



Designing for Differences

How to Prevent Adverse Impact in Virtual Reality for Naval Aviation Training

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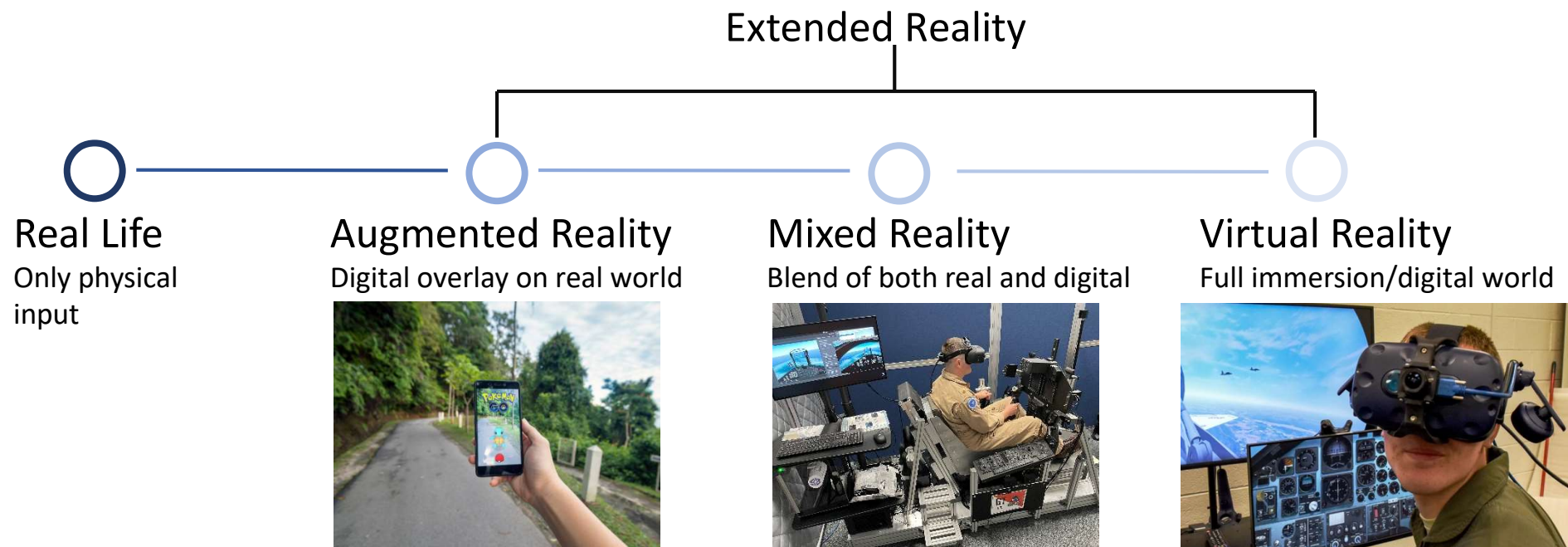
Overview

- Virtual Reality in Naval Aviation (Current and Anticipated)
 - Training
 - Assessment
 - Personnel Selection
- Potential for Unintentional Discrimination
 - Gender
 - Race
- Mitigation Strategies to Minimize Unintended Consequences



Virtual Reality

- VR falls under the XR umbrella
- Immersion in a “3D” virtual environment via hardware and software



VR in Naval Aviation

- Current
 - Training
 - Familiarity
- Future
 - Personnel selection
 - Assessment
- “Naval Aviation Training Next” uses VR and MR for training, content accessibility, instructional modules / 360 videos / publications





Avenger Class #1 Results:

- 25% faster completion of key milestones (e.g., solo flight)
- 14% fewer flights
- 8.5% faster to complete entire program
- Better than or equal to peers in advanced training phases



Sex Differences on VRSQ

Mann-Whitney *U* Tests by Sex

VRSQ Scale	Male		Female		<i>U</i>	Sig.	<i>r</i>
	Mean Rank	Median	Mean Rank	Median			
Oculomotor	45.71	33.3	46.73	33.3	864	0.866	0.018
Disorientation	41.53	13.3	57.17	20.0	1135.5	0.009	0.273
Total	43.82	23.3	51.46	27.9	987	0.212	0.131

Note. N = 91 (65 Male, 26 Female).

Takeaway:
Women reported more disorientation symptoms



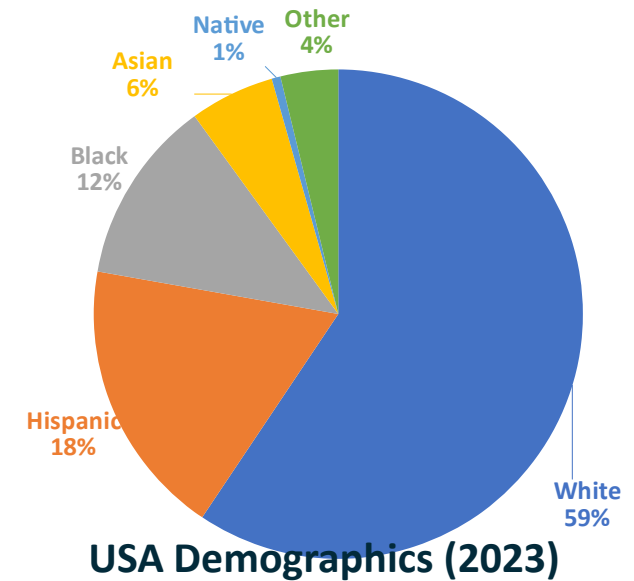
Adverse Impact (AI)

- Employment practices that unintentionally discriminate against demographic minorities
 - applies to hiring, training and development, promotions, terminations, transfer, and performance appraisals
 - 4/5ths or 80% rule
 - Ex) selection rate for a demographic subgroup is less than 80% of the group with the highest selection rate
- Integrating VR into employment practices has potential to favor certain subgroups over others



Aviation Demographics

- Military Aviators:
 - 92.3% Male, 7.7% Female
 - 82% White, 6.9% Hispanic or Latino
- NFOs:
 - 88.7% Male, 11.3% Female
 - 71.2% White, 11.4% Hispanic or Latino

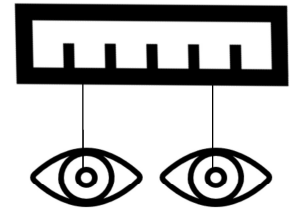


AI in VR

- How can VR introduce adverse impact or negatively impact one group?
- Potential future causes of AI:
 - Interpupillary Distance
 - VR Experience
 - Cybersickness



Interpupillary Distance

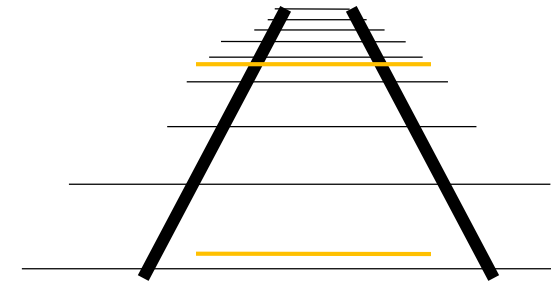
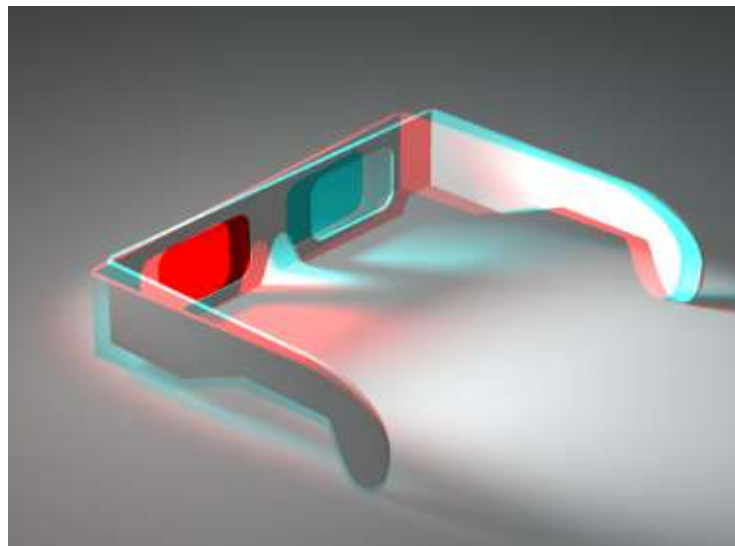


- IPD
 - Separation between the visual axes of the eye
 - Distance Viewing
- Importance of IPD Measurement
 - Binocular Viewing Systems
 - NVGs
 - Binocular Microscopes
 - HMDS (VR)



Stereoscopic Viewing

- Human eye is easy to trick
- We use perspective cues to see depth
 - Anaglyph invokes 3d Stereoscopic effect using chromatically opposite colors
 - Perceive as one 3d image



Ponzo Illusion

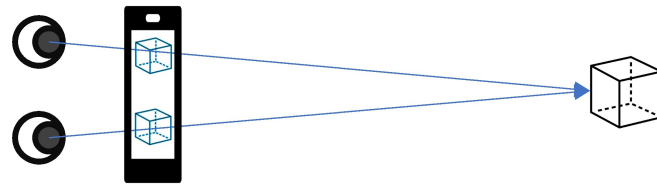


• Jastrow Illusion



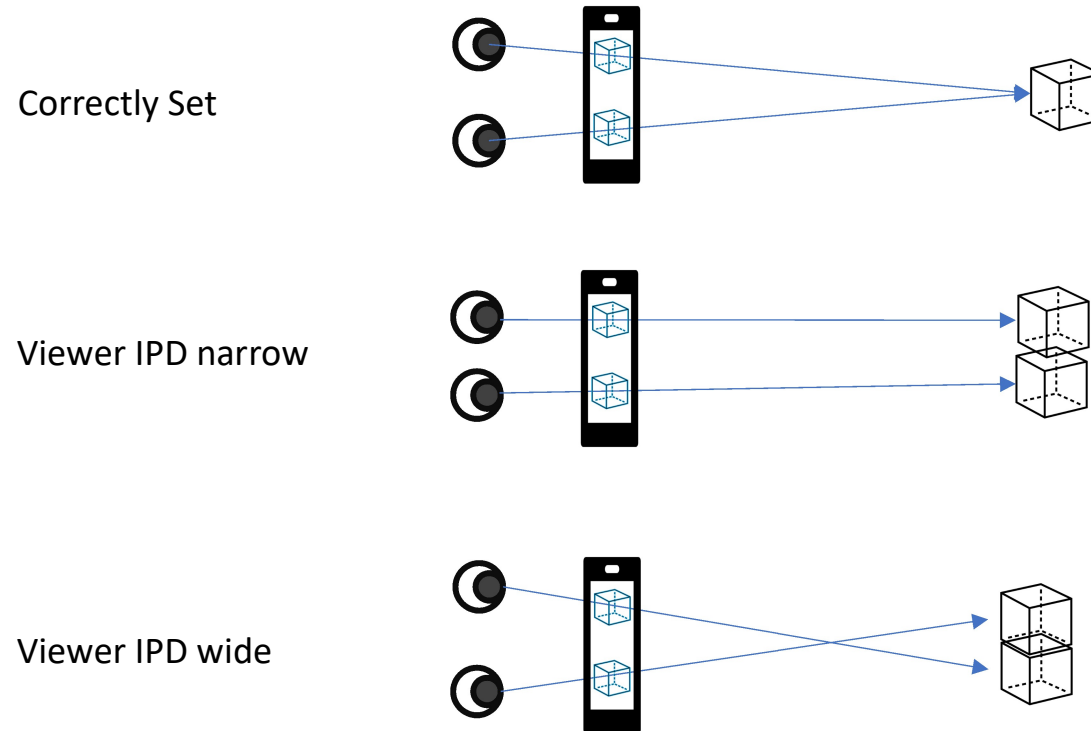
How VR “tricks” the eye

- A binocular HMD provides left image to left eye, right image to right eye
 - (Anaglyph invokes 3d Stereoscopic effect using chromatically opposite colors)
 - Perceive as one 3d image



IPD in VR

- To present different images to each eye, VR headsets must account for variability in individual IPD



IPD diversity

- ~2% of adult white American females have an eye separation less than 55 mm (Hofstetter, 1972).
- A 5th percentile female IPD is 55.5 mm (US Army Anthropomorphic Survey database, Gordon et al., 2014)
- Neil Dodgson's *Variation and Extrema of Human Interpupillary Distance*
 - “mean adult IPD is around 63 mm, the vast majority of adults have IPDs the range 50-75 mm, the wider range of 45-80 mm is likely to include (almost) all adults”
 - Breaks down IPD by sex and race



IPD diversity

- It is probable that the separation less
- Neil Dodgson's Variation and Extrema of Human Interpupillary Distance

Gender	Male	Female
Number	1771	2205
Minimum	52	52
Mean	64.67	62.31
Maximum	78	76
St'd Dev.	3.708	3.599

[58.71, 65.91]

- "mean adult IPD is a ... the vast majority of adults have IPD ... the range 50-75 mm, ... the wider range of 45-80 mm is likely to inc

[62.13, 69.11]

Racial group	white	black	Hispanic	Asian/Pacific Islander	American Indian	other
Number	2302	1376	125	58	26	89
Minimum	52	56	57	55	59	56
Mean	61.99	65.62	63.54	63.17	65.12	63.26
Maximum	75	78	71	71	72	70
St'd Dev.	3.429	3.489	3.104	3.146	4.003	3.315



Ideal IPD range

- As low as 58.7 mm to include -1SD of women
- As high as 69.11 mm to include +1SD African Americans
- Likely greater range for subgroups
- 68-95-99.7 rule



<https://www.vr-compare.com/>

210 commercially available VR/AR HMDs

104 have adjustable hardware for IPD range

71 headsets go as high as 69.11 mm

57 headsets go as low as 58.71



- Only 2 headsets go up to 78 mm (maximum)
- Only 1 headset goes as low as 52 mm (minimum)



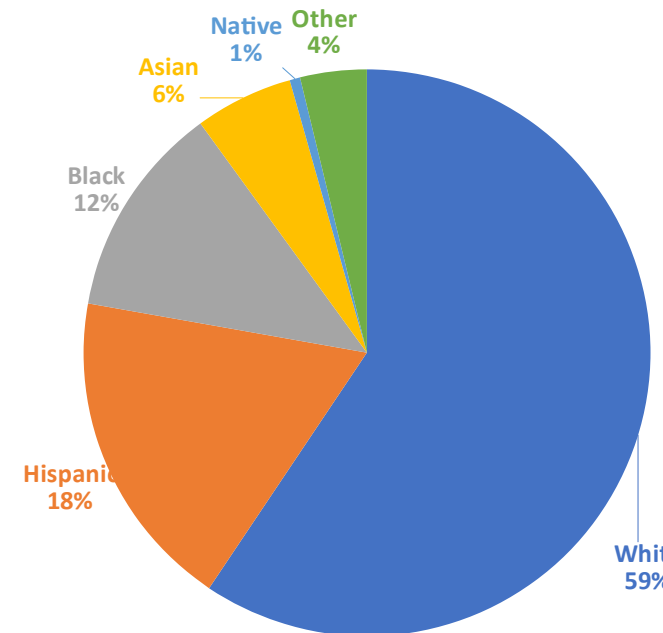
Sex and VR Research

- Women reported more disorientation symptoms (VRSQ) in an end-of-course survey (CNATRA, 2021)
- In general, women report higher scores on cybersickness measures (especially when IPD is not taken into account; Stanney et al., 2020)
 - Overall adverse effects higher on SSQ
 - Effects persisted longer
 - 22.0% higher scores on oculomotor subscale
 - 24.5% higher on disorientation subscale
- Women are statistically underrepresented as authors and participants in VR research (Peck et al., 2020)



Gamer Demographics (Zippia.com)

- In the USA...
- 82.7% of self-identified “gamers” are White
- 8.1% are Hispanic or Latino
- 3.9% are Asian
- 3.5% are African American



USA Demographics (2020)



Virtual Reality Demographics

- Survey of ages 16-64
 - 30% of men have used a VR headset
 - 16% of women have used a VR headset
- Of individuals who OWN a VR headset
 - 85.7% are male
 - 14.3% are female



Performance in VR

- Practice gaming (and practice in VR) correlates to skill at judged performance in games/VR
- Madden et al., 2020 “Ready student one: Exploring the predictors student learning in virtual reality”
 - Game experience and gender predicted performance
 - Game experience and gender were highly correlated
 - “either video game experience, being male, or a combination of the two provides an advantage”



Potential Issues of VR and Equity

- Fewer headsets offer IPD range to accommodate all women and minorities
- Women and minorities have less video game experience (potential impact on graded activities or learning)
- Women report higher experiences of cybersickness on subjective measures



Solutions

- Problem: Fewer headsets offer IPD range to accommodate all women and minorities
- Invest in those headsets with wider IPD ranges
 - Increased customization = increased diversity
 - This helps everyone: those on far ends of the range, those with 2 different measurements for monocular PD



Solutions

Problem: women and racial minorities have less video game experience (potential impact on graded activities or learning)

- STEM initiatives: encourage / sponsor VR based gaming and e-sports in women and minorities
- Inclusion of more diversity in research participants
- More practice events in VR, with “graded” events mainly in real world environments



Solutions

- Problem: women experience more cybersickness symptoms
- (Potential) cybersickness mitigation strategies
 - Wearables
 - Pharmaceuticals
 - Hardware Refinement
 - Software Refinement
 - Behavioral





Why does this matter?

- women comprise only 3%, and minorities are 9%, of Naval Aviation's Commanding Officers, Major Commanders, and Flag Officers
- 1/10 women who begin flight training serve beyond initial service obligation
- 1/8 minority aviators continue beyond initial service obligation
- In order to attract and retain best personnel, we must embrace the diversity of our population



Questions?



PERCENTILES				
FEMALES			MALES	
<u>CM</u>	<u>IN</u>		<u>CM</u>	<u>IN</u>
5.35	2.11	1ST	5.60	2.20
5.40	2.13	2ND	5.70	2.24
5.45	2.15	3RD	5.75	2.26
5.55	2.19	5TH	5.85	2.30
5.70	2.24	10TH	6.00	2.36
5.80	2.28	15TH	6.05	2.38
5.85	2.30	20TH	6.15	2.42
5.95	2.34	25TH	6.15	2.42
6.00	2.36	30TH	6.20	2.44
6.05	2.38	35TH	6.25	2.46
6.10	2.40	40TH	6.30	2.48
6.15	2.42	45TH	6.35	2.50
6.20	2.44	50TH	6.40	2.52
6.20	2.44	55TH	6.45	2.54
6.25	2.46	60TH	6.45	2.54
6.30	2.48	65TH	6.50	2.56
6.35	2.50	70TH	6.55	2.58
6.40	2.52	75TH	6.60	2.60
6.45	2.54	80TH	6.70	2.64
6.55	2.58	85TH	6.75	2.66
6.65	2.62	90TH	6.85	2.70
6.75	2.66	95TH	7.00	2.76
6.85	2.70	97TH	7.05	2.78
6.95	2.74	98TH	7.15	2.81
7.05	2.78	99TH	7.25	2.85

IPD from ANSUR

