Drawing Visual Perception

Robert Pepperell
Cardiff Metropolitan University & Fovotec

1.
The world

2.
The perception of the world

1.
The world

2.
The perception of the world

1.
The world

3.
The depiction of the world

2.
The perception of the world

4.
The perception of the depiction of the world

1.
The world

3.
The depiction of the world

The mental display

The world

The physical display

Two kinds of display


SUHD TV
Quantum dot display


SAMSUNG


distant journeys

How do we align what we perceive in our mental display when looking at the world with what we perceive when looking at physical displays?

The mental display

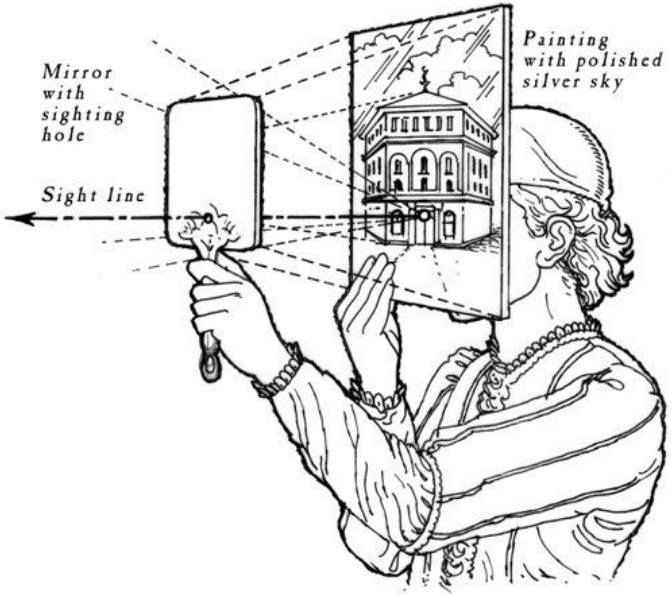
The world

The physical display

How can these be best aligned?

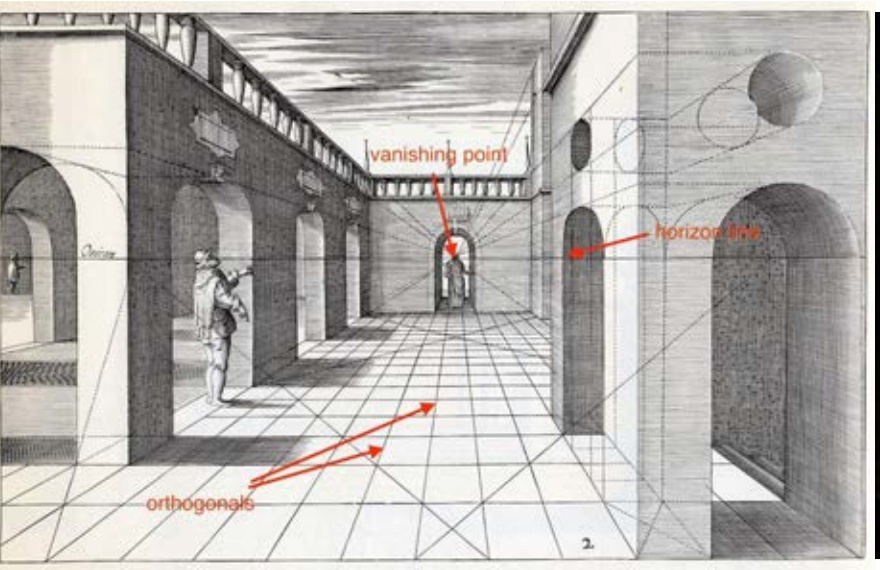
Here I’m talking about the geometry of visual space rather than colour, dynamic range, contrast, sensitivity, etc.

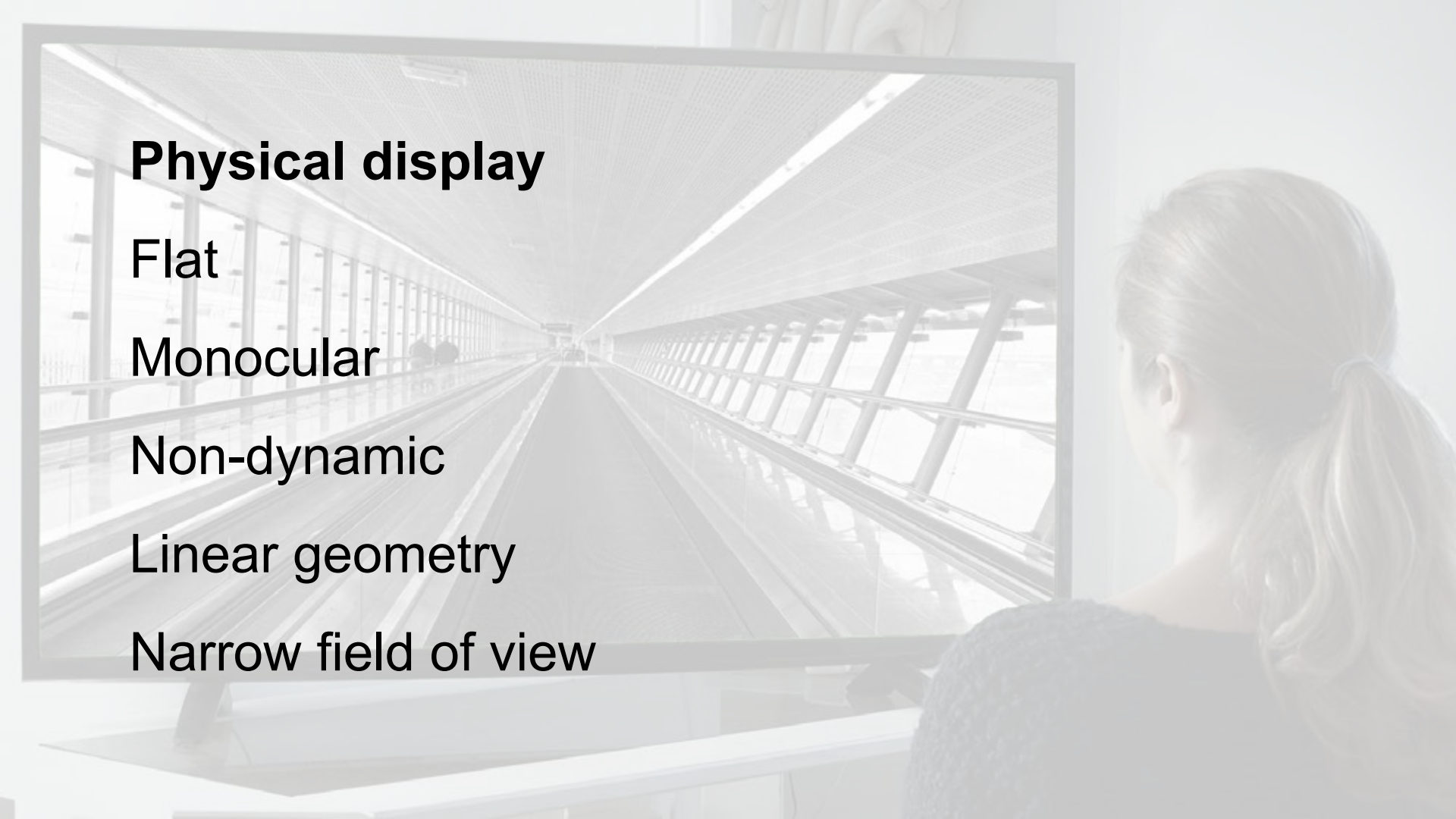
In terms of spatial geometry, for a long time the standard approach has been to use linear perspective…



Brunelleschi (c. 1420)

Linear perspective geometry





Physical display

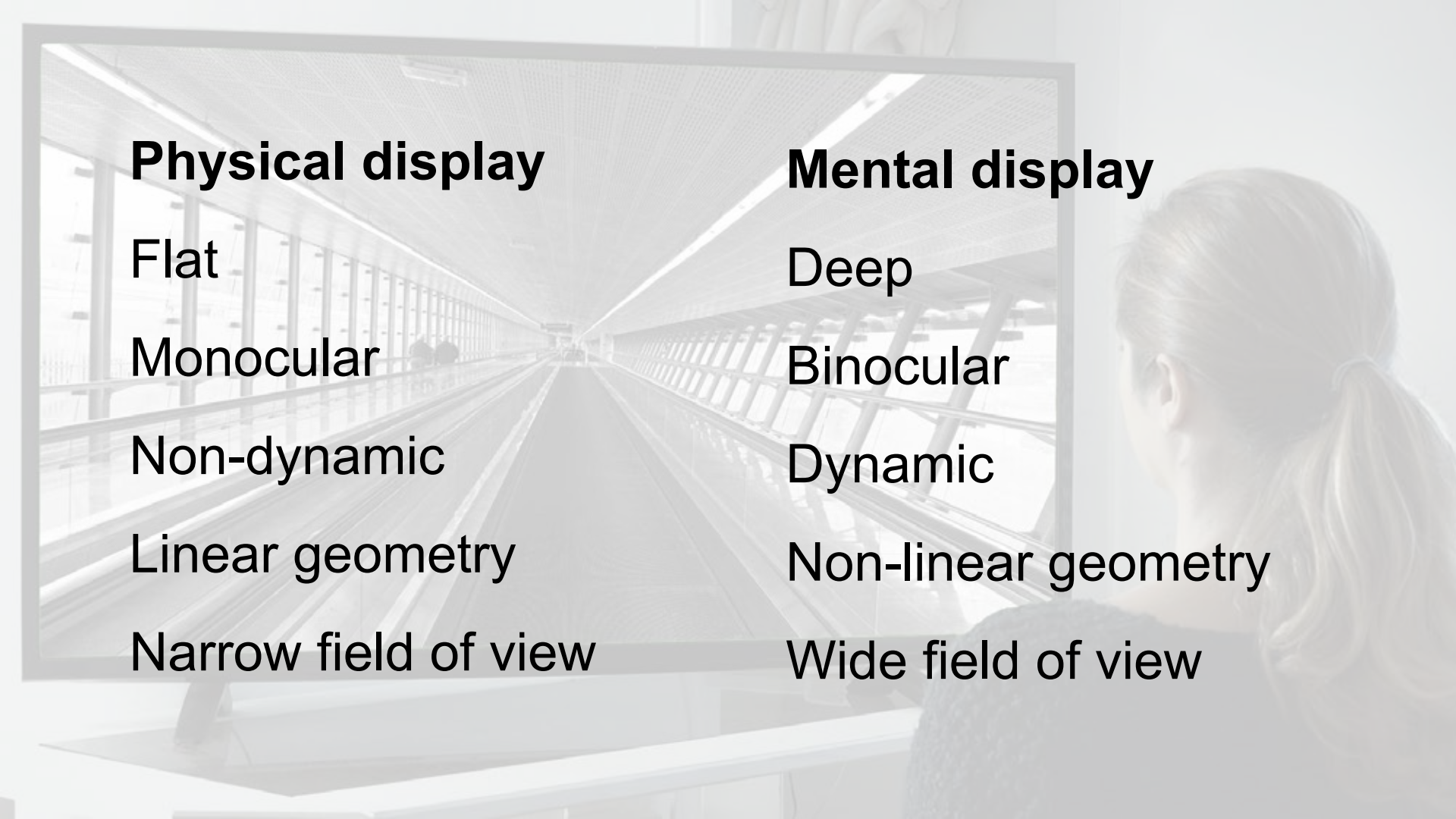
Flat

Monocular

Non-dynamic

Linear geometry

Narrow field of view



Physical display	**Mental display**
Flat	Deep
Monocular	Binocular
Non-dynamic	Dynamic
Linear geometry	Non-linear geometry
Narrow field of view	Wide field of view

Linear perspective does not reflect the non-linear geometry of visual space

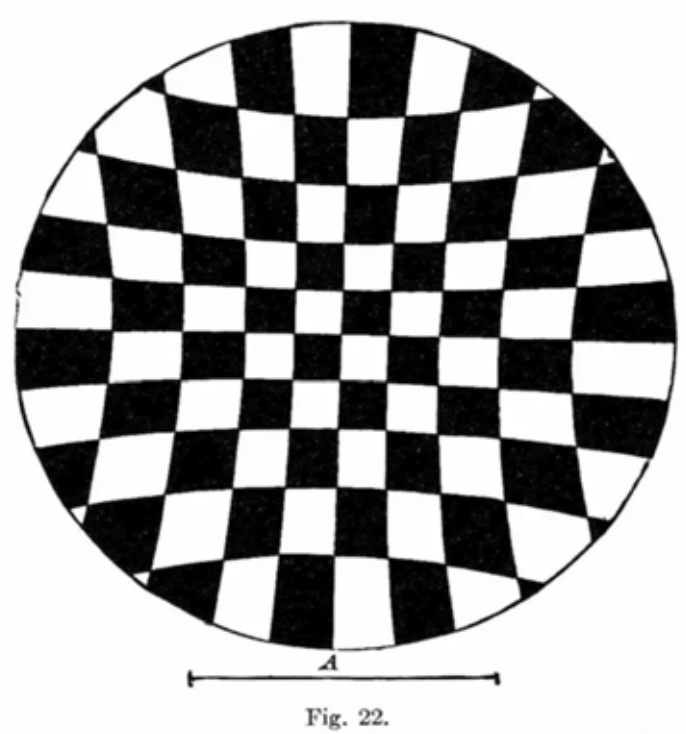


Fig. 22.

Helmholtz (1866)

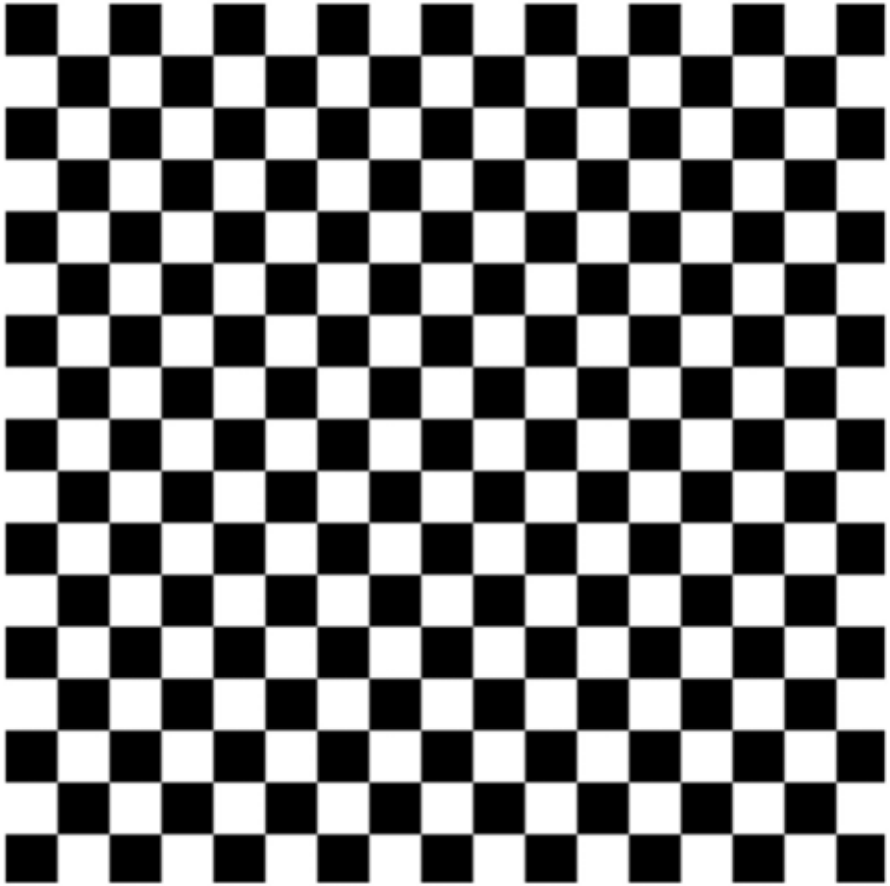
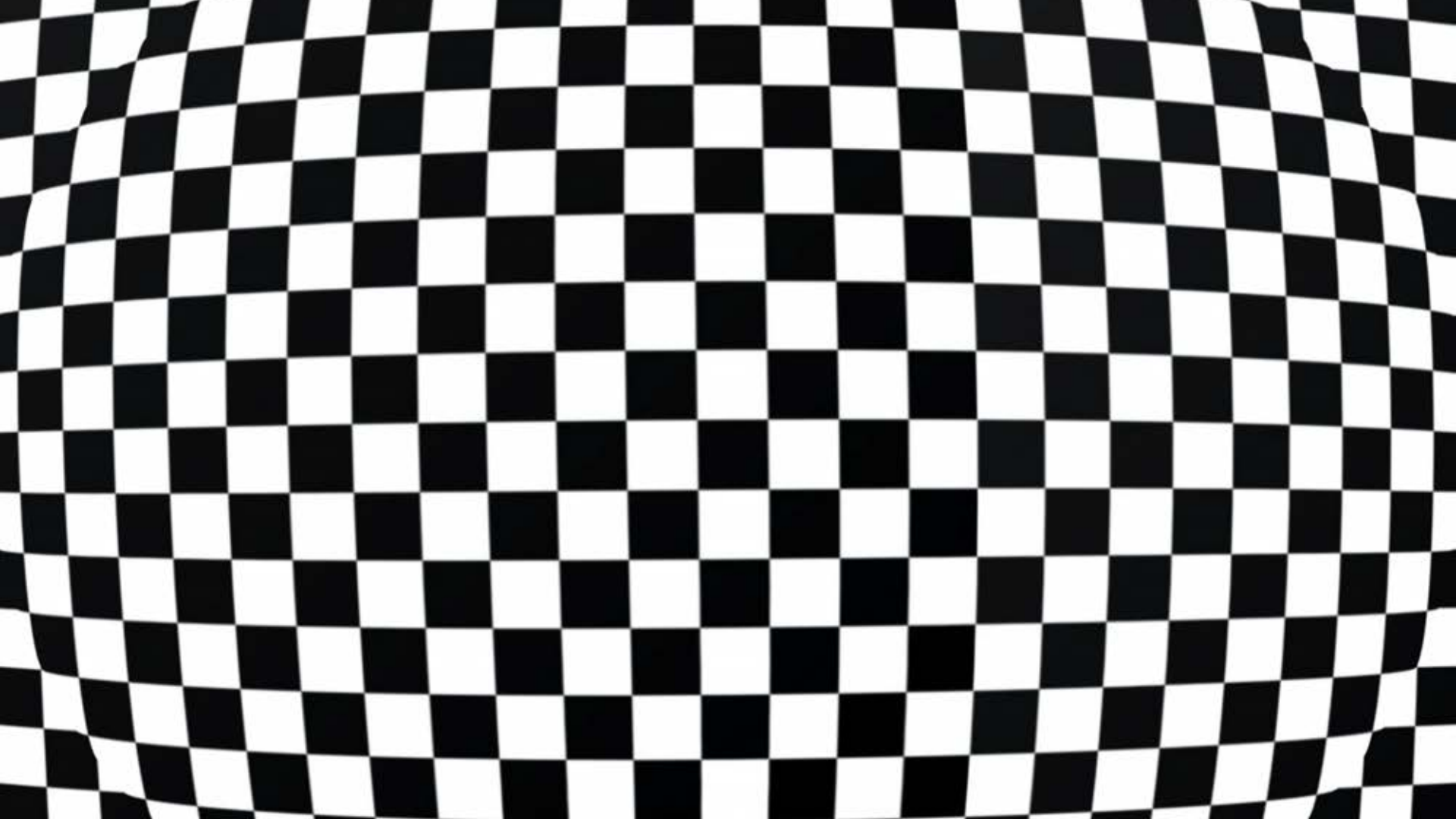
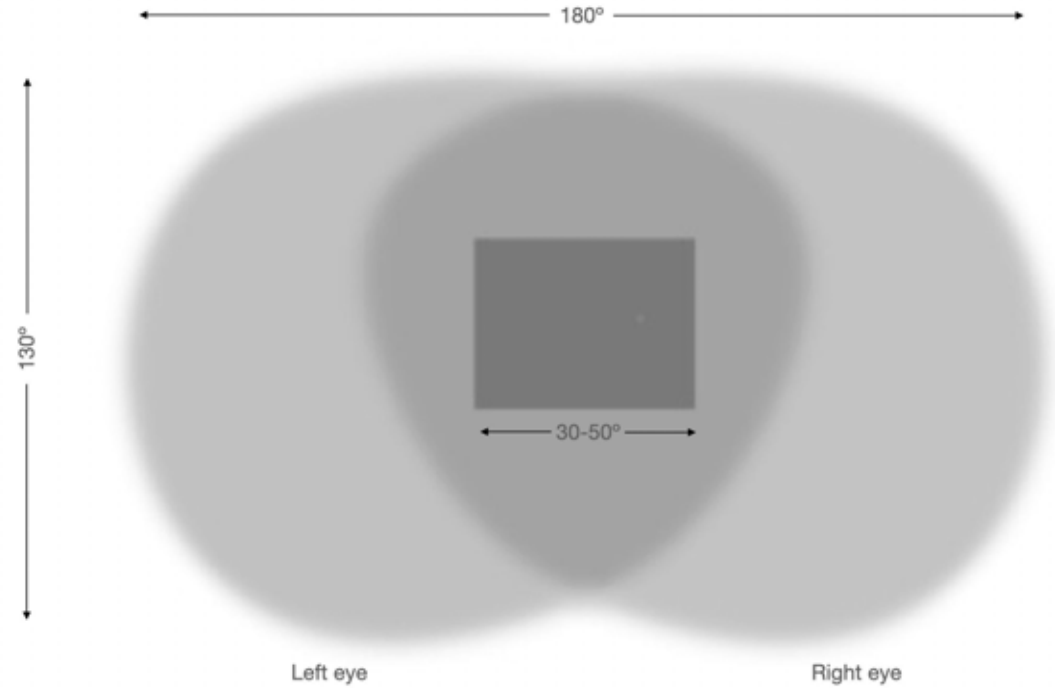


Figure 1. The bulging grid.

Foster & Altschuler (2001)



Linear perspective cannot adequately represent the full scope of the human field of view



After Gibson (1950)

(a) A wide-angle photo with distortions on subjects' faces.

150º horizontal

How can we align the space that appears on physical displays more closely with that of our mental display?

Natural perspectives based on non-linear projections…

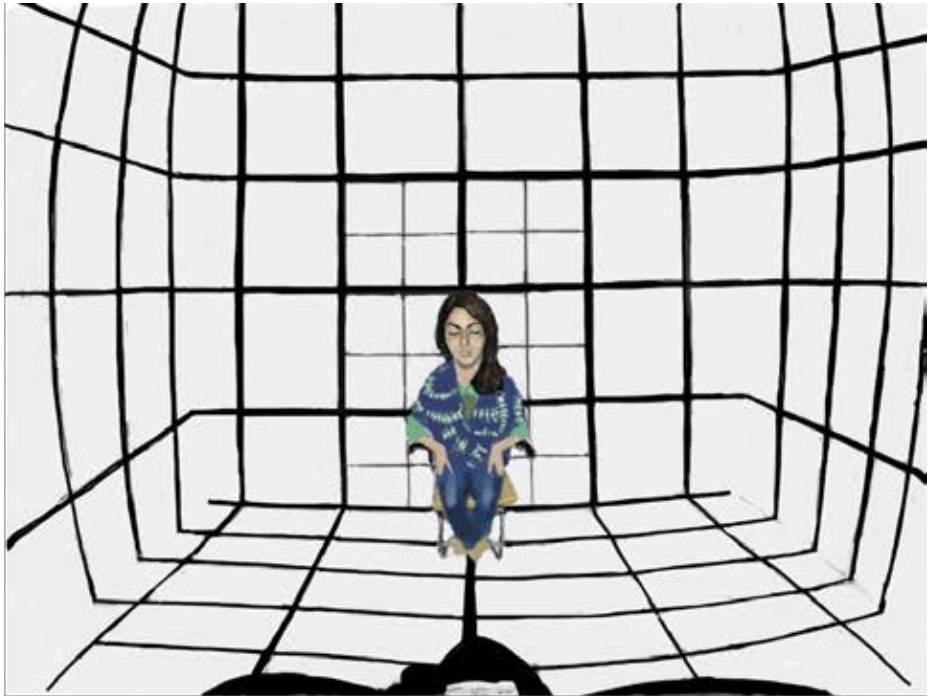
Linear Perspective

Natural Perspective

Self As Seen (after Mach), 2012, iPad

Self Portrait (after Mach), 2012, Oil

Optical perspective (Fisheye)

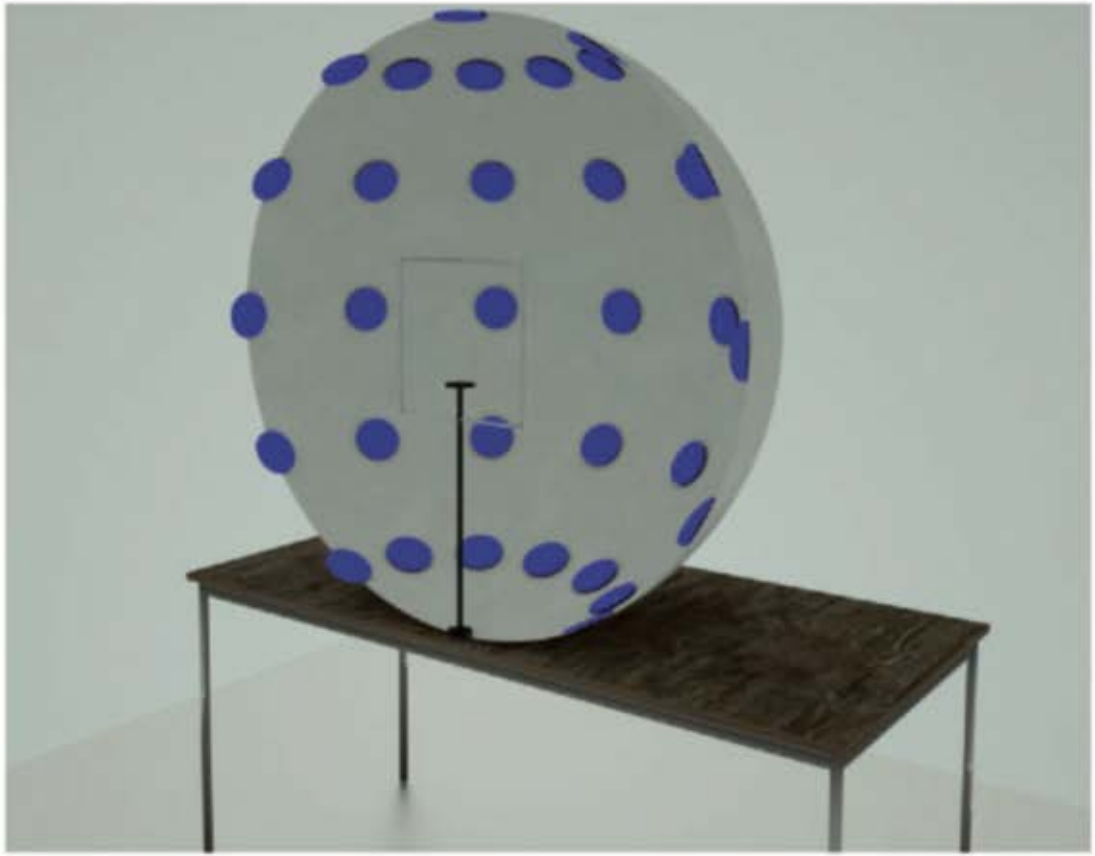


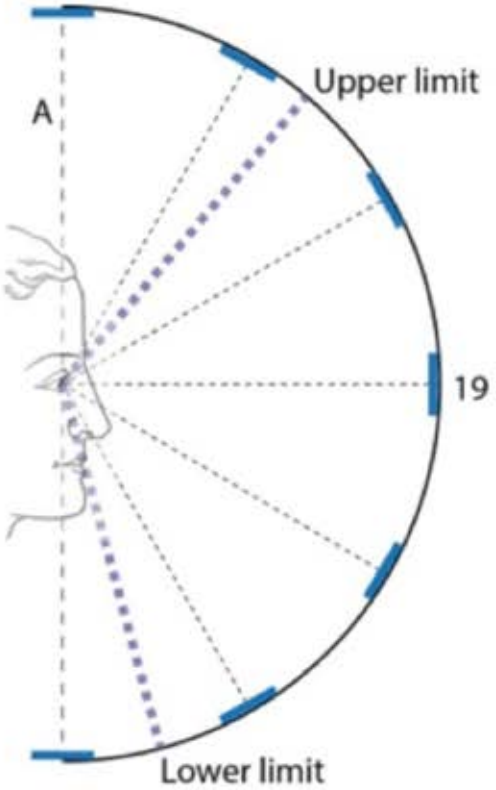
Natural perspective

Fixated objects seem bigger and closer

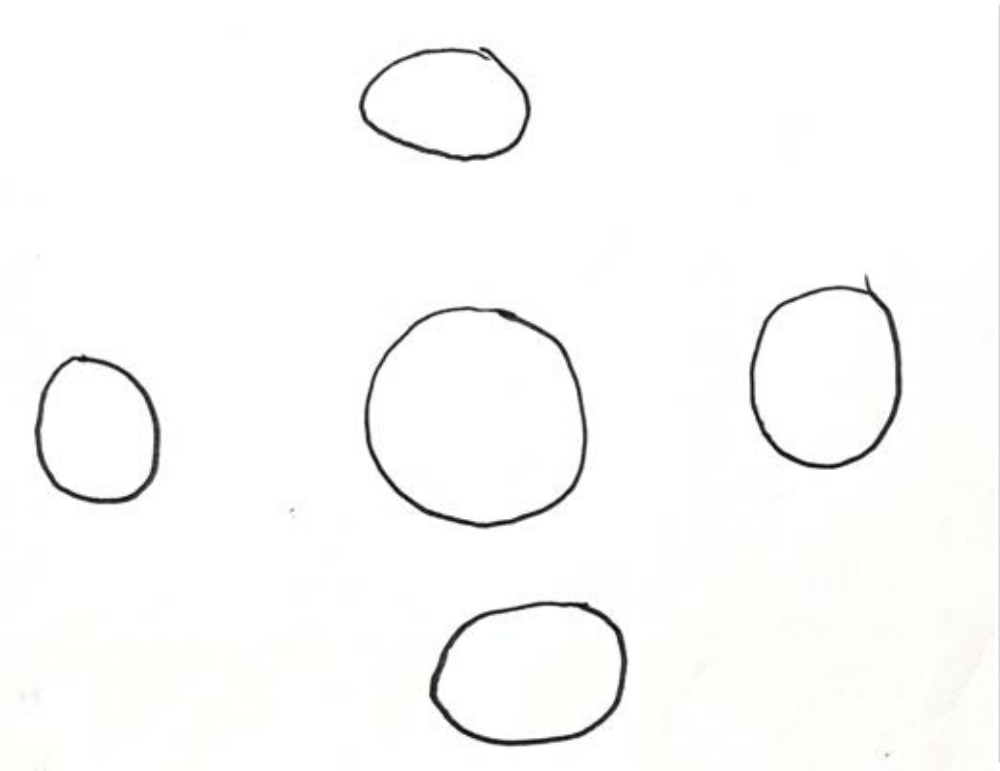
JMW Turner, The South Wall of the Square Dining-Room, gouache and watercolour on paper, 1827 ©Tate

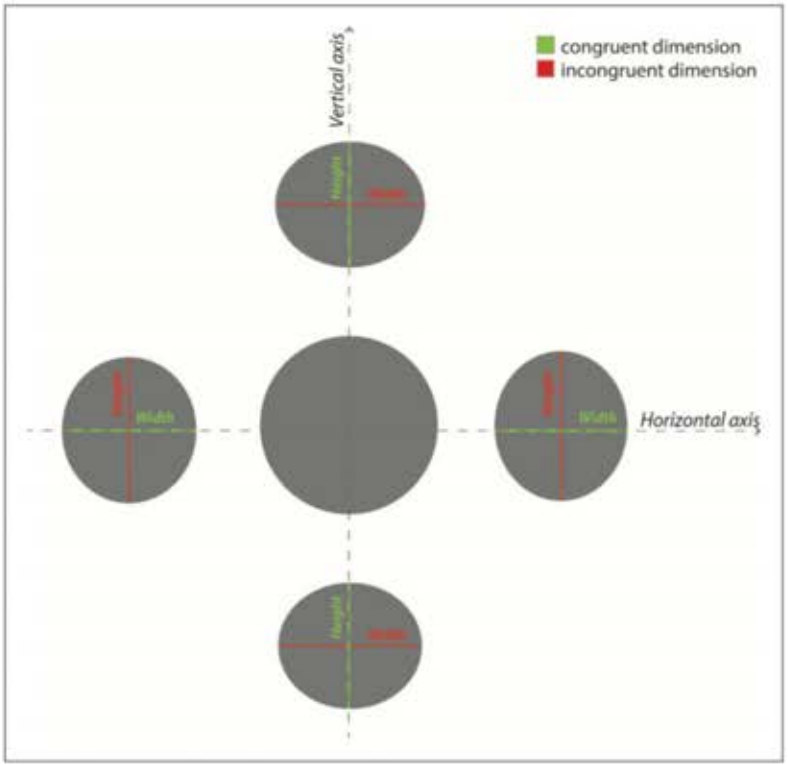
Measuring the structure of visual space with art and science



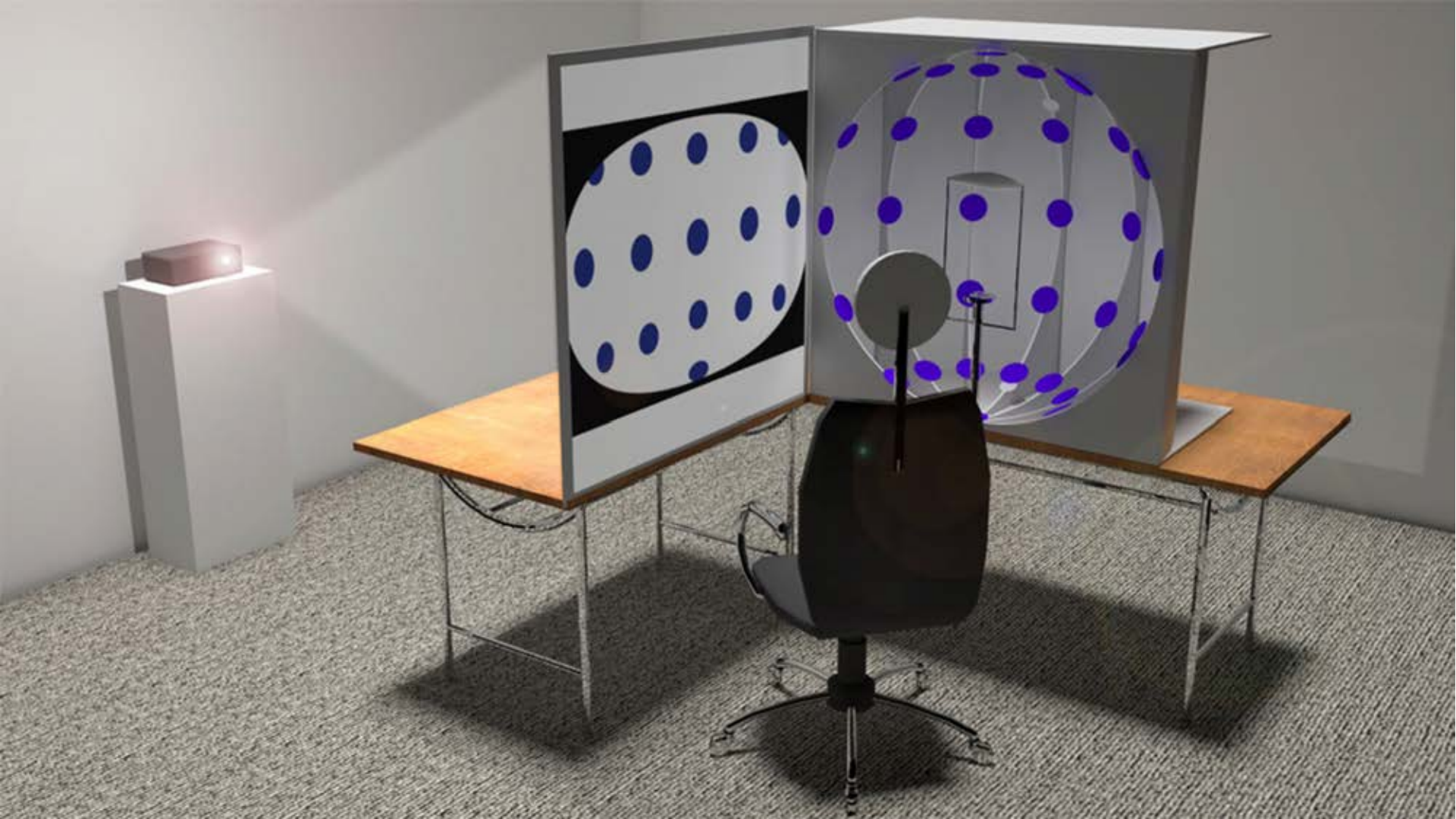


Baldwin et al. (2015)

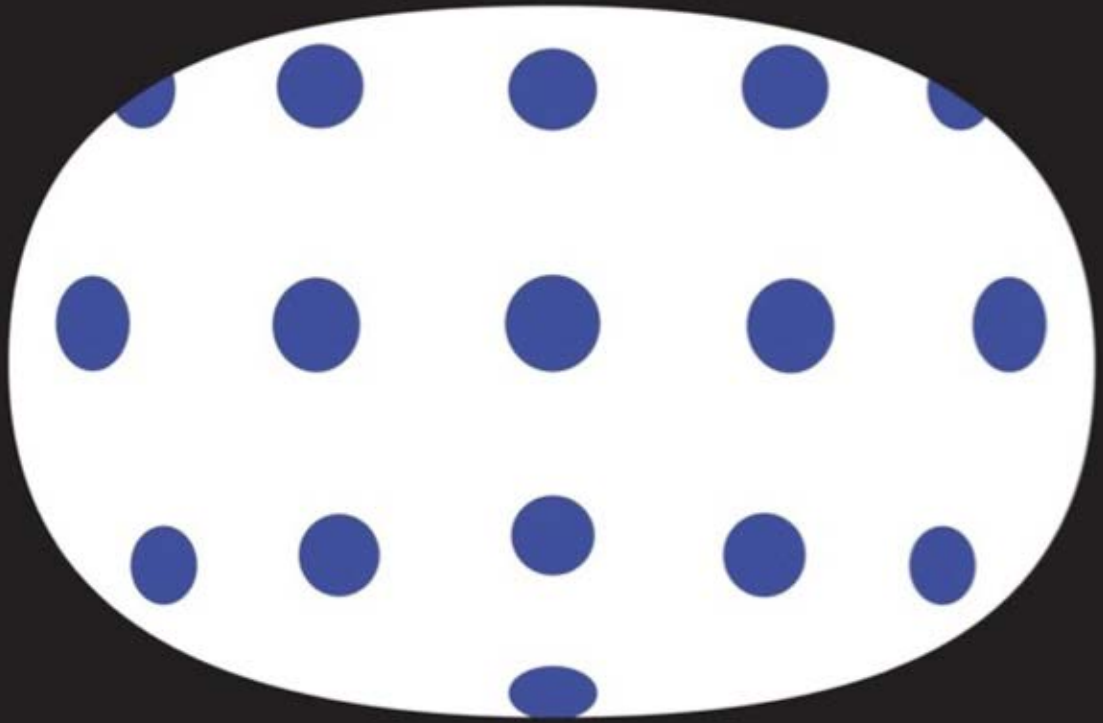




Baldwin et al. (2015)

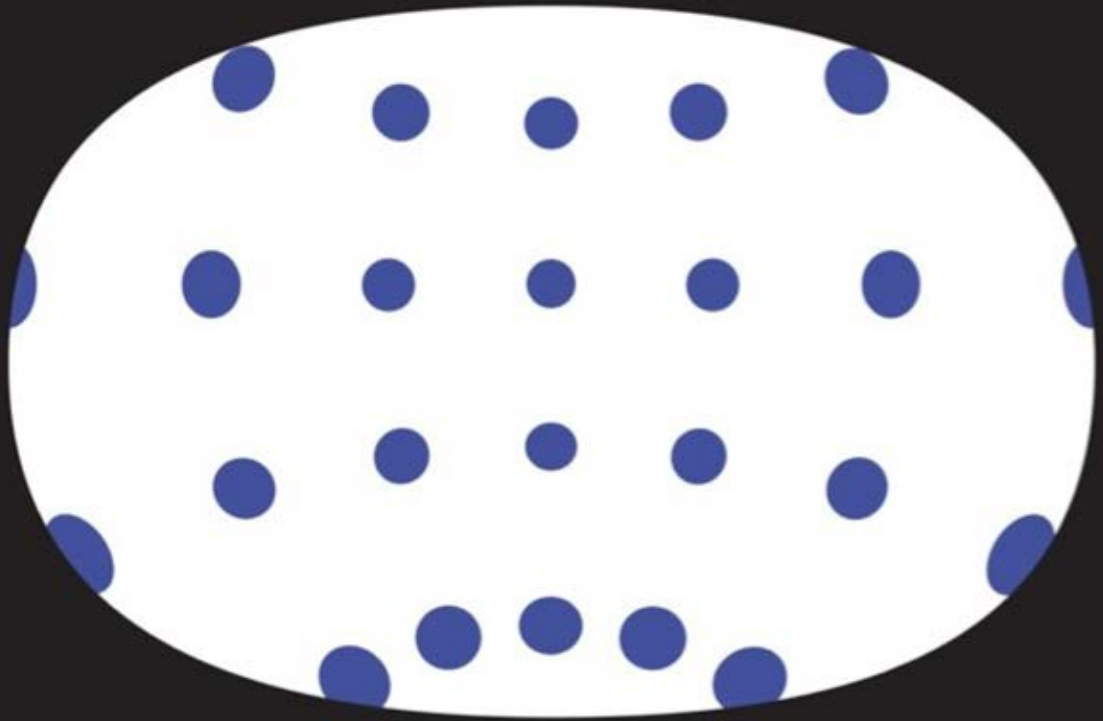


very high | high | moderate | low | very low



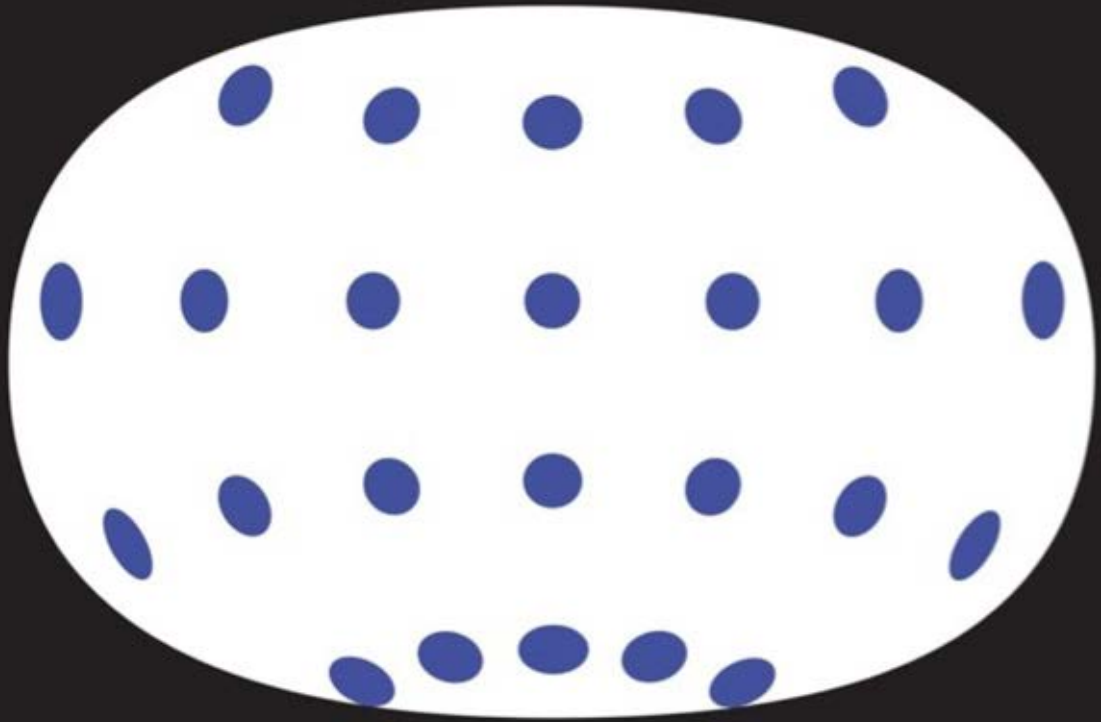
Artistic

very high | high | moderate | low | very low



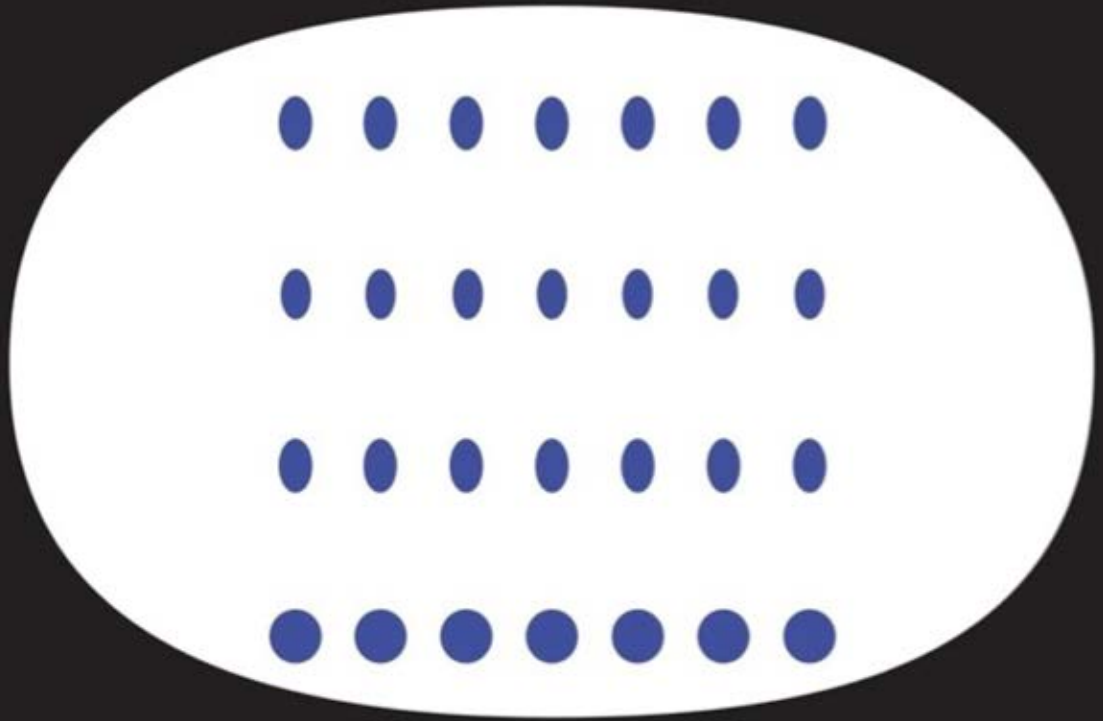
Stereographic

very high | high | moderate | low | very low



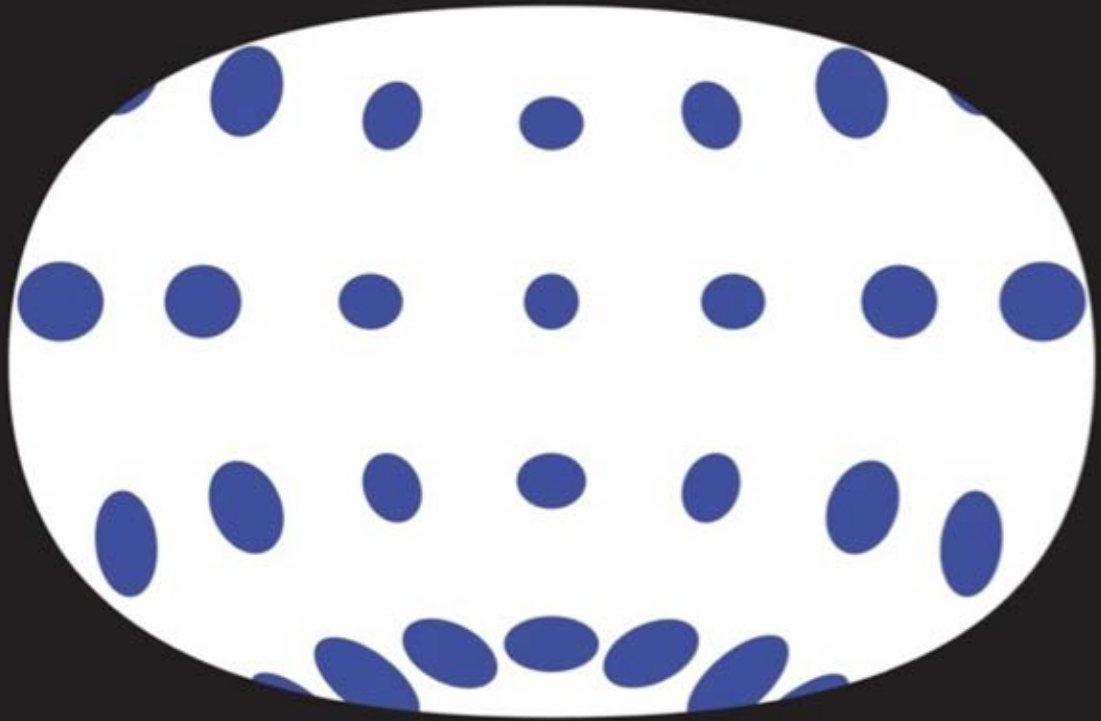
Fisheye monocular

very high | high | moderate | low | very low

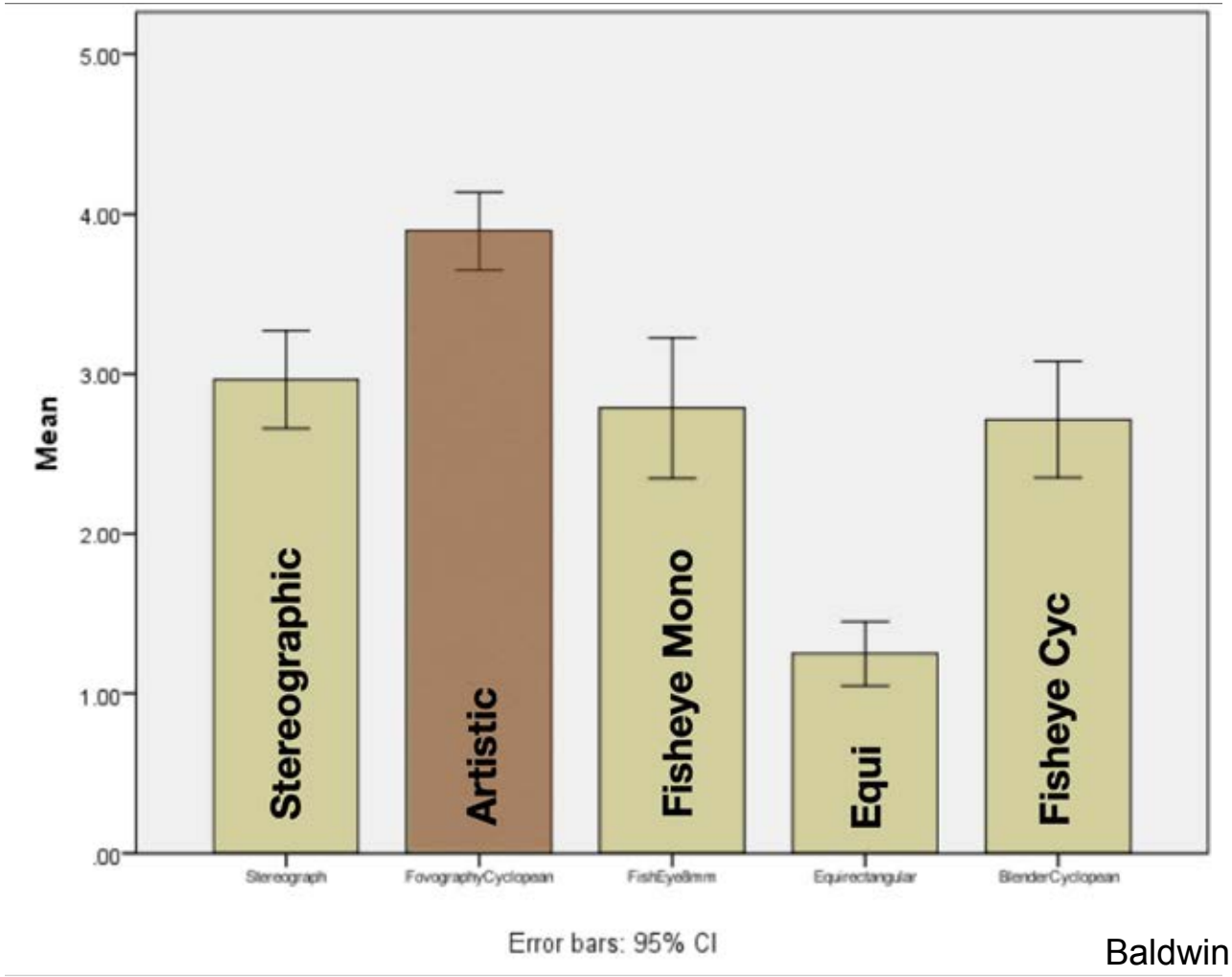


Equirectangular

very high | high | moderate | low | very low

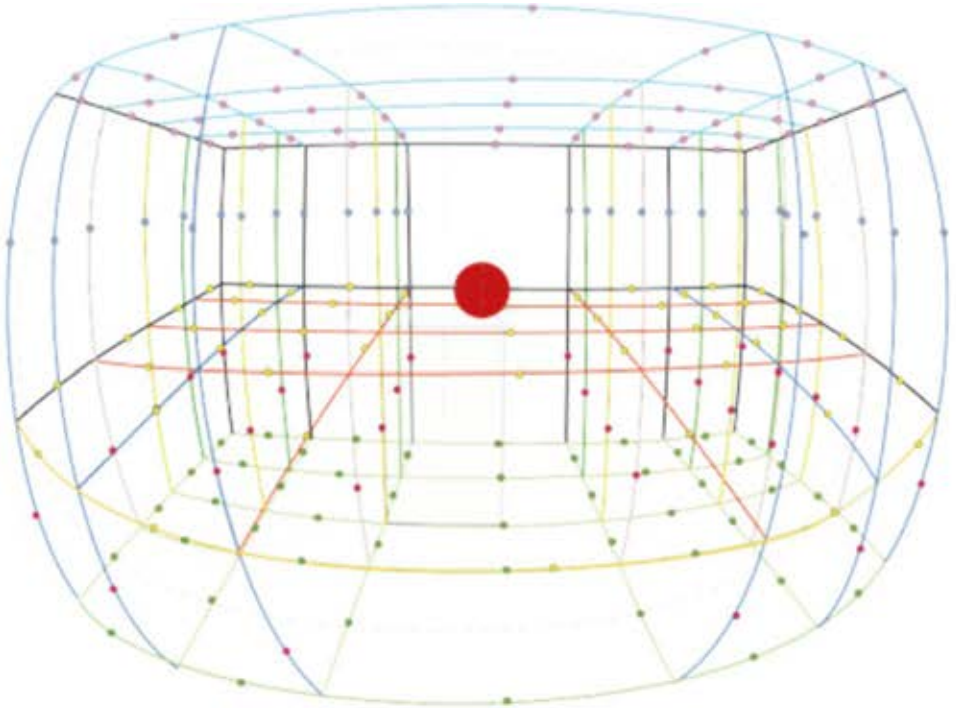


Fisheye cyclopean



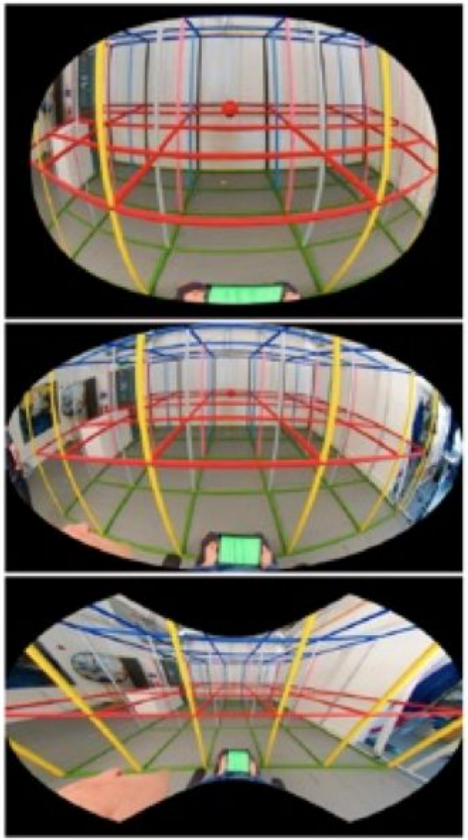
N = 30

Baldwin et al. (2015)



Burleigh et al. (2018)

Photographic stimuli

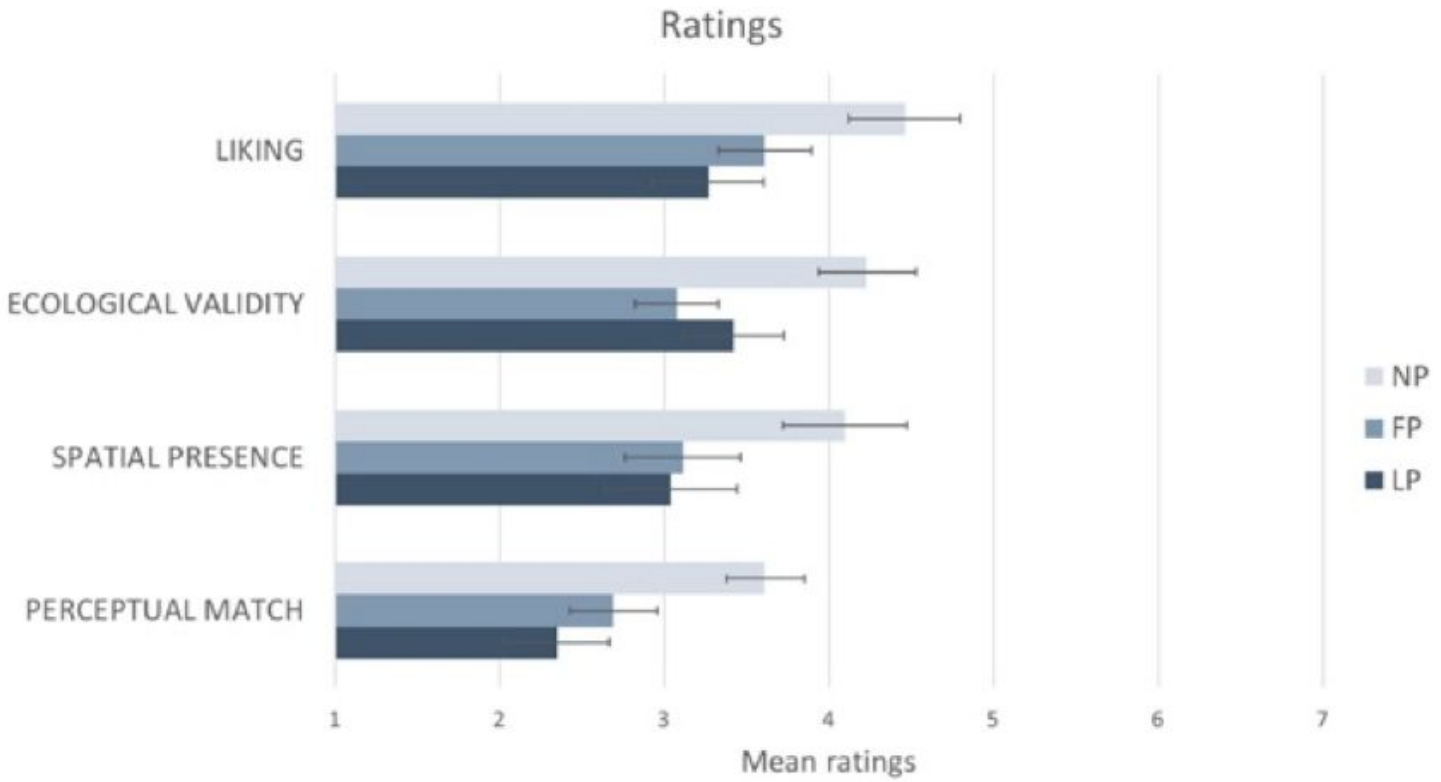


Natural perspective (NP)

Fisheye perspective (FP)

Linear perspective **(LP)**

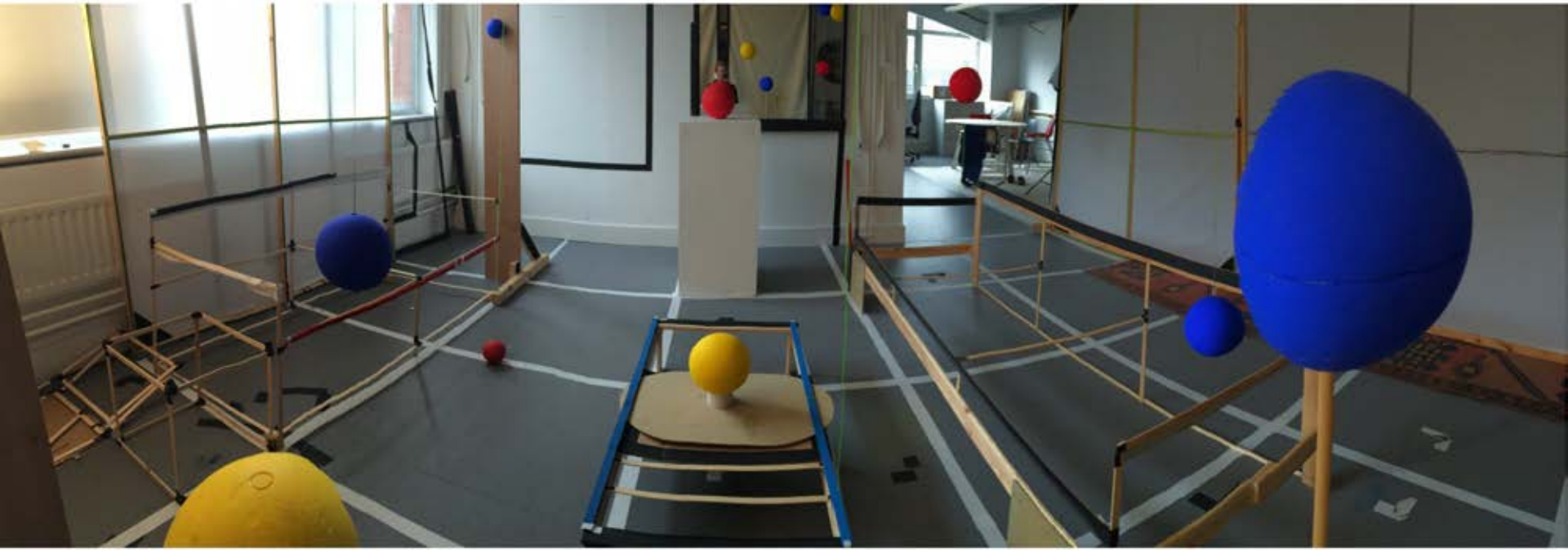
Burleigh et al. (2018)

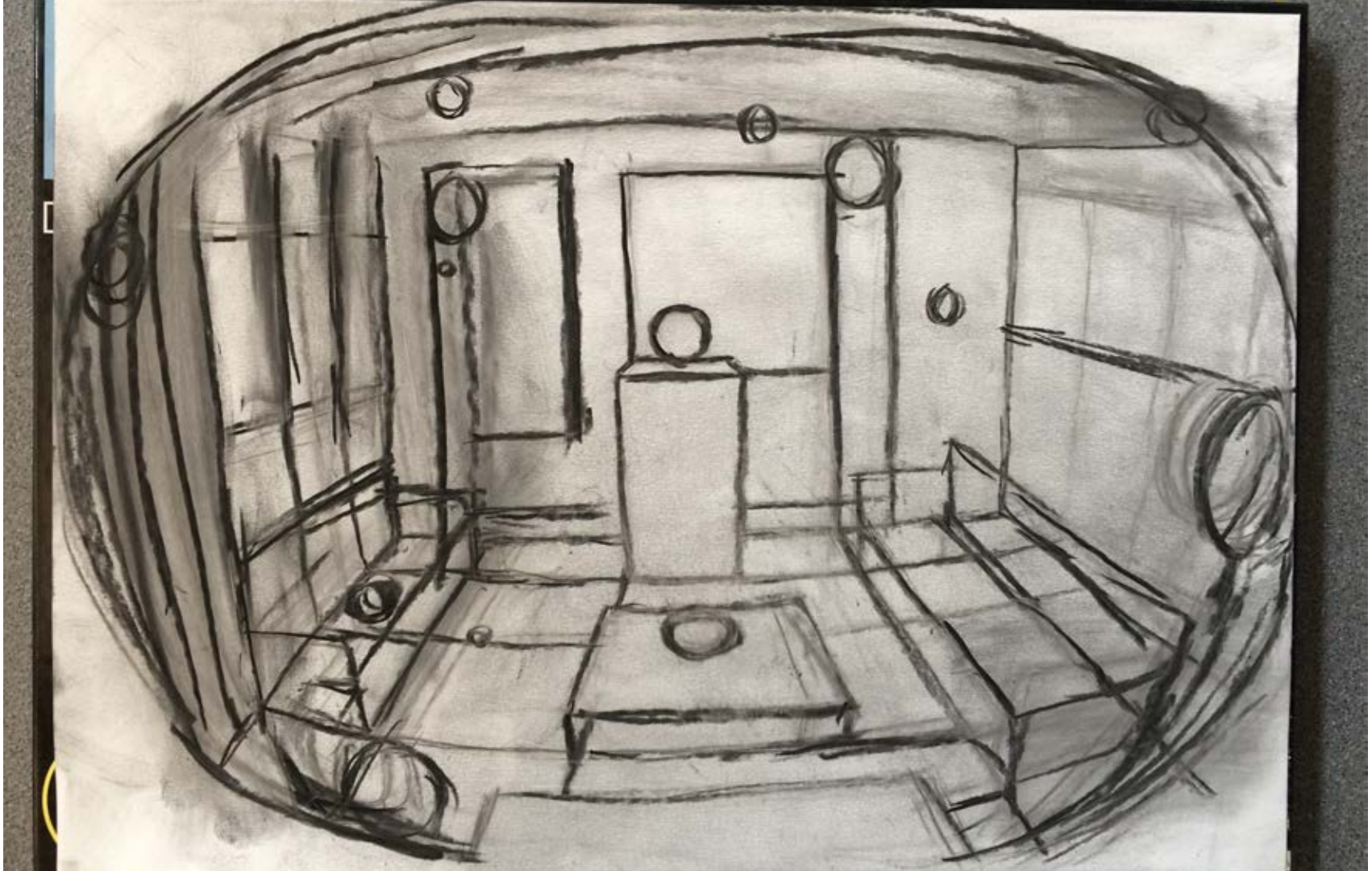


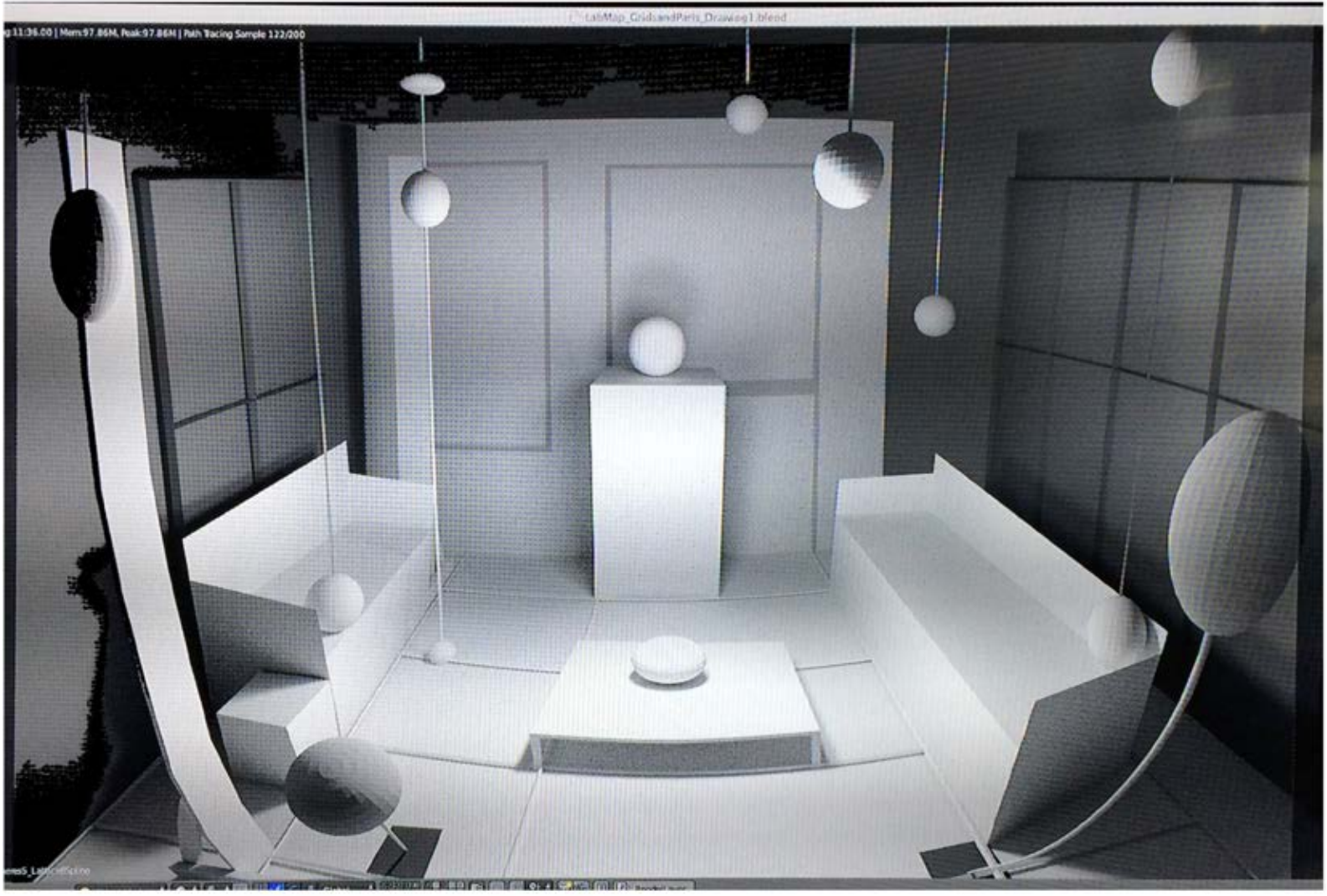
N = 30

Burleigh et al. (2018)

Computational modelling of visual space geometry






11:36.00 | Mem:97.86M, Peak:97.86M | Path Tracing Sample 122/200

Natural perspective rendering

FovoRender

- Runs in Unreal 4.27.2 (current primary) & past versions in Unity, Cinema 4D (with either C4D's standard renderer, or Octane, or Arnold Renderers using Open Shading Language)
- Real time and path tracing modes:

  - Real time rasterizer mode adjusts vertex shader and adds tessellation on GPU

  - Path tracing mode alters ray direction, origin, and shape
- Both modes employ non linear projection techniques to adjust an image volumetrically (not a screen space or lens effect)
- Default settings are provided mapped to features of visual perception
- Or flexible user controlled settings based on subjective values for creative effect


Linear render


FovoRender


Linear render


FovoRender

Gaming

Linear render

Gaming

Metaverse/Social

Linear render

Metaverse/Social

Visualisation

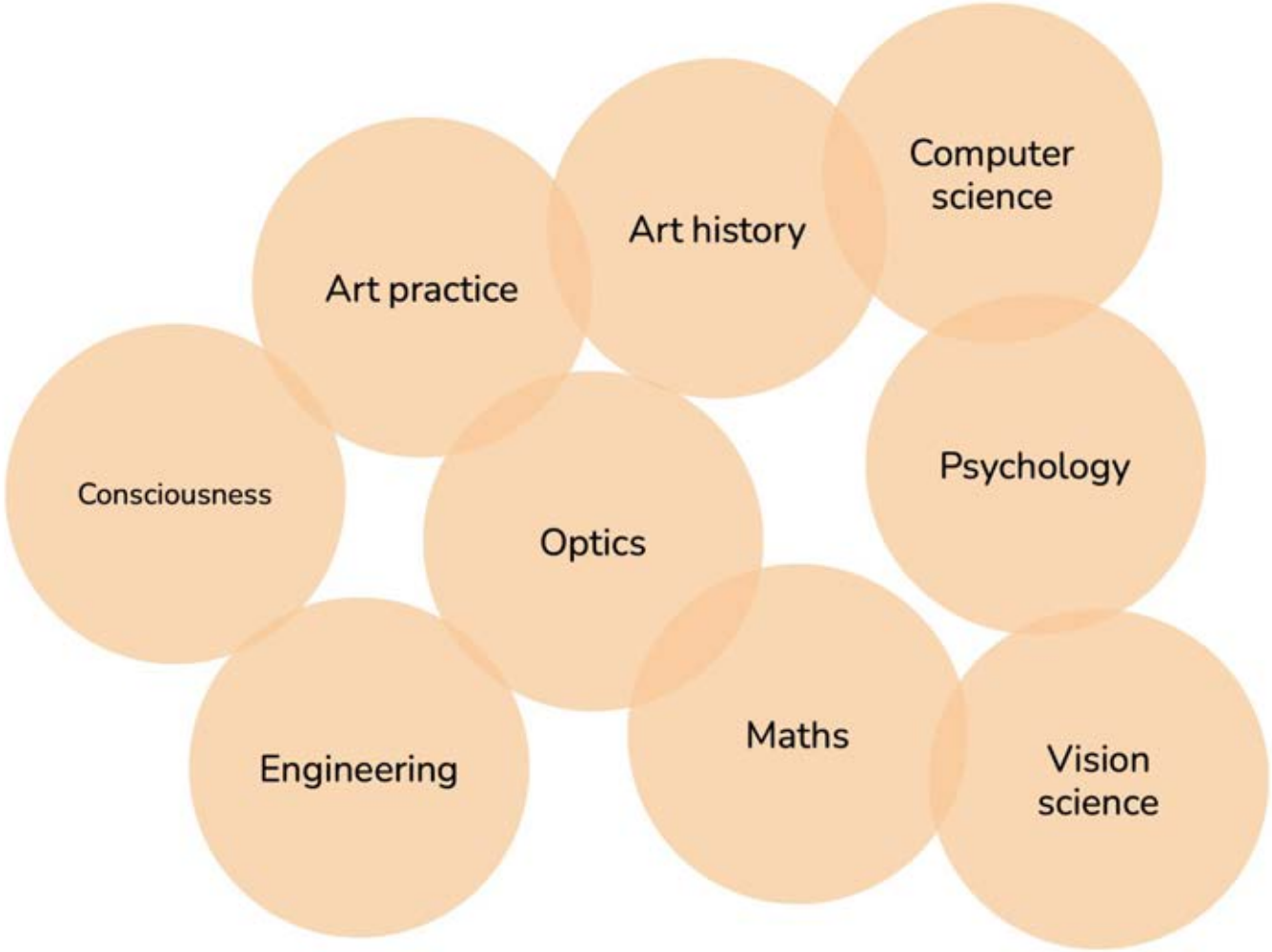
Linear Perspective: 120° Equivalent

DAVIDBAYLIS
DESIGN

FovoRender: 120° Equivalent

DAVIDBAYLIS
DESIGN

Related work


Computer science
Art history
Art practice
Consciousness
Optics
Psychology
Engineering
Maths
Vision science

Non-linear rendering and computational photography

Agrawala. M., Zorin, D. & Munzer, T. (2000). Artistic Multiprojection Rendering. Rendering Techniques, DOI:10.1007/978-3-7091-6303-0_12.

Carroll, R., Agrawala, A., and Agrawala, M. (2010). Image Warps for Artistic Perspective Manipulation. ACM Trans. Graph. 29.4 (July 2010). ISSN: 0730-0301. DOI: 10 . 1145 / 1778765.1778864

Sharpless, T., Postle, B. & German, D. (2010). Pannini: A new projection for rendering wide angle perspective images, in Proceedings of the Sixth international conference on Computational Aesthetics in Graphics, Visualization and Imaging. Eurographics Association, 2010, pp. 9–16.

Coleman, P. & Singh, K. (2004). Ryan: rendering your animation nonlinearly projected. NPAR '04 7 June 2004.

Singh, K. (2002). A Fresh Perspective, in Graphics Interface, vol. 2002, pp. 17–24.

Liu, S., Agrawala, M., DiVerdi, S., & Hertzmann, A. (2022). ZoomShop: Depth-Aware Editing of Photographic Composition. EUROGRAPHICS 2022, eds. R. Chaine and M. H. Kim, Vol. 41 (2022), No. 2.

Curvilinear and natural perspectives

Floçon, A. & Barre, A. (1988). Curvilinear perspective: From visual space to the constructed image. Berkeley, CA: University of California Press.

Hauck, G. (1879). Die Subjektive Perspektive und die Horizontalen Curvaturen des Dorischen Styls. Eine Perspektivisch- Ästhetische Studie, Wittwer, Stuttgart, Germany.

Hansen, R. (1973). This curving world: Hyperbolic linear perspective. Journal of Aesthetics and Art Criticism, 32(2), 147– 161.

VIsual space geometry

Luneburg, R. K. (1947). Mathematical analysis of binocular vision. Princeton, NJ: Princeton University Press.

Koenderink, J. & van Doorn, A. (2008). The Structure of Visual Spaces. Journal of Mathematic Imaging and Vision, 31: 171.

Oomes, A.H.J., Koenderink, J.J., van Doorn, A.J. and de Ridder, H. (2009). What are the Uncurved Lines in Our Visual Field? A Fresh Look at Helmholtz's Checkerboard. Perception, 38(9), pp.1284–1294.

Conclusion:

- We can improve alignment between mental and physical displays when depicting the perceived world

Conclusion:

- We can improve alignment between mental and physical displays when depicting the perceived world

- This can be achieved by close analysis of the structure of visual space and by developing non-linear natural perspectives that more closely emulate that structure

Conclusion:

- The benefit of natural non-linear perspectives can be to improve the user experience of 3D content on standard displays

Conclusion:

- The benefit of natural non-linear perspectives can be to improve the user experience of 3D content on standard displays

- Drawing is a key research tool that, along with science methods, can be used to investigate perceptual geometries

‘What does the world really look like?
I know it doesn’t look like photographs.
The camera sees geometrically, and we
must see psychologically.

So what does it really look like?
I think you have to draw it.’

David Hockney, 2021


STOP

Alistair Burleigh
Computer coding
Vision research
Computer graphics

Joe Baldwin
Data collection
and analysis

Nicole Ruta
Psychophysical
research
Data collection
and interpretation
and analysis

Heddwyn Loudon
Data collection
and analysis

FOVOLAB
www.fovography.com

wellcome

Cardiff Metropolitan University | Prifysgol Metropolitan Caerdydd

Llywodraeth Cymru
Welsh Government

NVIDIA. | INCEPTION PROGRAM

Network proposal

Beyond linear perspective: Representing visual experience in art & technology