

Human Factors Guidelines for Binocular Near-Eye Displays

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Sponsored by United States Display Consortium (USDC)



Abstract of Results

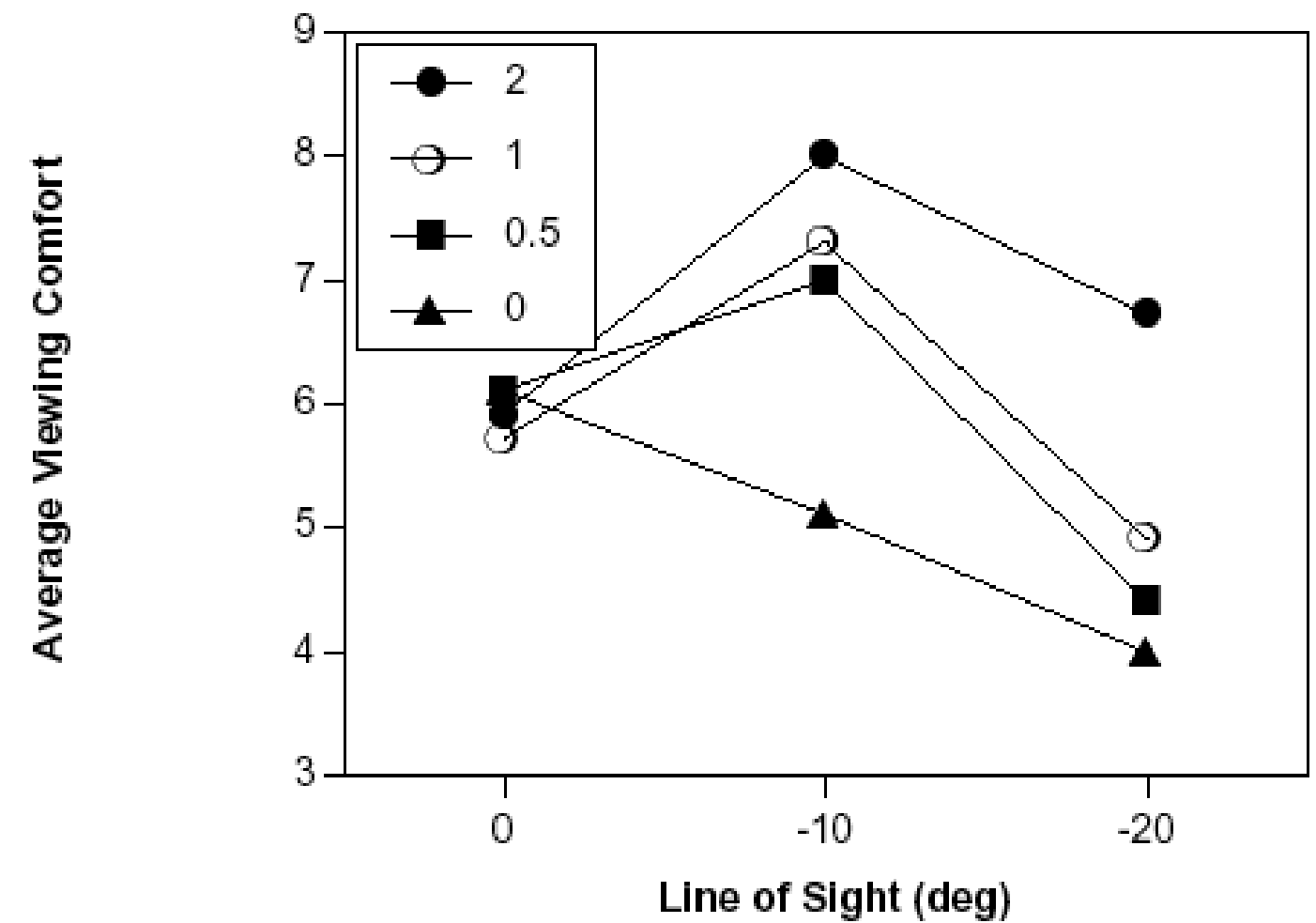
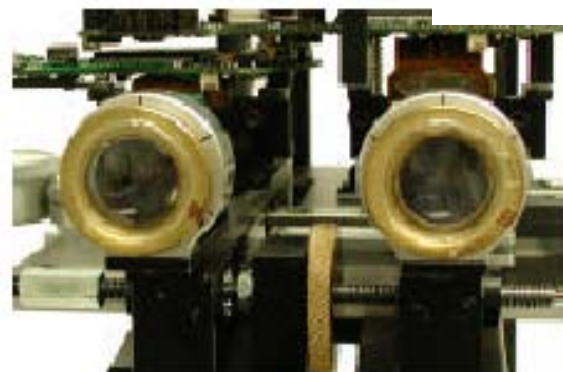
- Preferred LOS and focus: -10° at 0.5 to 2.0 meters
- FOV for SVGA display: 28° to 32° horizontal
- FOV for QVGA display: 16.5 to 19.5° horizontal
- Larger FOV are preferred for video; narrower for text
- Extensive databases for head size and our simulation and measurement methodology can improve fit and accommodation
- An 8% transmission occluder is recommended for eliminating rivalry in monocular displays
- Design the IPD and other critical dimensions using databases for the age, ethnic/cultural make up of your target market
- Use the eye box measurement technique to evaluate a design
- Model designs after the Olympus and Sony eyeglass style to enhance comfort
- Existing monocular displays are rated as difficult to adjust
- Expect users to adopt diverse approaches for donning and fitting monocular displays with regard to eye dominance
- For short term comfort, limit eyeglass style display weight to 160 gm, halo style to 240 gm.
- Headmounted binocular displays can tolerate a wide range of interior illumination levels, but require a substantial increase in brightness to function in outdoor illumination levels.

MCG Human Factors Lab and Binocular Display Panel



Exp 1: Focus & LOS

- Define preferred focus and LOS
 - Preferred focus on image type
 - Test preference for downwards LOS
 - LOS/Bifocal link
- Parameters
 - Focus 0, 1/2, 1 & 2 D, LOS 0, -10, -20 deg
 - Bifocal correction



- the -20 degrees LOS was given low ratings
- The highest rated combination for the bifocal group was a focus of +2 diopters or 1/2 meter at a LOS of -10 degrees.

Exp 2a: Binocular FOV

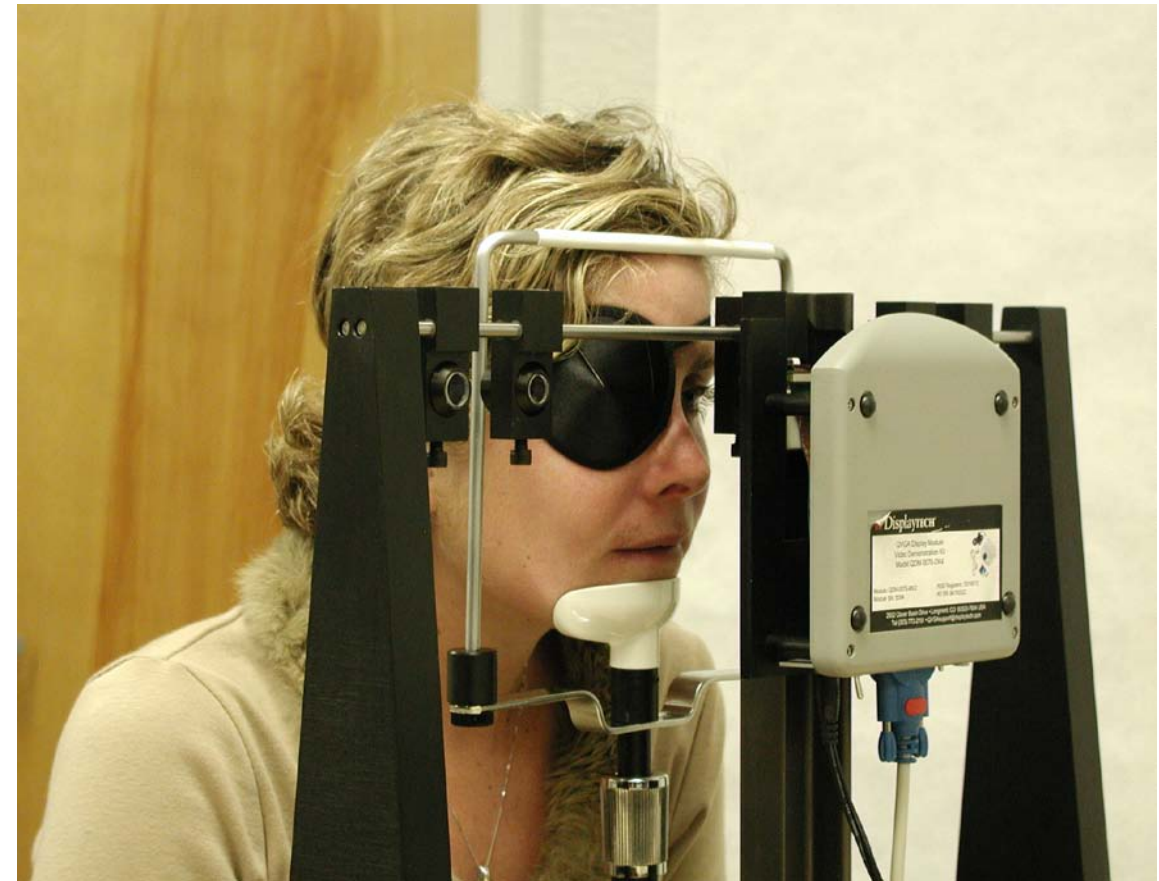
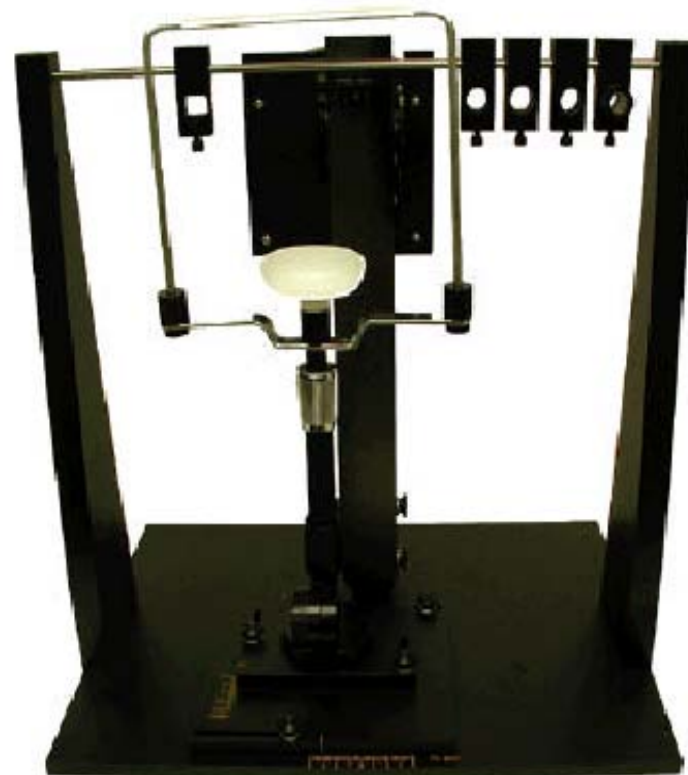
- Define preferred FOV for information and video binocular SVGA near-eye displays
- Parameters
 - *FOV 22, 26, 30, 34 & 38 deg horizontal*
 - *PC & video displays*
- Data
 - *Ratings for preferred focus and LOS*
 - *Two-way repeated-measures ANOVA*
- Near eye displays
 - *Embedded: None (projection simulation)*
 - *Follow up testing: All binocular headsets*



- Final test series used three expert observers who were in agreement on judging the FOV that was just too large or uncomfortable to view.
- For the web/information image this occurred at 30 degrees, and for the scenic/photographic image this occurred at 34 degrees.
- This translates into threshold values of 28 degrees horizontal for the web image and 32 degrees horizontal for the scenic image.

Exp 2b: Monocular FOV

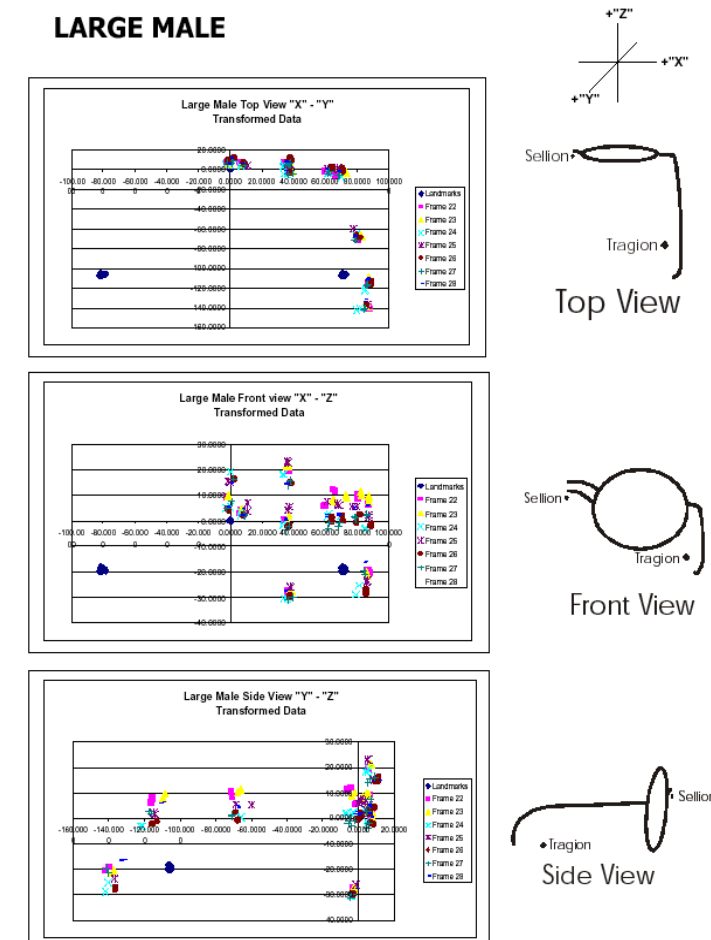
- Define preferred FOV for QVGA bring-to-eye displays for information and video imagery
- Parameters
 - *FOV 8, 10.7, 13.3 & 16 deg horizontal*
- Data
 - *Ratings for preferred FOV*
- Near eye displays
 - *Embedded: One Displaytech QVGA development kit*
 - *Follow up testing: All monocular headsets and viewers*



- In a third experimental series, three expert observers judged the FOV that was “just too large or uncomfortable to view”.
- For the PDA/information image this occurred at 18 degrees, and for the scenic/photographic image this occurred at 21 degrees.
- This translates into threshold values of 16.5 degrees horizontal for the PDA image and 19.5 degrees horizontal for the scenic image.
- For the PDA display, observers were willing to accommodate a lower resolution image in favor of increasing the size and FOV of the image.

Exp 3: Eyewear Compatibility

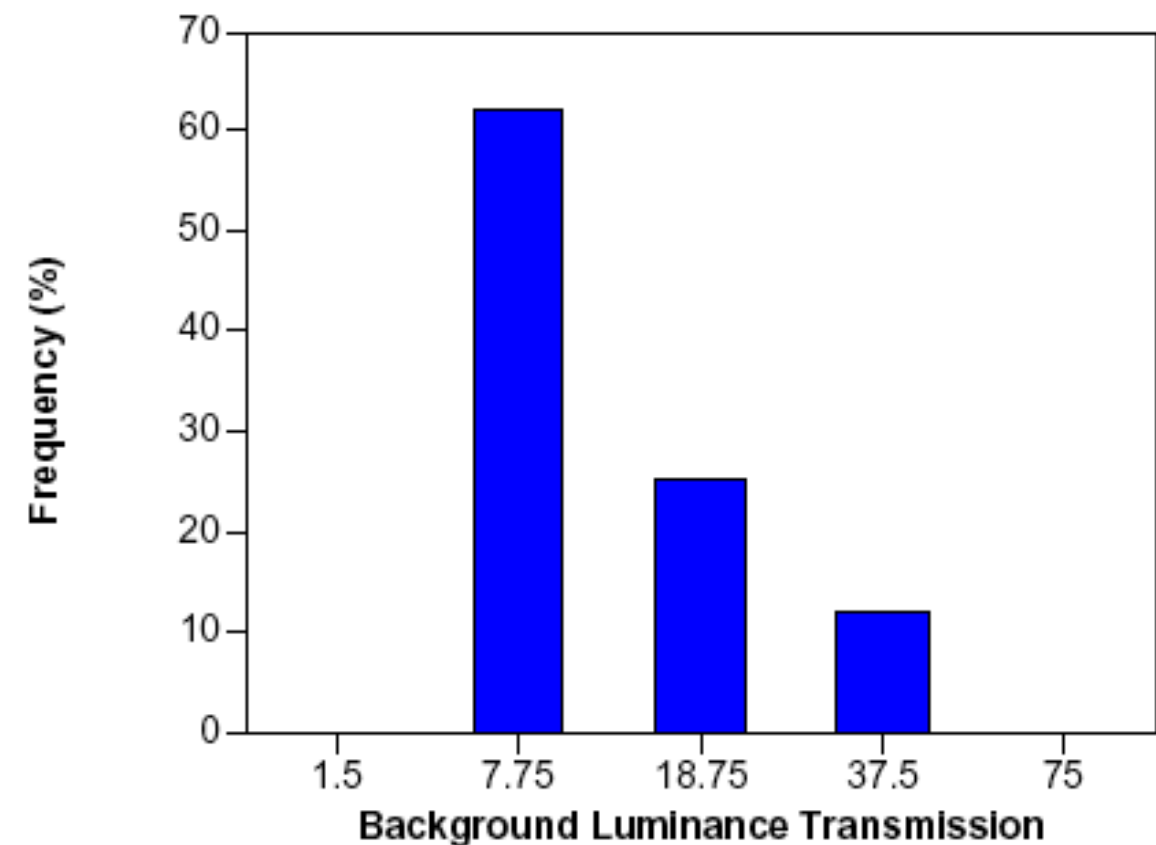
- Define 3D eyewear compatibility for a range of eyewear for near-eye displays.
- Approach
 - Acquire 3D head scan data
 - Construct eyewear fixture and collect 3D scans from assortment of eyewear
- Data
 - Use the head and eyewear data to construct spatial envelopes for common eyewear



- Report quantifies the dimensions required to accommodate corrective lenses. It defines the critical head landmarks, measuring methodology, and equipment.
- Most compact consumer designs present a problem for viewers requiring prescription glasses.
- Head- or forehead-supported displays (e.g., I/O Display, Daeyang) clear the nose and ear space, making them more compatible for corrective eyewear.

Exp 4: Binocular Rivalry

- Evaluate solutions for minimizing binocular rivalry with monocular near-eye displays in common viewing environments
- Parameters
 - *Display viewed by right eye*
 - *Series 1: Variety of filters and occluders*
 - *Series 2: Neutral density filters*
- Data
 - *Ratings for presence of rivalry as a function of solution and viewing environment*
- Near eye displays
 - *One Micro-Optical monocular display mounted on Zeiss halo mount with variable occluder*



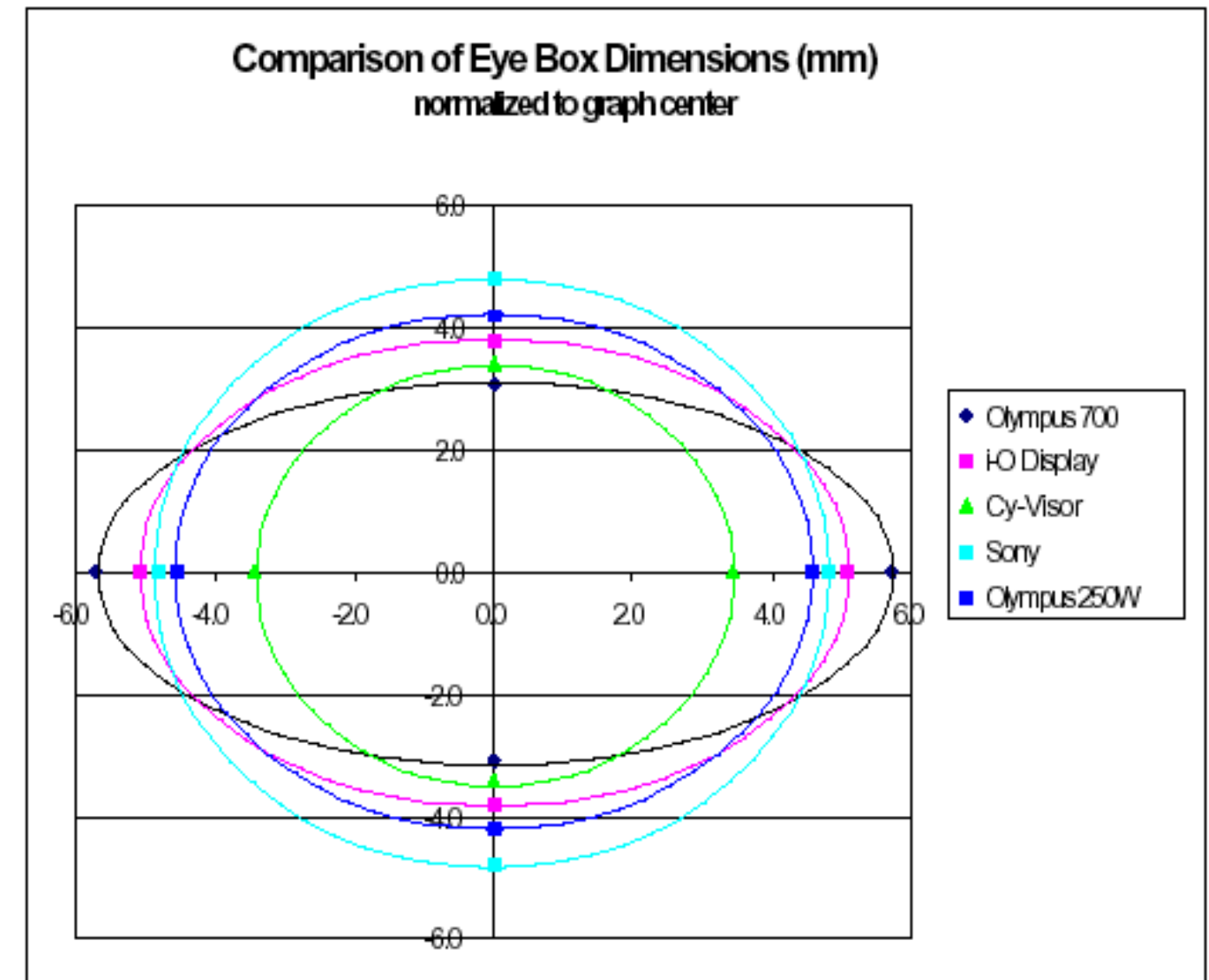
- A neutral density filter used to reduce ambient brightness for the non-display-eye can dramatically reduce binocular rivalry in a monocular viewing.
 - *The results of this experiment indicate that a viable alternative is to optically filter the non-display eye with a transmission of 8 to 19%.*
- A more integrated solution is to use the optical filtering for both eyes, placing the monocular display between the eye and the filter.
- An alternative approach is the use of a variable transmission or reactive filter.

Exp 5: IPD

- Trading off IPD adjustment with exit-pupil size is a critical design decision. Developers need accurate IPD normative data, and should not have to rely on outdated military standards.
- Is a one size fits all product strategy viable?
- Databases acquired and analyzed:
 - *DoD Handbook 743A (U.S. Department of Defense, 1991): Compilation of 10 studies 1950-1970*
 - *1988 Anthropometric study of U.S. Army Personnel: Gender, ethnic detail*
 - *1988 Army study normalized to match racial/ethnic mix of U.S population*
 - *Dayton CARD lab database on civilian population*
 - *Japanese Anthropometric Handbook*
- 1. Do not use the older military data found in Military Handbook 743A. These data are outdated.
- 2. Do not use the widely published data found in the 1988 Anthropometric Survey of U.S. Army Personnel and presented in Table 6-2 -- unless you are specifically designing for an Army population.
- 3. The data presented in Table 6-3, though based on a military population, can be used in designing for the adult U.S. population.
- 4. If racial/ethnic marketing data are available, the data presented in Tables 6-4 and 6-5 may be useful.
- 5. Both the pupil and infraorbitale Dayton data should be used with caution.
- 6. The Japanese data are recommended for that market segment, and for incorporation into estimates of international markets.

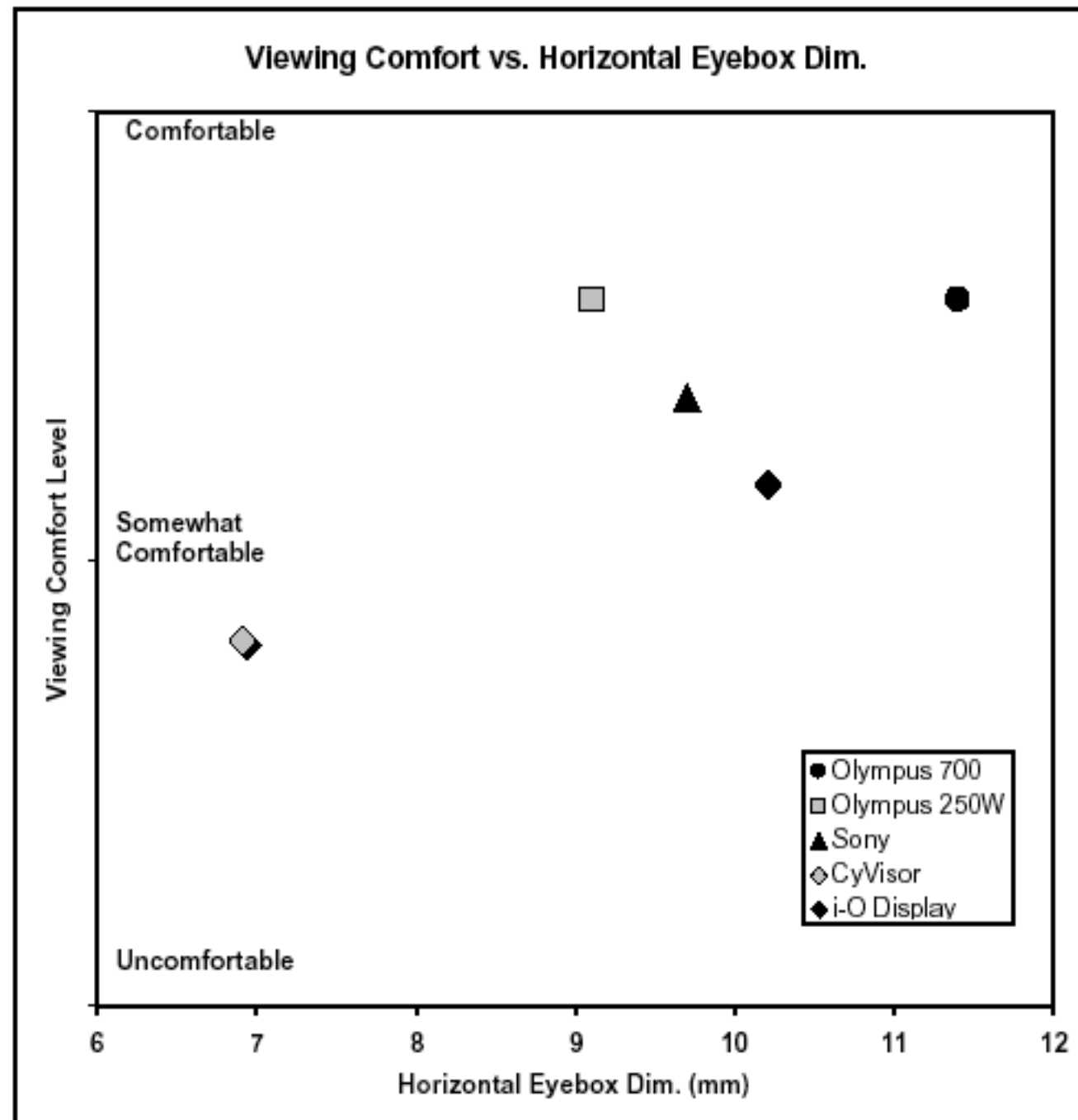
Exp 6: Exit Pupil / Eye box

- Develop equipment and procedure to characterize eye box size for panel of displays and to investigate the relationship between eye box size and viewer ease of fit
- Data
 - *Eye box size at a range of eye relief distances*
 - *Observer ratings of ease of fitting and adjustment*



	Eyebox			Ranking
	X mm	Y mm	(X*Y) mm ²	
Olympus 700	11.4	5.1	58.1	4
Olympus 250W	9.1	8.4	76.7	2
I/O Displays	10.2	6.6	67.1	3
Cy-Visor	6.9	6.9	47.0	5
Sony	9.7	9.7	93.2	1

Exp 6. Comfort vs. Eye Box Size



- Generally, all binocular headsets proved functional, but:
 - Eyeglass style binocular displays were preferred even by those requiring corrective lenses
 - The Olympus headsets received overall highest marks
- Monocular displays were also rated acceptable, but:
 - Head mounted proved difficult to adjust
 - Wide variety of responses to eye dominance and occluders

– A method was developed to measure the size of the eye box

• Binocular displays with a eyewear design were rated as more comfortable than those with a forehead mount

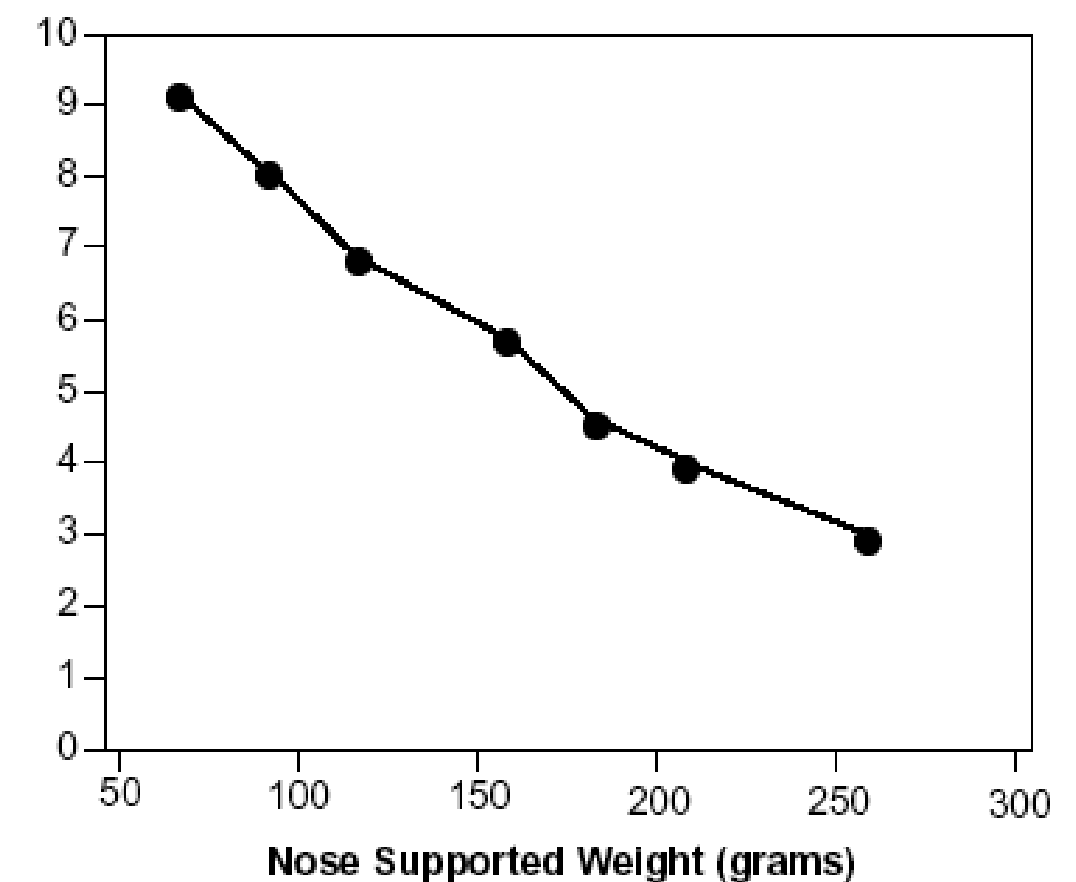
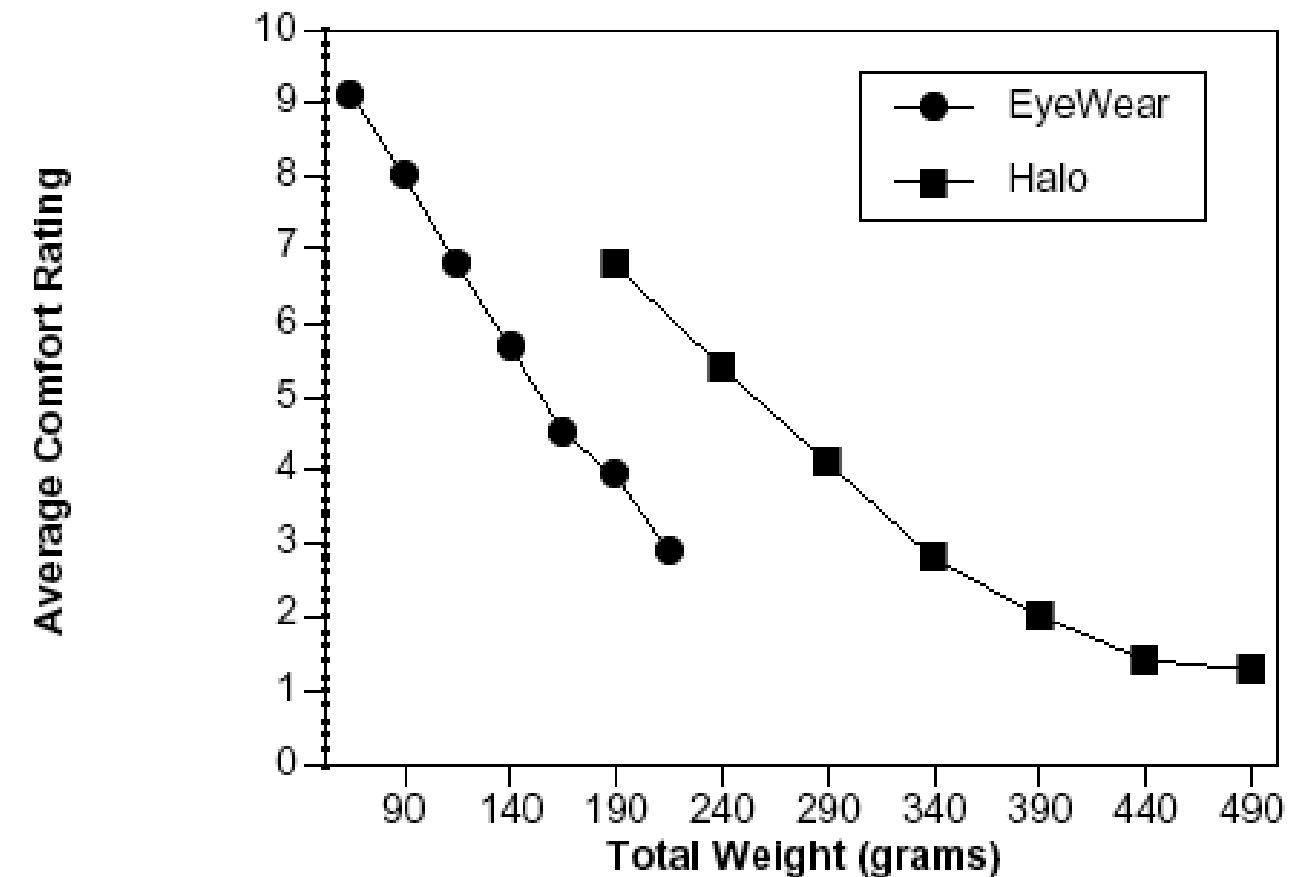
• In binocular displays, eye box size was related to ease of viewing.

• Head mounted monocular were rated as difficult to fit and adjust for ease of viewing.

- Chart show relationship between observer ratings and measured horizontal dimension of eye box at 25mm eye relief.

Exp 7: Weight & Balance

- Establish rated comfort of eyewear and halo type headset displays as a function of weight
- Parameters
 - H-Headsets: Spectacle and Halo Headband mounts adapted for variable weights
 - W-Total weight: 100 to 300 grams for halo
 - S-Total weight: 50 to 200 grams for spectacle

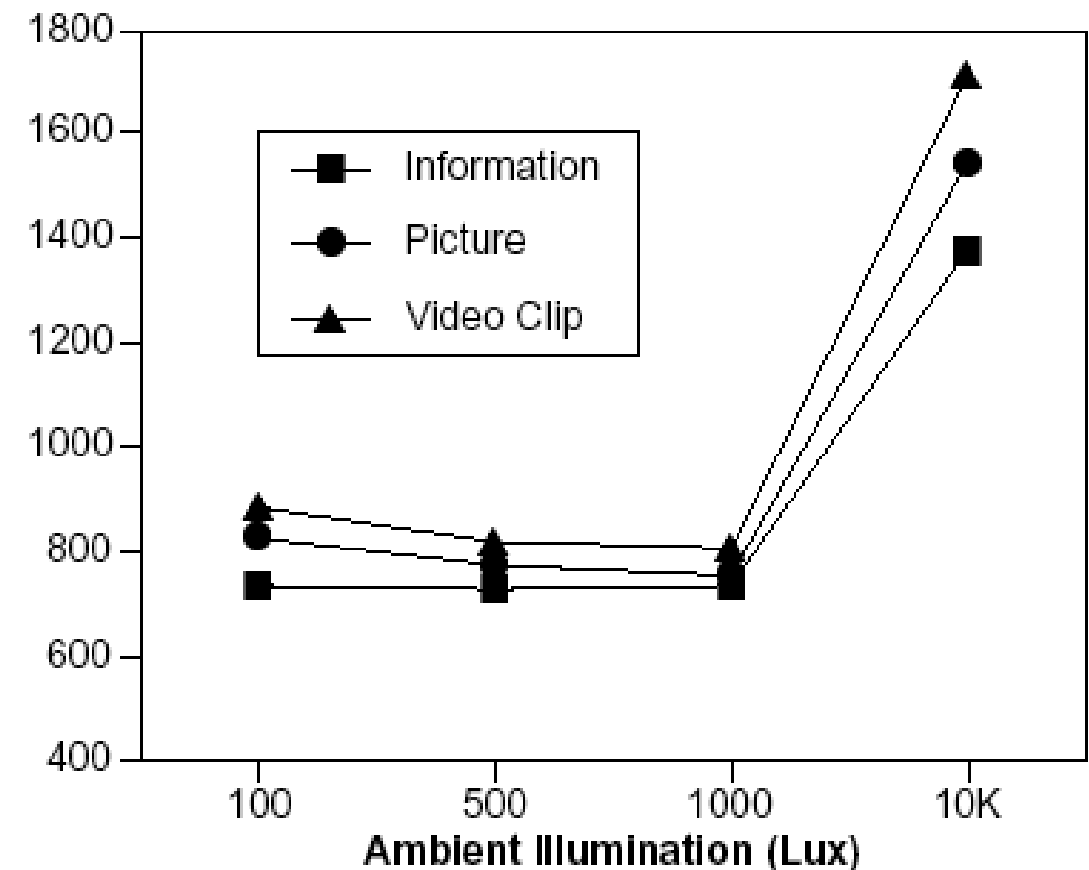


Exp 8: Brightness & Contrast

- Define binocular headset preferences for brightness in several common illumination environments (airplane cabin, office, outdoors) for information and video imagery
- Parameters
 - *Adjustable luminance*
 - *Information and video imagery*
 - *Three background lighting environments typical of airplane cabin, office, outdoors*



Average Selected Display Luminance (Nits)



- This experiment produced a strong effect at daylight illumination.
 - *Subjects preferred more display luminance at this high level of illumination for video than for pictorial or information imagery.*
- The display luminance levels selected for the AMLCD display used in the simulation were much higher than those available in a commercial headset
 - *More analysis is required to understand the relationship of the simulator luminance to that of an actual binocular display*