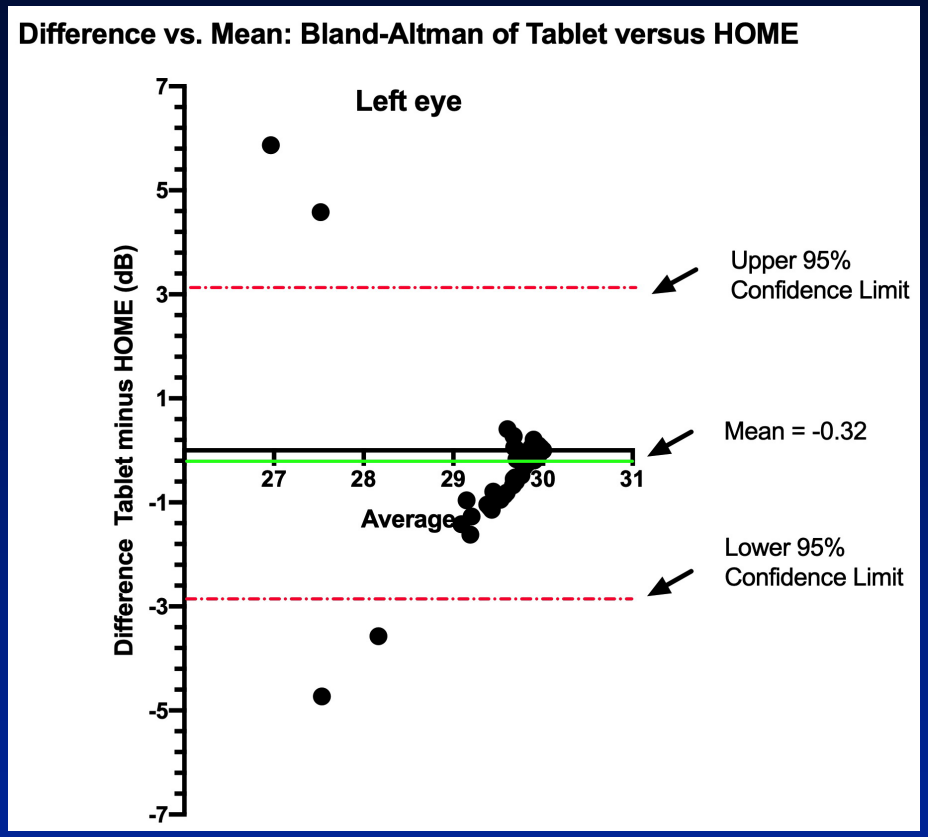

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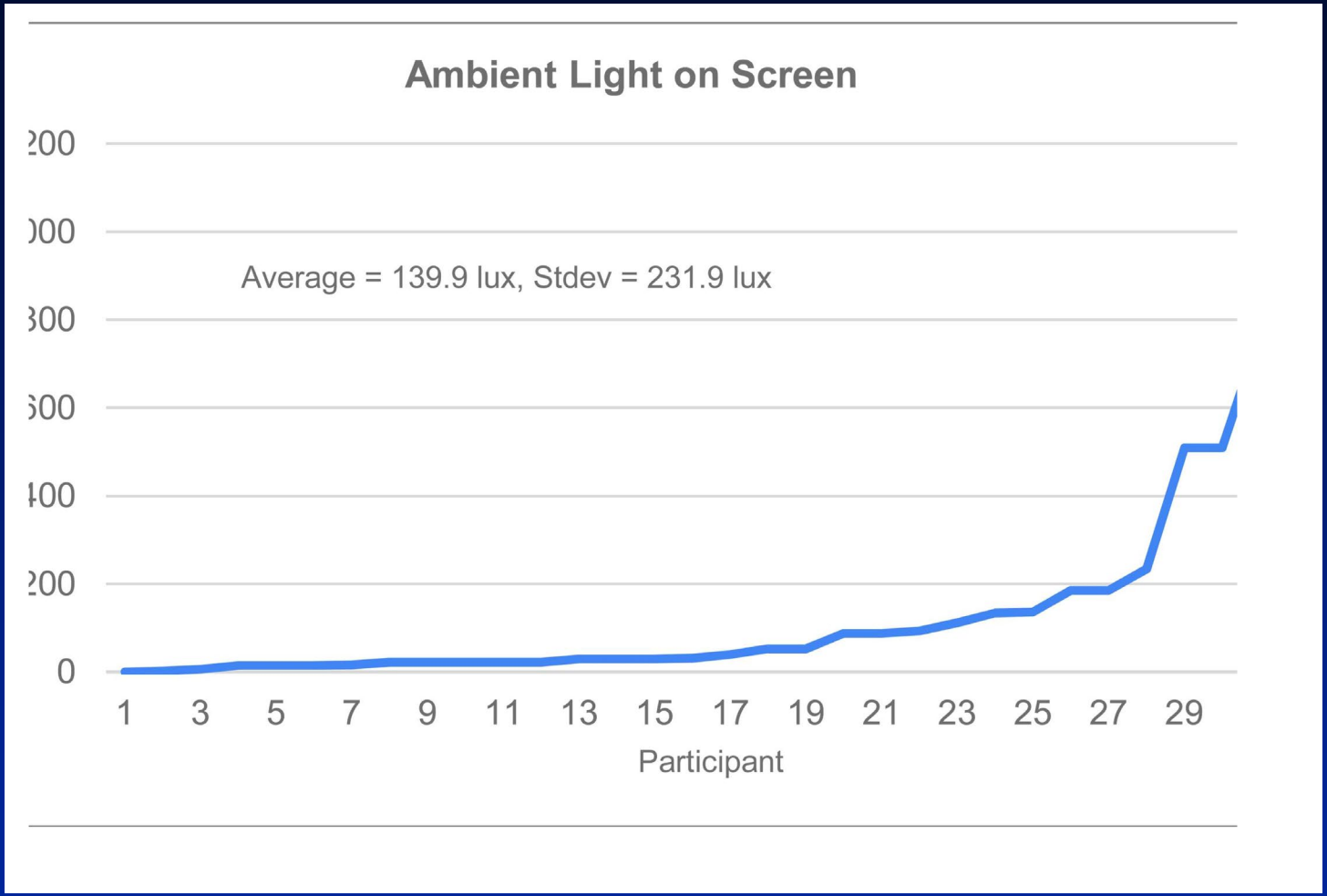

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Virtual Reality Headsets

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There are a Lot of Virtual Reality Headsets

- Vivid Vision Perimetry

- VF 200 Palm Scan

- VisALL Perimeter

- Heru

- OLLEYES

- C3FA

- M&S Smart System

- IMO Smart Perimetry

- Virtual Field

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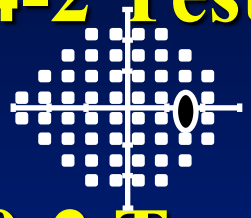
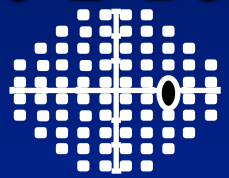
Available Visual Field Tests on some Virtual Reality Headsets

- 24-2 Test

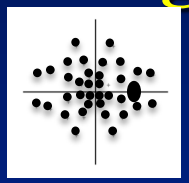


- 30-2 Test



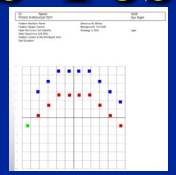
- 10-2 Test

- Screening Test

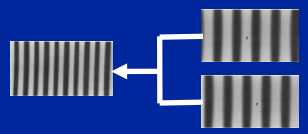


- Esterman Binocular

- Ptosis Test



- Frequency Doubling



ID:
CENTRAL 24-2 THRESHOLD TEST

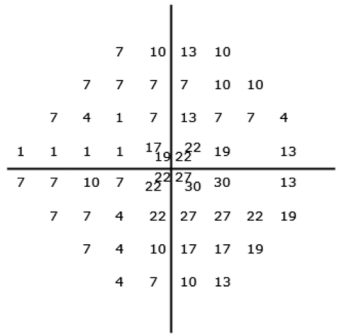
DOB:
Eye: Right

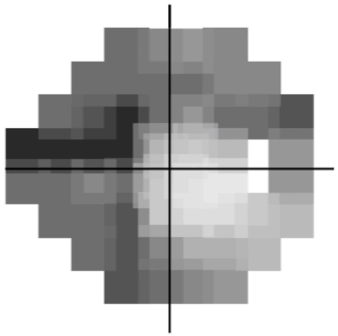
Fixation Monitor: Eye Tracker
Fixation Target: Central
False Pos Errors: 0/4 (0%)
False Neg Errors: 2/4 (50%)
Fixation Losses: 0 (No Blindspot Test)
Test Duration: 6m7s

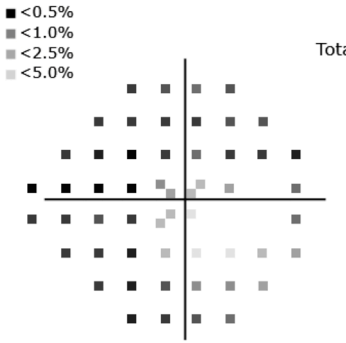
Stimulus: III, White
Background: 15.8 ASB
Strategy: S-Zest

31 Jul 2022
10:25AM
Age:
VC: 40.82%

Fovea: 22.6

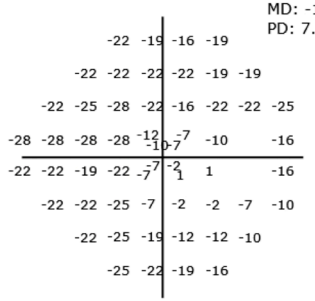


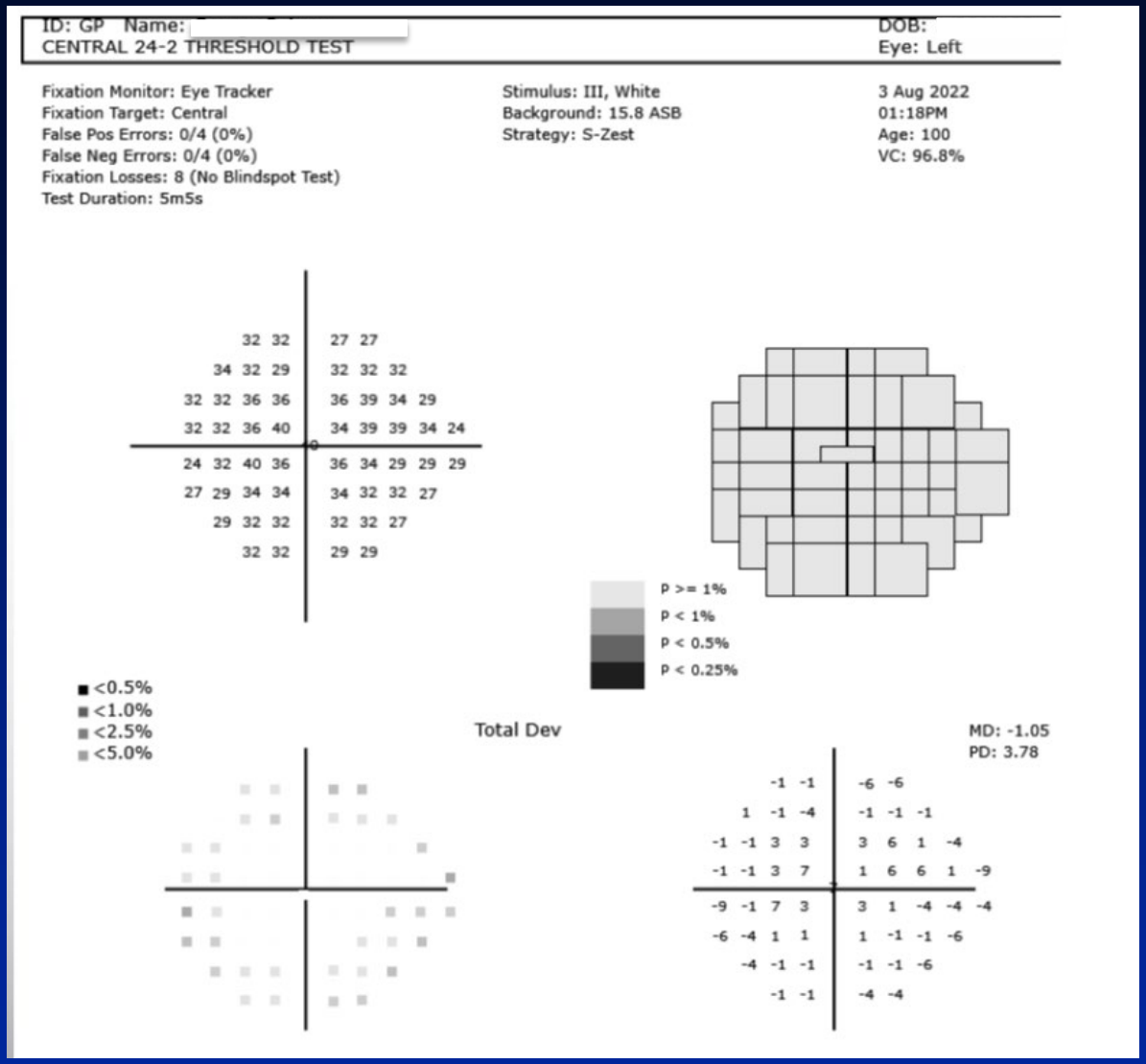




Total Dev

MD: -17.4
PD: 7.89




ID: GP Name:
DOB:
CENTRAL 24-2 THRESHOLD TEST
Eye: Left
Fixation Monitor: Eye Tracker
Fixation Target: Central
False Pos Errors: 0/4 (0%)
False Neg Errors: 0/4 (0%)
Fixation Losses: 8 (No Blindspot Test)
Test Duration: 5m5s
Stimulus: III, White
Background: 15.8 ASB
Strategy: S-Zest
3 Aug 2022
01:18PM
Age: 100
VC: 96.8%
32 32 27 27
34 32 29 32 32 32
32 32 36 36 36 39 34 29
32 32 36 40 34 39 39 34 24
24 32 40 36 36 34 29 29 29
27 29 34 34 34 32 32 27
29 32 32 32 32 27
32 32 29 29
P >= 1%
P < 1%
P < 0.5%
P < 0.25%
<0.5%
<1.0%
<2.5%
<5.0%
Total Dev
MD: -1.05
PD: 3.78
-1 -1 -6 -6
1 -1 -4 -1 -1 -1
-1 -1 3 3 3 6 1 -4
-1 -1 3 7 1 6 6 1 -9
-9 -1 7 3 3 1 -4 -4 -4
-6 -4 1 1 1 -1 -1 -6
-4 -1 -1 -1 -1 -6
-1 -1 -4 -4

What are the Important factors for testing ?

- Calibration - how was intensity measured ?
- Test retest reliability – how consistent is it ?
- Ambient lighting – does it affect testing ?
- Refractive error – How tolerant of blur ?
- Validation – does it compare to clinical test ?
- Comparison – Do different methods give the same results ?

Limitations of Portable Testing

- Dynamic Intensity range is smaller than conventional clinical visual field testing devices
- Elderly individuals or those with significant vision impairment may have difficulty with the test
- Without eye tracking testing is difficult
- A demonstration test is helpful
- A hard copy printout is necessary
- Validation of the test is essential
- Tablets and web sites are not appropriate for testing now
- Headsets will work, but not all headsets are alike.

CONCLUSIONS

- Tablet and internet web sites have high test-retest reliability.
- Results are highly comparable for tablet and web site.
- Test time is shorter than SITA Standard and slightly longer than SITA Fast.
- Dynamic intensity range is slightly smaller than for the Humphrey Field Analyzer.
- High correlations with the Humphrey Field Analyzer.
- Easy to sanitize.
- Testing can be performed at non-clinical sites & at home.

Future Studies

- Add more tests (visual acuity, contrast sensitivity, glare disability, visual acuity in noise, etc)
- Large study of headsets in India (5,000 patients)
- Refinement of test strategies and implementation of AI approaches (both for analysis and acquisition of sensitivity values)

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Introduction

- Visual field testing is an important diagnostic procedure for detection and monitoring of glaucomatous damage.
- Most automated perimetry devices employ a hemispherical bowl with a chin rest to test one eye at a time, which can be challenging for older patients with posture difficulties (kyphotic, rheumatoid arthritis, etc).
- Current automated perimetry testing requires a separate room in the clinic with trained personnel administering the test.
- The purpose of this investigation was to evaluate the performance of a visual field test using a virtual reality headset in comparison to a similar test on the Humphrey Field Analyzer.

Photo obtained with Permission from the participant

Background is 3 dB lower than the HFA

Dynamic range is 30 dB

Target size increases at greater stimulus eccentricities

Uses a modified ZEST Procedure (locations that are different from all horizontal and vertical neighbors are repeated, and post processing - neighborhood analysis

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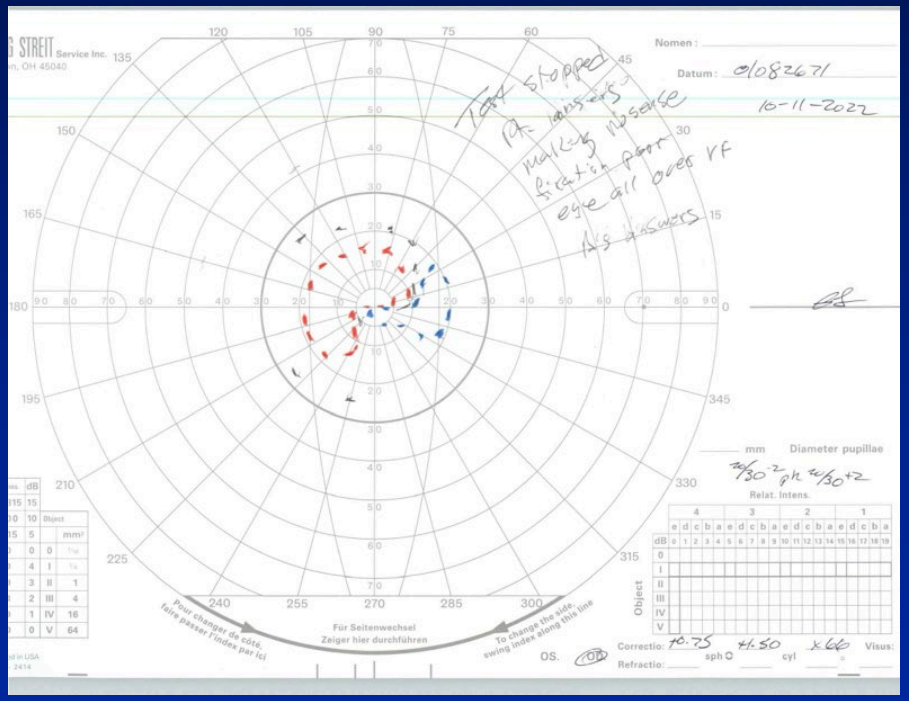
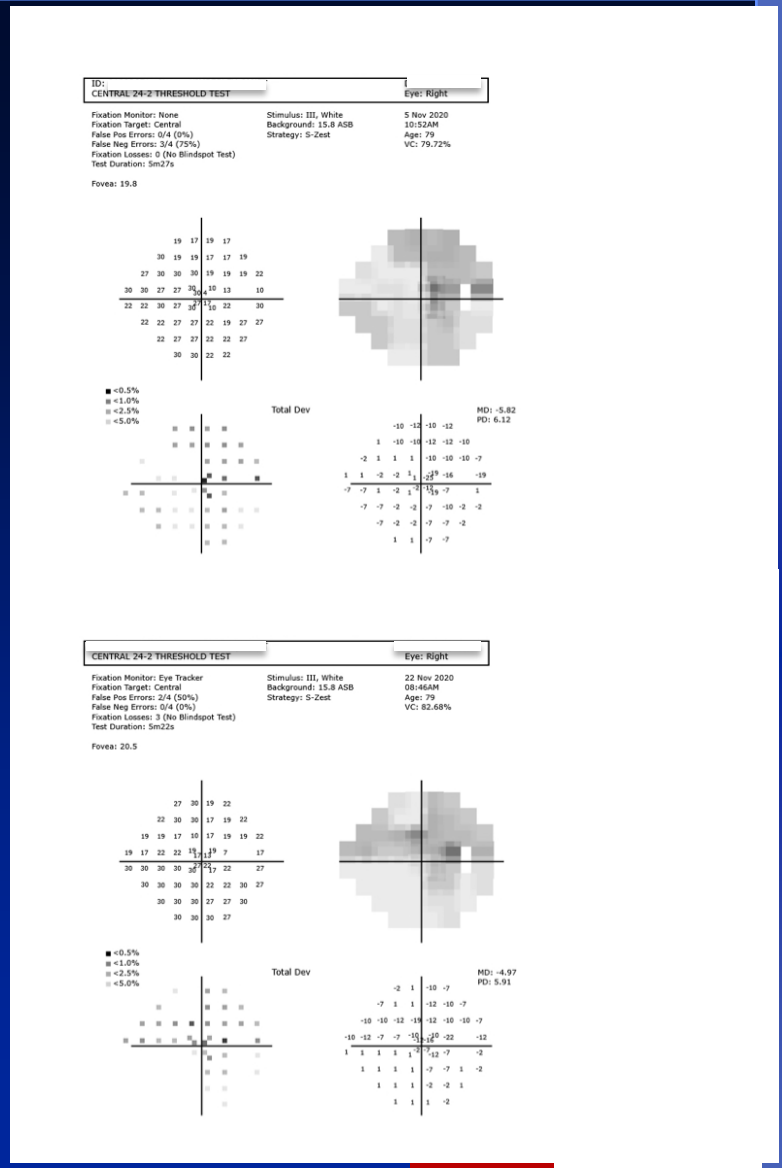
Use photo of the patient using it, who allowed us to

Kyphotic 81 year old glaucoma patient With a painful spinal cord injury

She could not perform HFA or Goldmann, but did well with the headset when in a comfortable position.





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Methods

- 81 eyes of 45 glaucoma patients were tested with the 24-2 procedure on the Smart System Virtual Reality (SSVR) headset (M&S Technologies) with a Zippy Estimation of Sequential Thresholds (ZEST) strategy compared to the 24-2 SITA Standard test on the Humphrey Field Analyzer. Eye tracking enabled (TOBII system, 60 Hz, 0.25 deg accuracy)
- Mean Deviation (MD), Pattern Standard Deviation (PSD) and test time were assessed, along with a survey concerning preferences, comfort and other properties of the two devices.
- Parametric (t test), nonparametric (Wilcoxin signed rank) and Bland- Altman analyses were performed.
- All participants had a comprehensive exam, including history review, applanation tonometry, optic disc evaluation, visual acuity, slit lamp evaluation.

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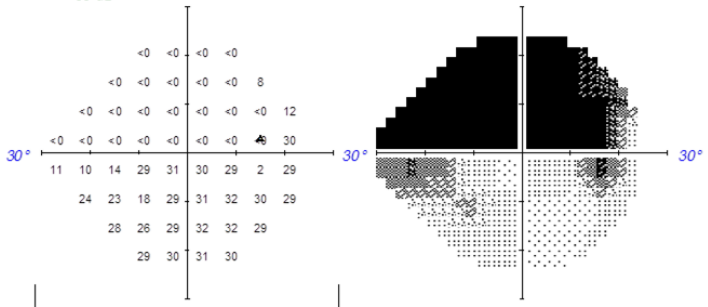
Demographics	(n = 81)
Age (Mean±SD)	73.70±8.27
Sex	n (%)
Male	16 (35.56)
Female	29 (64.44)
Ethnicity	
White	44 (97.78)
Hispanic or Latino	1 (2.22)
Eye Tested	
OD	40 (49.38)
OS	41 (50.62)
Glaucoma Diagnosis	
Normal Tension	31 (38.27)
Primary Open Angle	27 (33.33)
Pseudoexfoliative	10 (12.35)
Mixed-Mechanism	6 (7.41)
Steroid-Induced	3 (3.70)
Chronic Angle Closure	2 (2.47)
Aphakic	2 (2.47)
Glaucoma Severity (Hodapp-Parrish-Anderson)	
Early	25 (30.86)
Moderate	22 (27.16)
Severe	34 (41.98)
Spherical Equivalent (Mean±SD)	
OD	-0.72±1.98
OS	-0.63±1.85
Total	-0.67±1.90

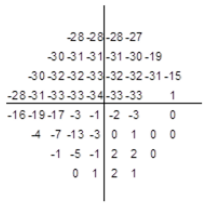
A

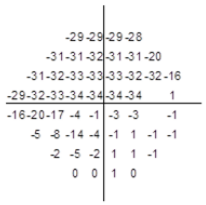
Fixation Monitor: Blind Spot
Fixation Target: Central
Fixation Losses: 2/15
False POS Errors: 10%
False NEG Errors: 0%
Test Duration: 06:39
Fovea: 33 dB

Stimulus: III, White
Background: 31.5 asb
Strategy: SITA Standard
Pupil Diameter: 5.9 mm *
Visual Acuity: 20/20
Rx: +0.00 DS

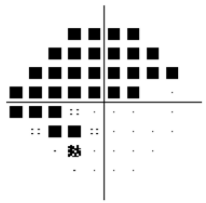
Date: Jan 20, 2023
Time: 12:49 PM
Age: 68



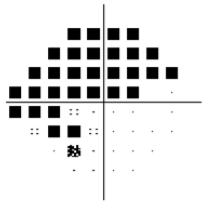




Total Deviation



Pattern Deviation



GHT: Outside Normal Limits

VFI: 48%
MD24-2: -15.27 dB P < 0.5%
PSD24-2: 15.63 dB P < 0.5%

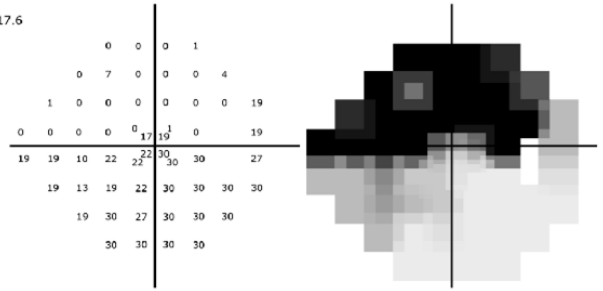
P < 5%
P < 2%
P < 1%
P < 0.5%

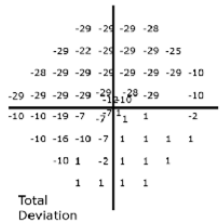
B

Fixation Monitor: Eye Tracker
Fixation Target: Central
False Pos Errors: 0/4 (0%)
False Neg Errors: 1/4 (25%)
Fixation Losses: 0 Fixation Losses:
Test Duration 6m14s
Fovea: 17.6

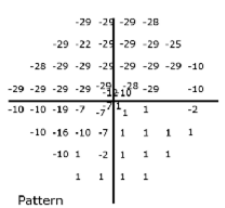
Stimulus: III, White
Strategy: S-Zest

11/15/2020
09:22AM
Age: 69
VC: 48.47%



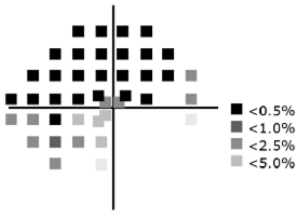


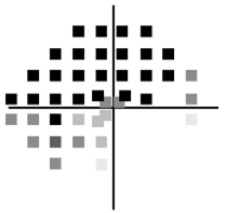
Total Deviation



Pattern Deviation

MD: -15.15
PSD: 12.59





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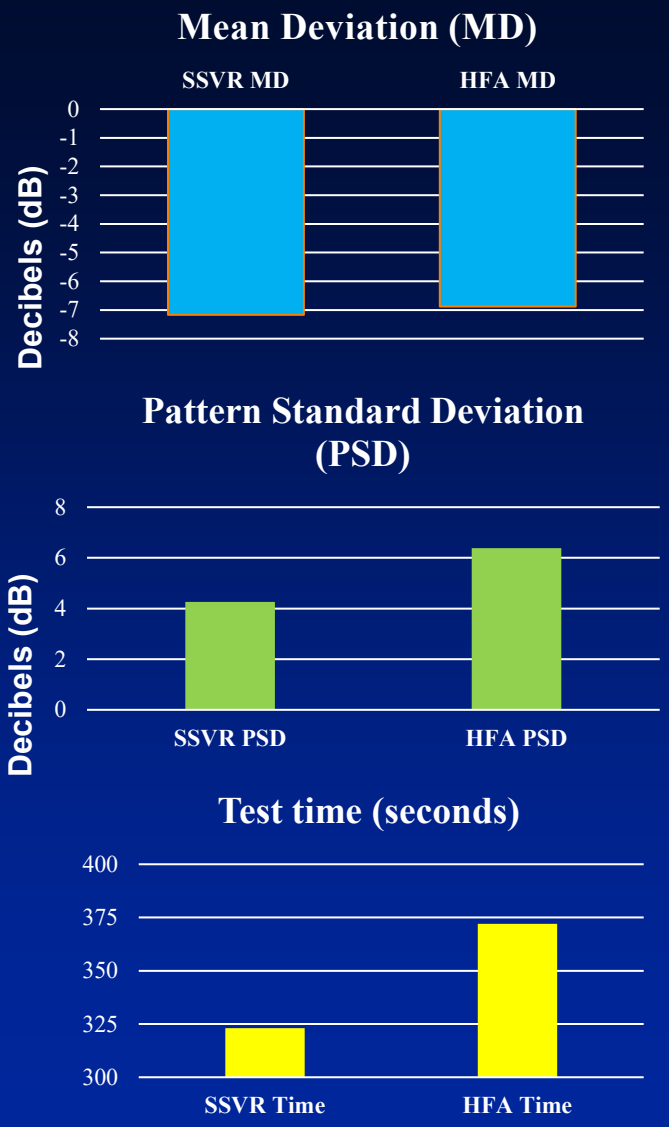
Results

Table 2. Comparison of visual field indices between the Smart System Virtual Reality Headset and the Humphrey Field Analyzer.

	SSVR	HFA	p
MD (dB)	-7.17±6.36	-6.88±6.78	0.297
Mean Difference	-0.29±2.49		
95% LOA	-5.17 to 4.59		
PSD (dB)	4.26±2.37	6.38±4.51	<0.001*
Mean Difference	-2.11±2.81		
95% LOA	-7.62 to 3.40		
Test Duration (s)	323.44±72.27	372.20±61.44	<0.001*
Mean Difference	-48.75±56.48		
95% LOA	-159.45 to 61.95		

SSVR = Smart System Virtual Reality Headset, HFA = Humphrey Field Analyzer, MD = Mean deviation, PSD = Pattern standard deviation, LOA = Limits of Agreement

* indicates a statistically significant difference ($p<0.05$)



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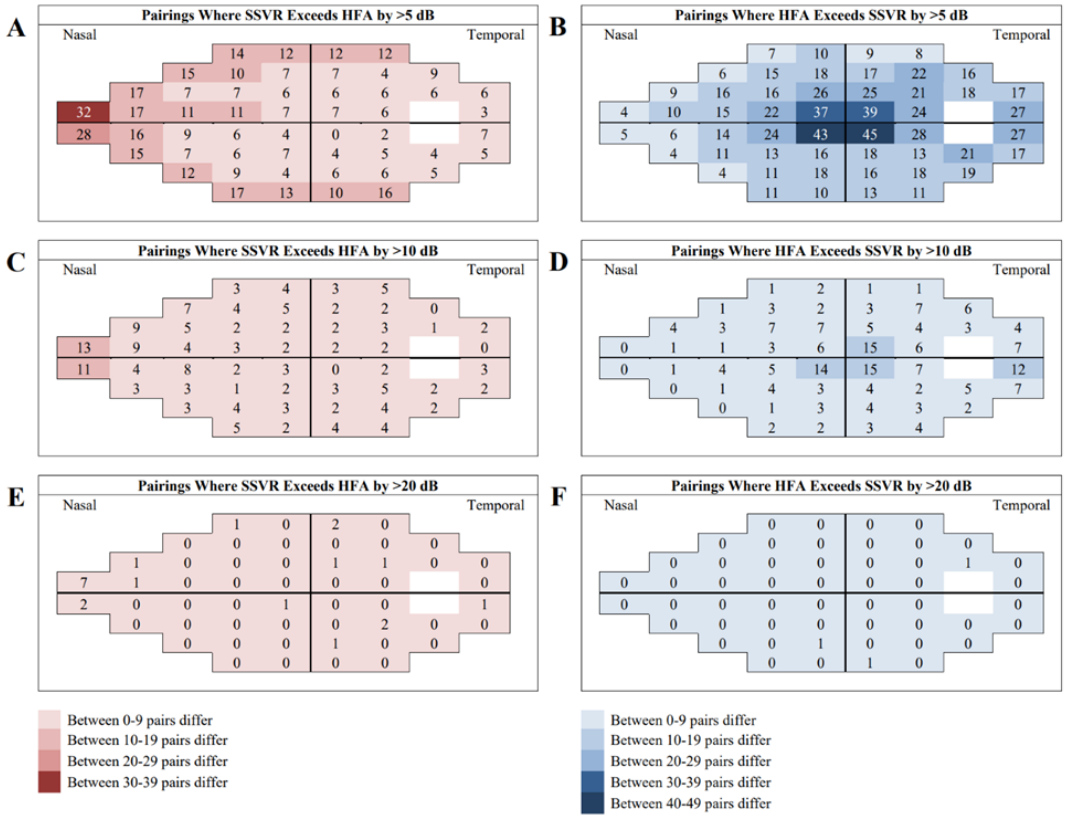
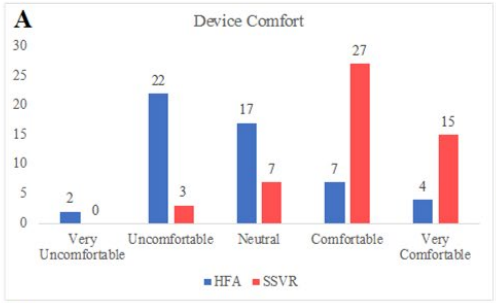
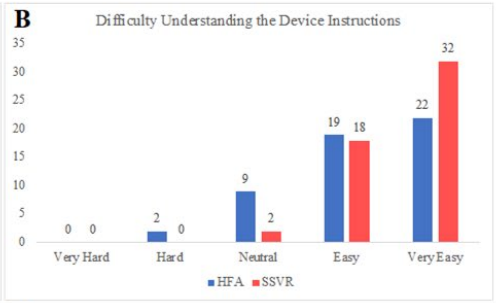


Comfort

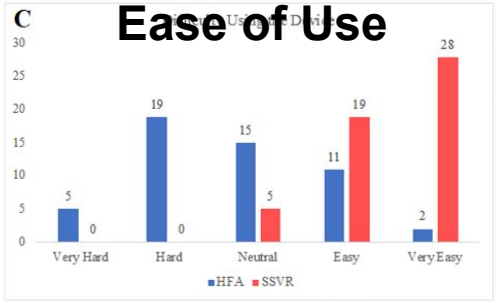
Understanding Instructions

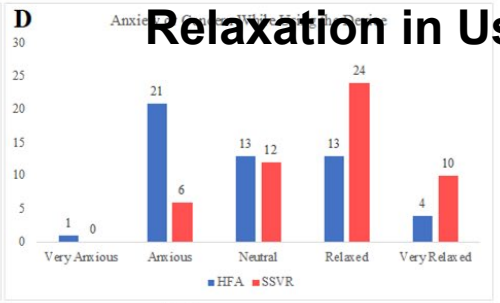


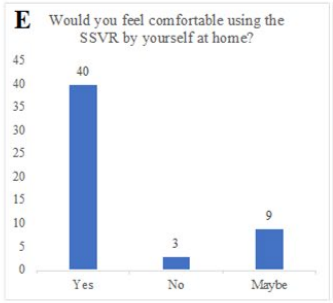


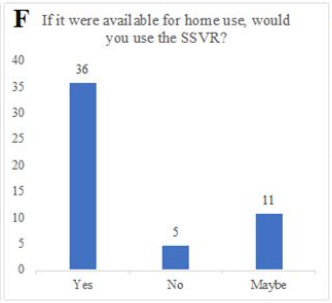
Ease of Use

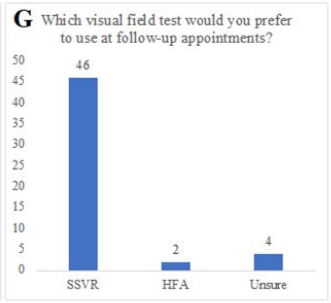
Relaxation in Use











Use at Home

Use SSVR

Test Preference

SSVR

HFA

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Discussion

- VR headsets can provide a useful means of performing visual field testing.
- Additional modules (visual acuity, contrast sensitivity, stereoacuity, ptosis fields, Esterman binocular field, etc) can also be added.
- Eye tracking can be performed, and head movements are not affecting the test procedure.
- Results compare well with current SITA Standard results on the Humphrey Field Analyzer, with the exception of pattern standard deviation.
- Initial results appear to be promising.

Conclusion

- Advantages
  - Testing can be performed anywhere, including at home.
  - Patients prefer it and it is comfortable and easy to use.
  - Patients with postural difficulties (arthritis, spinal injuries) can do the test when in a comfortable position.
  - Both eyes can be tested at the same time.
- Disadvantages
  - Dynamic range is smaller than for the HFA.
  - Stimulus size varies and hill of vision becomes plateau or mesa of vision.
  - Separation of widespread and local loss is not as good.

Future Developments

- Customize headset for vision testing purposes
  - Software enhancements
    - Use of AI and statistical approaches to optimize testing and assessment.
    - Provide tutorials and practice for new users.
    - Make test procedure more interactive.
  - Hardware enhancements
    - Improve eye tracking accuracy and speed.
    - Use different displays (eg, OLEDs) for larger dynamic range.
    - Implement procedures similar to the HFA.

Thank you for your attention !!

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