# HFVE Working Group

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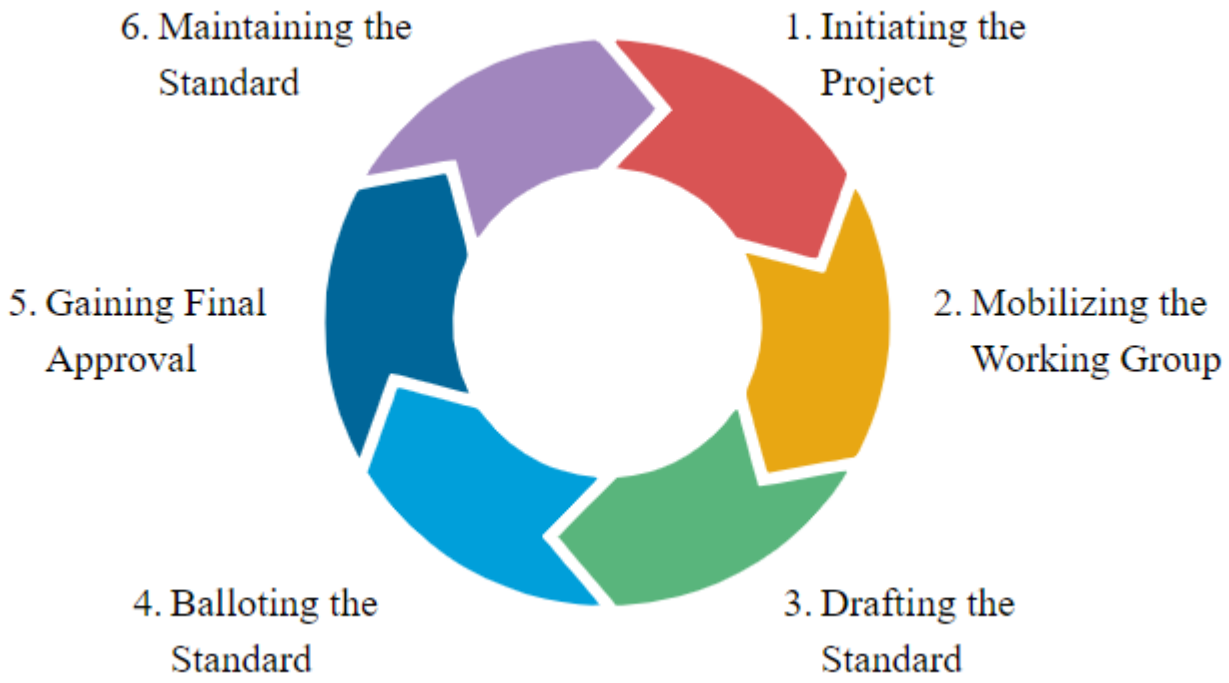
# IEEE Standardization



# IEEE Standardization

**Approved standards:**

- P3333.1.1-2015 - IEEE Standard for Quality of Experience (QoE) and Visual-Comfort Assessments of Three-Dimensional (3D) Contents Based on Psychophysical Studies

- P3333.1.2-2017 - IEEE Standard for the Perceptual Quality Assessment of Three Dimensional (3D) Contents based on Physiological Mechanisms

# IEEE Standardization

## Ongoing activities

P3333.1.3 - Standard for the (Deep Learning-Based) Assessment of Visual Experience Based on Human Factors

Note: the focus is now specifically on AR/VR/MR

Other topics expected to be included in new items:

- Light Field Imaging, High Dynamic Range

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# Quality of Experience for Light Field Imaging

## Examples of Kingston University research on the topic

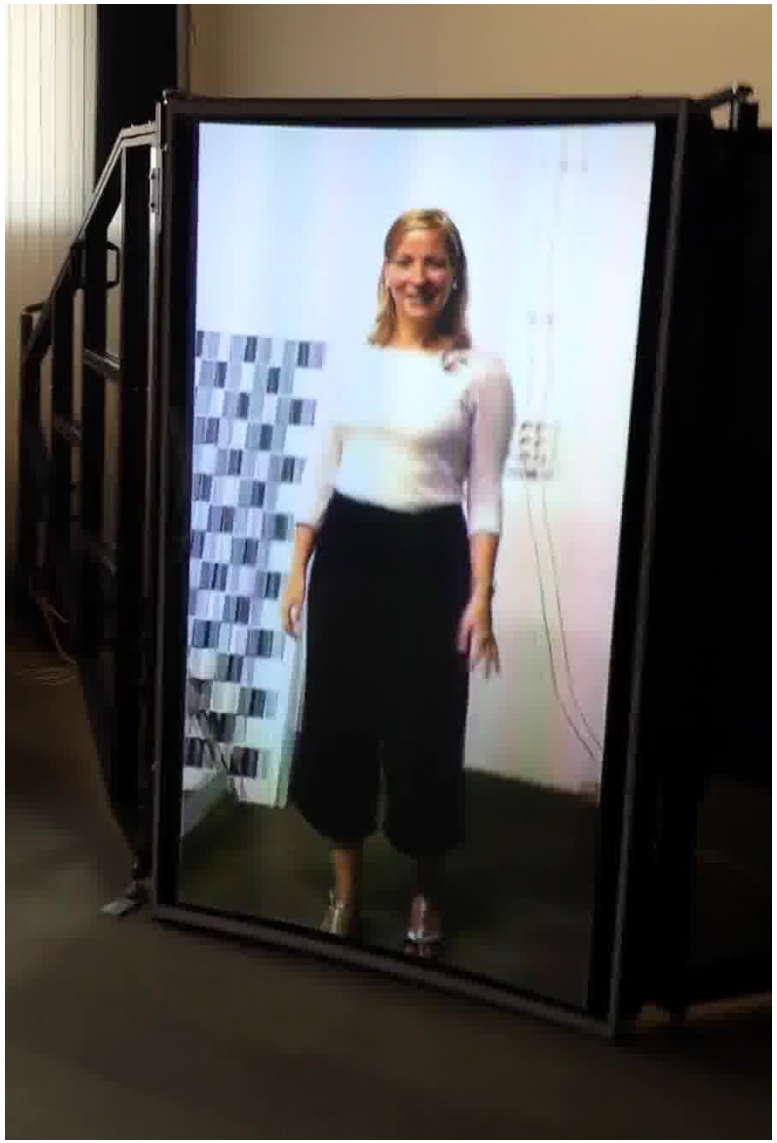
# Light Field Displays

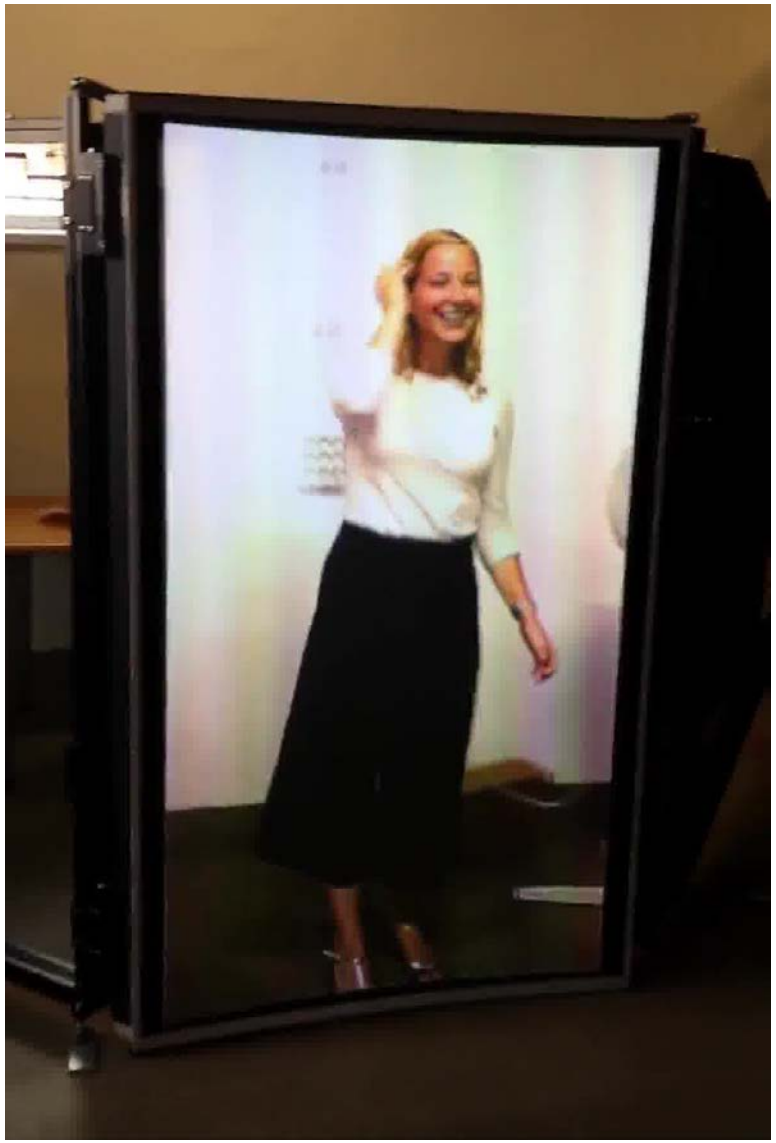
## Key aspects

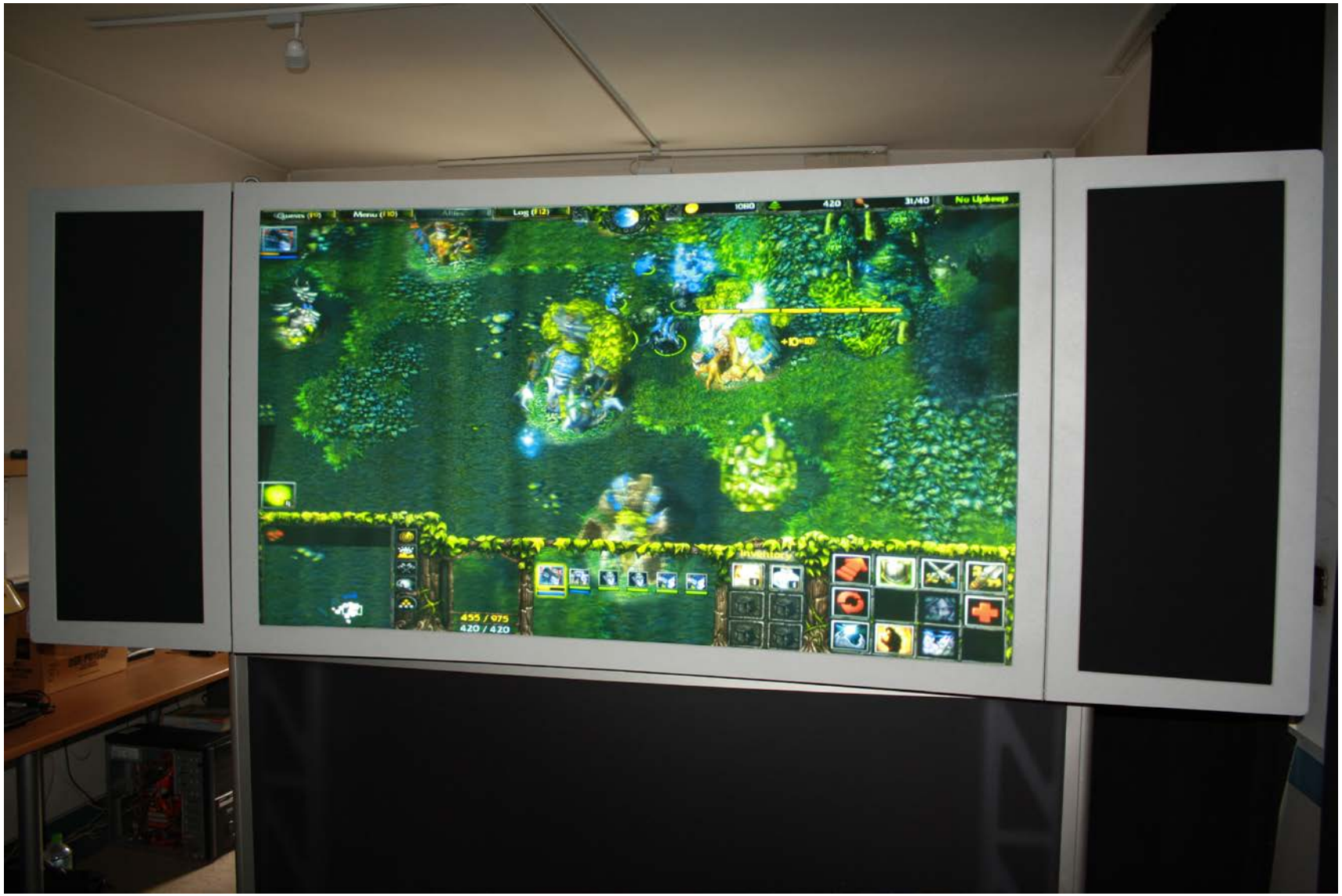
- Projection-based light field displays emit light rays from a multitude of locations, originating from a large number of optical engines. As these light rays cross the projection screen, **the hit points might not necessarily be at discrete positions on a regular grid**
- The total angle in which light rays are emitted from the screen surface determines the viewing angle of the display, that is, the angular range from which viewers can observe the image from.
- The user perceives the part of the content that represents one point of view of the scene depending on his position and is able to move around the object to take benefits of the motion parallax
- The viewer perceives continue **horizontal  parallax**

# Potentials

- Medical applications
- 3D design
- Resource exploration
- Traffic control / HUD
- Exhibitions
- Telepresence
- Gaming
- Home video entertainment
- Cinema






455 / 975
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# Perceived quality of angular resolution for light field displays and the validity of subjective assessment

*Kara, P.A., Martini, M.G., Kovacs, P.T., Imre, S., Barsi, A., Lackner, K. and Balogh, T*

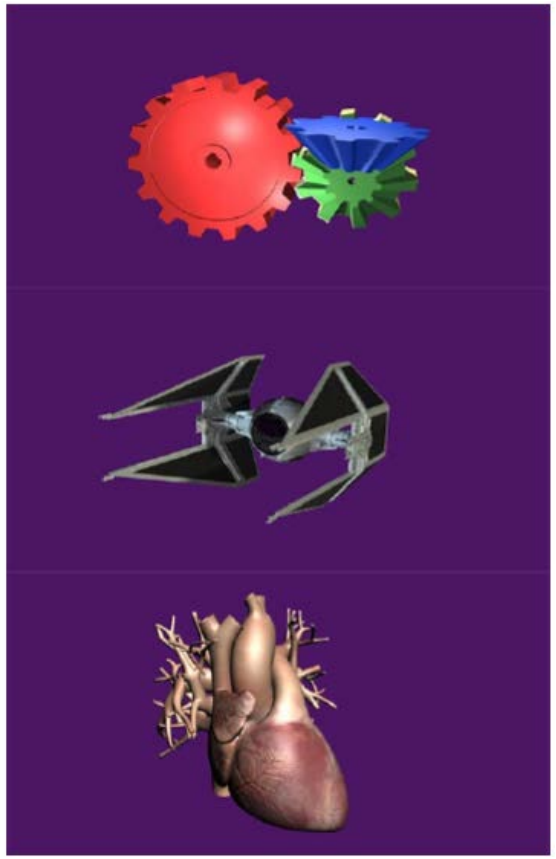
# Introduction

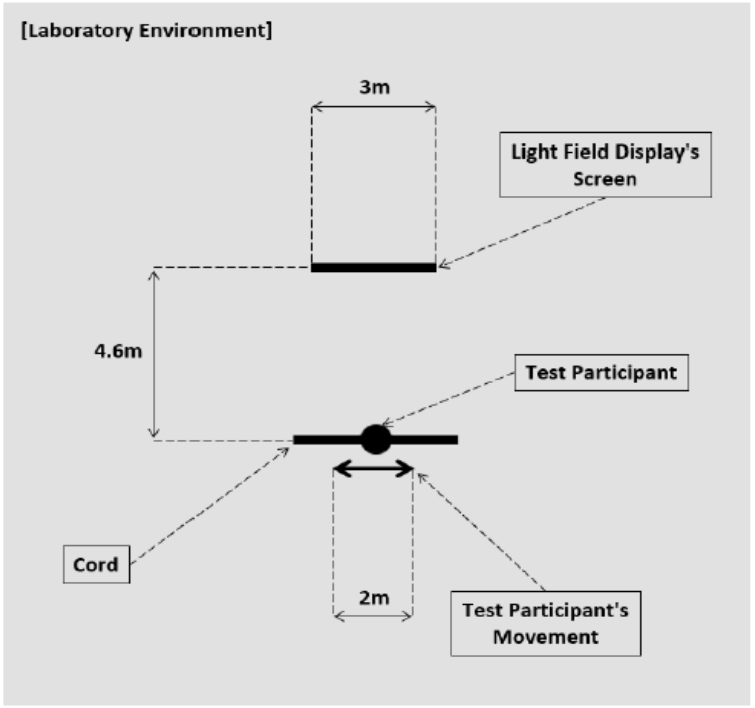
- Angular resolution plays a vital role in the perceived quality when displaying visual content on autostereoscopic 3D displays, since it affects the motion parallax effect
  - Note: here angular resolution of content: number of views / field of view
- Subjective quality assessment was carried out on a light field display, investigating the perceptual quality of visual content with different angular resolutions
- We also addressed the question of subjective assessment validity, since the visual experience of suboptimal, reduced angular resolution is currently a completely new phenomenon for test participants

Kara, P.A., Martini, M.G., Kovacs, P.T., Imre, S., Barsi, A., Lackner, K. and Balogh, T., 2016, December. Perceived quality of angular resolution for light field displays and the validity of subjective assessment. In *3D Imaging (IC3D), 2016 International Conference on*

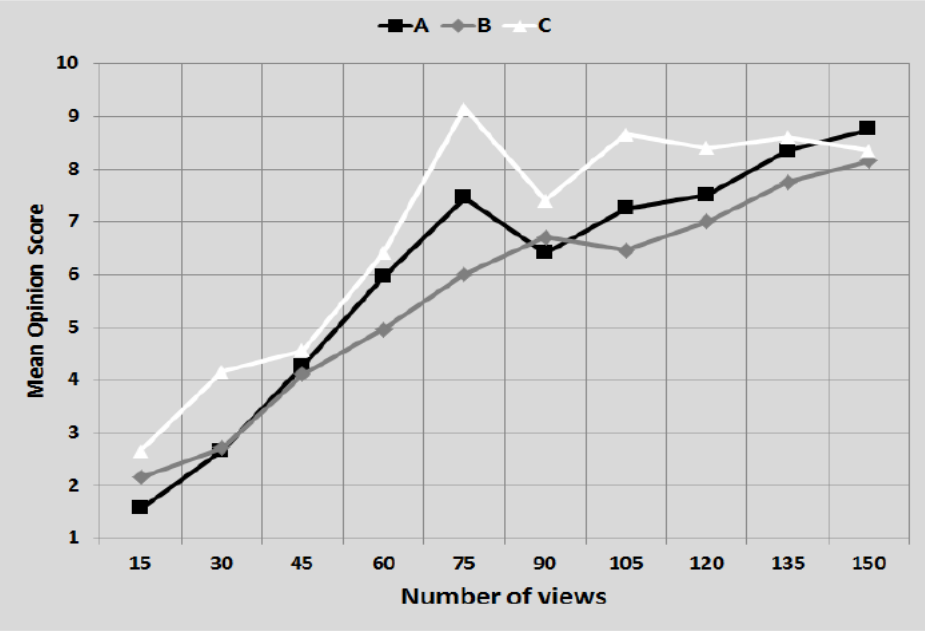
# Experimental setup

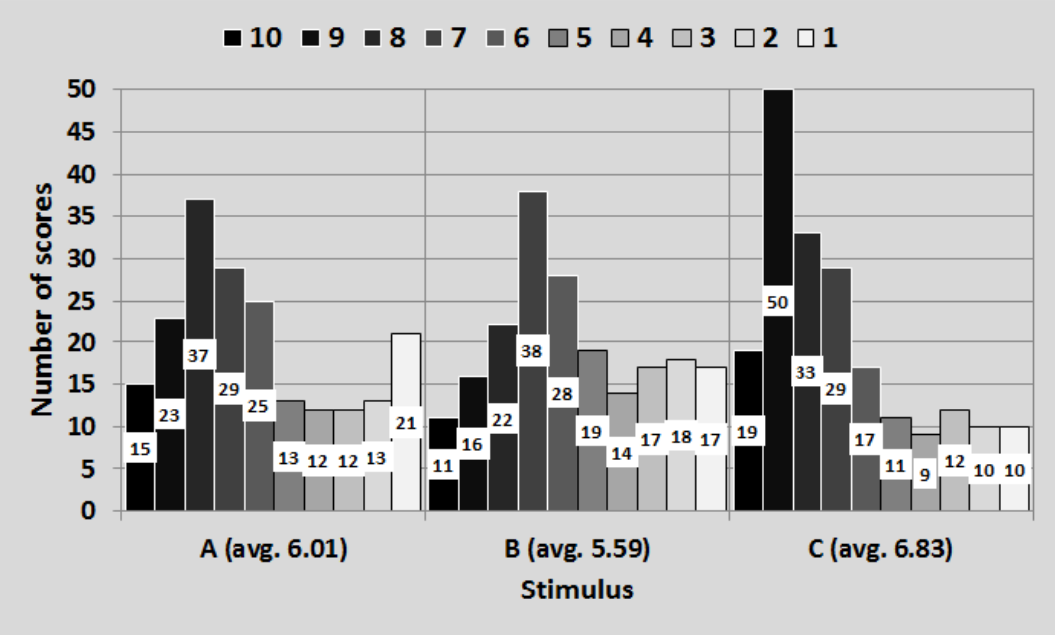
- 20 users
- Task: rate the perceived quality of the displayed objects, focusing on angular resolution
- ACR 1-10
- Display: 3-meter wide glasses-free HoloVizio 3D cinema system
- Brightness :1500 cd/m2
- Horizontal viewing angle: 40 degrees
- Closed laboratory environment, with lighting conditions of 25 lx





# Results


A
B
C
Mean Opinion Score
10
9
8
7
6
5
4
3
2
1
15
30
45
60
75
90
105
120
135
150
Number of views


10
9
8
7
6
5
4
3
2
1
Number of scores
50
45
40
35
30
25
20
15
10
5
0
15
23
37
29
25
13
12
12
13
21
11
16
22
38
28
19
14
17
18
17
19
50
33
29
17
11
9
12
10
10
A (avg. 6.01)
B (avg. 5.59)
C (avg. 6.83)
Stimulus

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# The Perceivable Differences between Image Resolutions for Light Field Displays

# Objective

To study

- the perceivable differences between resolutions
- the acceptability of resolution degradation should it be visible.

# Experimental setup

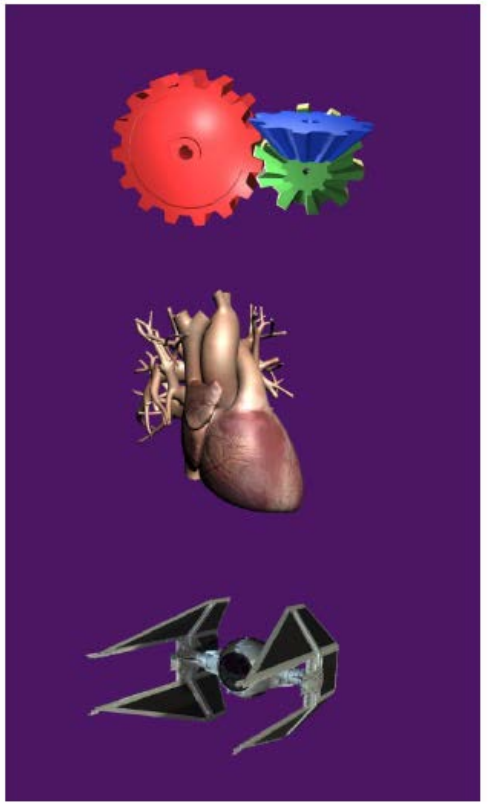


Image Resolutions (not final resolutions):

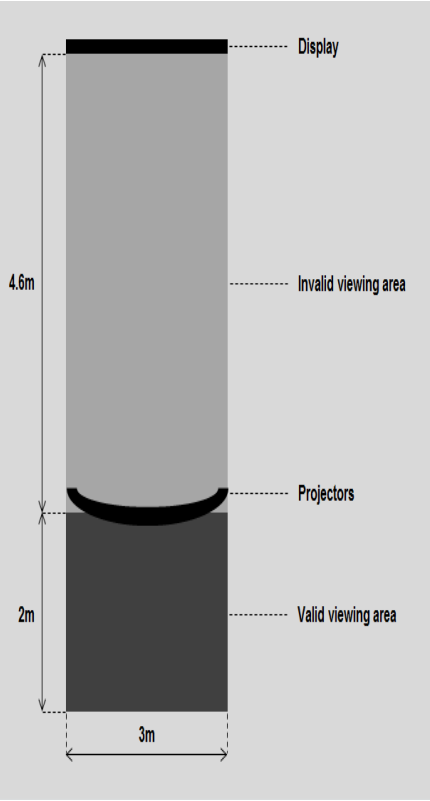
- 854x480 (WVGA)
- 1024x576 (PAL)
- 1280x720 (720p)
- 1920x1080 (1080p)
- 3840x2160 (2160p)

Controlled environment, with lighting conditions of 25 lux.

Projection-based light field display (HoloVizio C80 3D cinema system

- 40 degrees of horizontal viewing angle and
- brightness of 1500 cd/m2.
- 20 test participants

5-point Degradation Category Rating Scale (DCR)

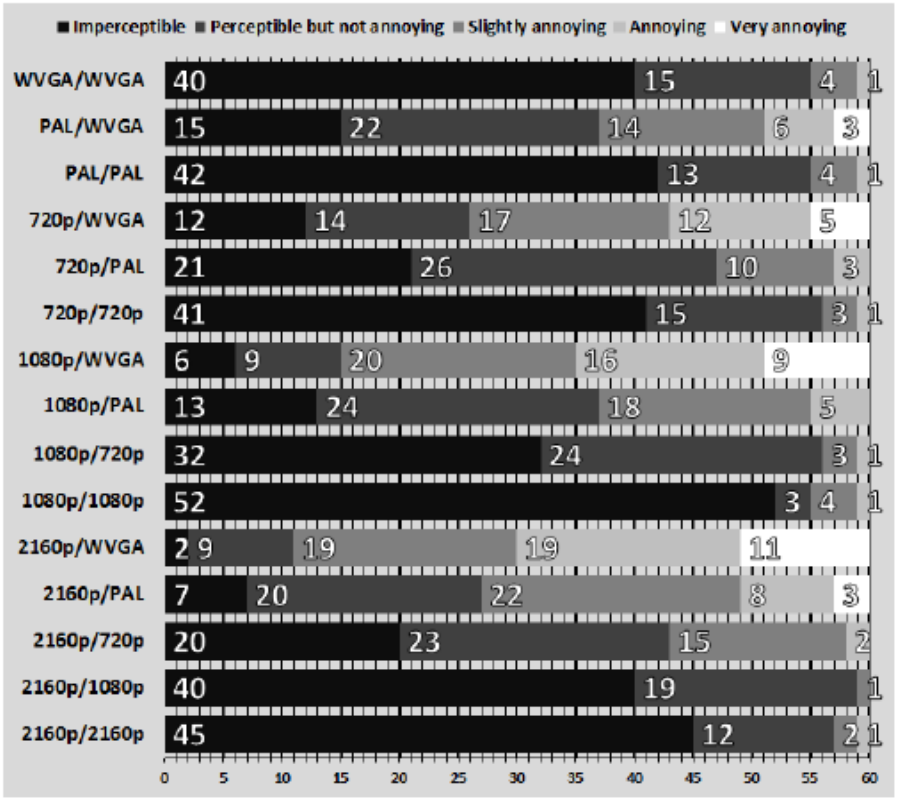


# Results

On such displays:

- 2160p and 1080p resolutions are either hardly distinguishable or distinguishable but completely tolerable.
- 720p is an adequately good resolution for specific use cases, since the difference can be rather hard to tell from higher resolutions.
- Even the lowest resolutions can be acceptable in some scenarios, as only half of the test observers found it considerably annoying in comparison with the highest available resolution.

Separate results for source images show that the structural complexity of the displayed objects has a higher impact on resolution degradation than textures



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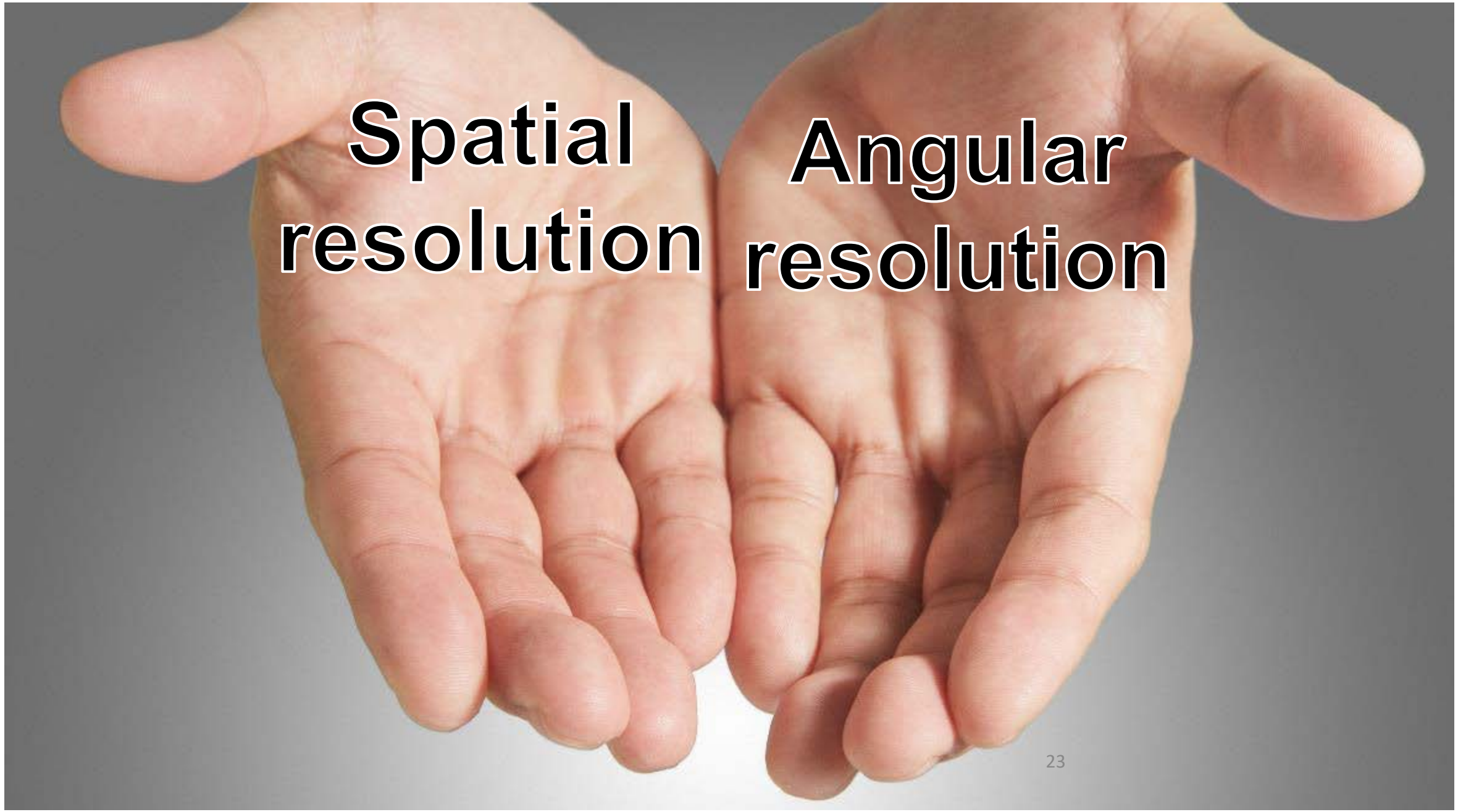
# The Interdependence of Spatial and Angular Resolution in the Quality of Experience of Light Field Visualization

Kara, P.A., Cserkaszky, A., Barst, A., Papp, T., Martini, M.G. and Bokor, L., 2017, December. The interdependence of spatial and angular resolution in the quality of experience of light field visualization. In *3D Immersion (IC3D), 2017 International Conference on*.

# Introduction

**Definitions used in the following**

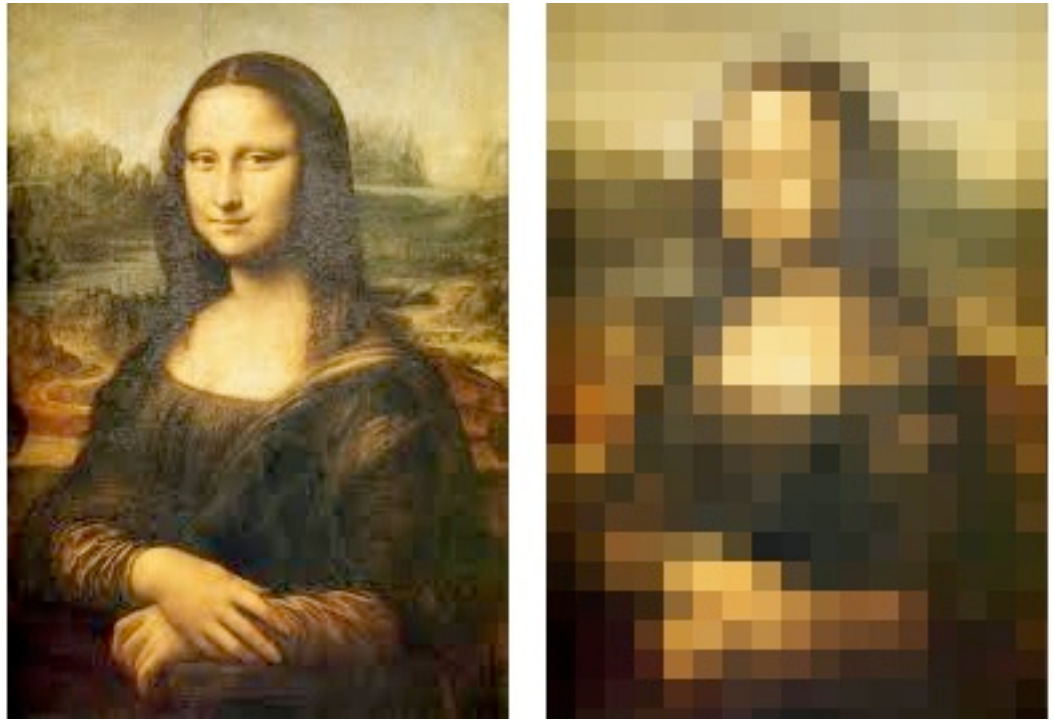
- **Angular resolution** (of content): density of source images allocated to a given field of view; similarly to spatial resolution, it has a fundamental effect on the visual experience.
- **Spatial resolution** (of content): resolution of the images before rendering
- We investigated how the reduction of angular and spatial resolution affect each other.


Spatial resolution
Angular resolution

# Reduction of angular and spatial resolution

- Horizontal motion parallax is affected by reduced **angular resolution**, that can result in
  - crosstalk effect (when adjacent source views interfere with each other)
  - discrete view jumps (when there is a perceivable sudden shift between source views, without proper transition).
- Insufficient **spatial resolution** results in blur that is not uniform across the screen of the display, as light rays hit irregular positions

# Is blur the enemy?



# Hypothesis

**Reducing the spatial resolution**

for visualization with **disturbed horizontal motion parallax**

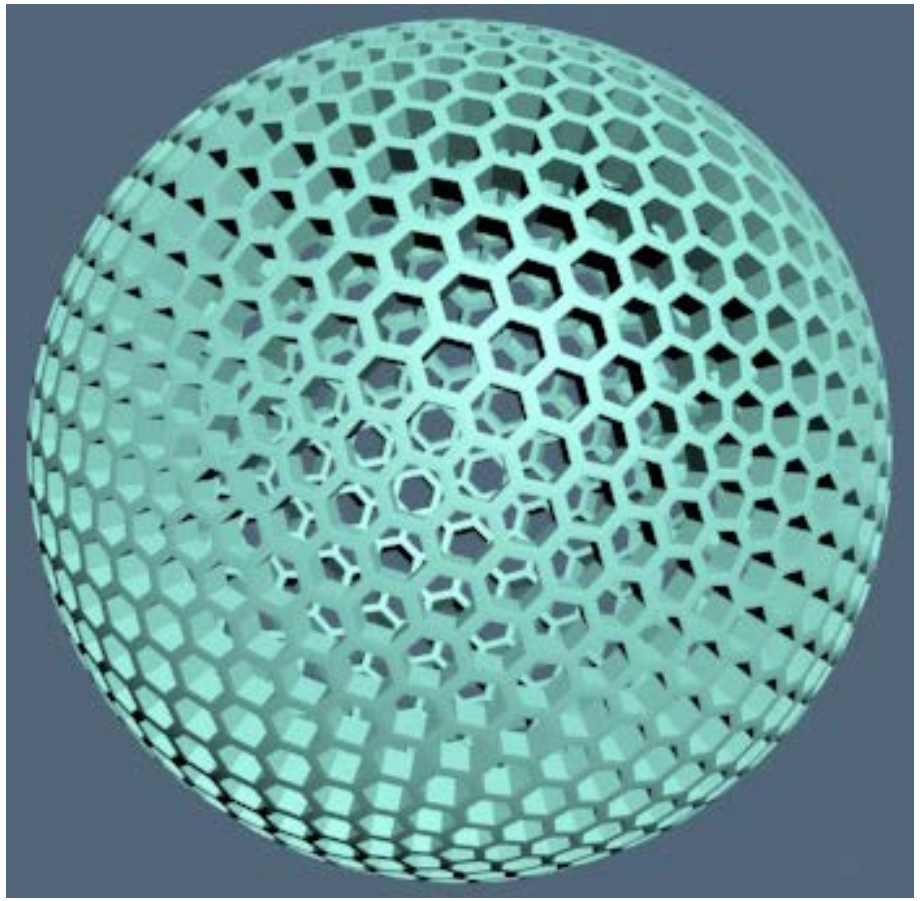
will not have a negative effect on the parallax effect,

and in fact, it may even improve it.

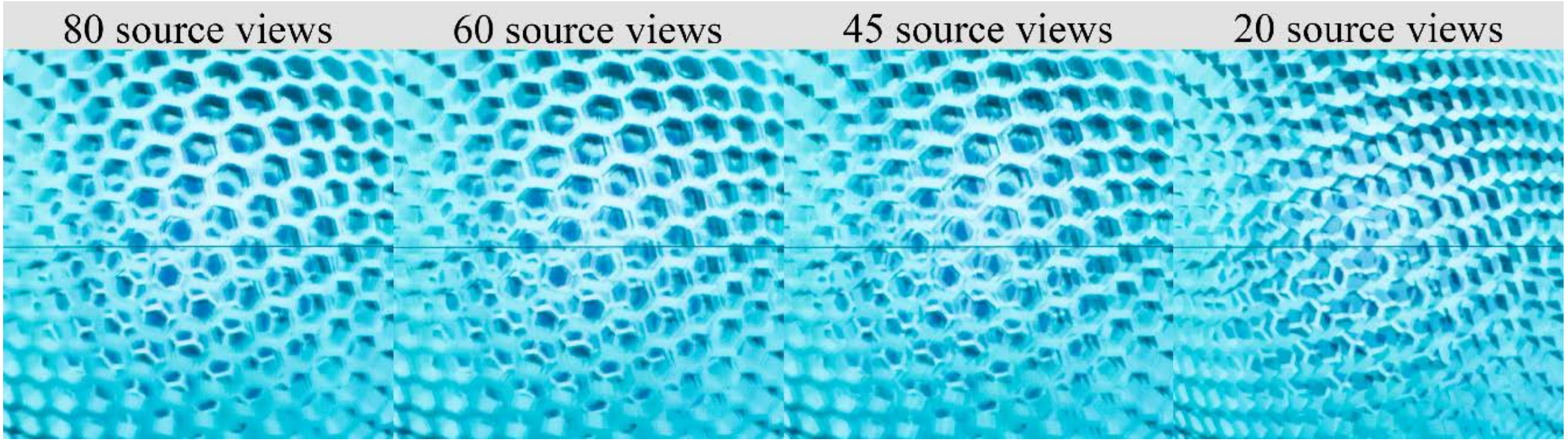
# Experimental setup

- Spatial resolutions: 1440x1080 / 1024x768 / 640x480
- Angular resolution: 0.33˚ / 1˚ / 1.5˚ (135 / 45 / 30 views in a 45˚ FOV)
- Paired comparison, +3/–3 comparison scale
- Pairs: down-switching spatial resolution → 9 comparisons per source
- 8 source stimuli
- C80 light field cinema system from 2.5H viewing distance
- 22 test participants (age 18–58, avg. age 31, 16 male, 6 female)
- Test question: **rate the smoothness of the horizontal motion parallax**

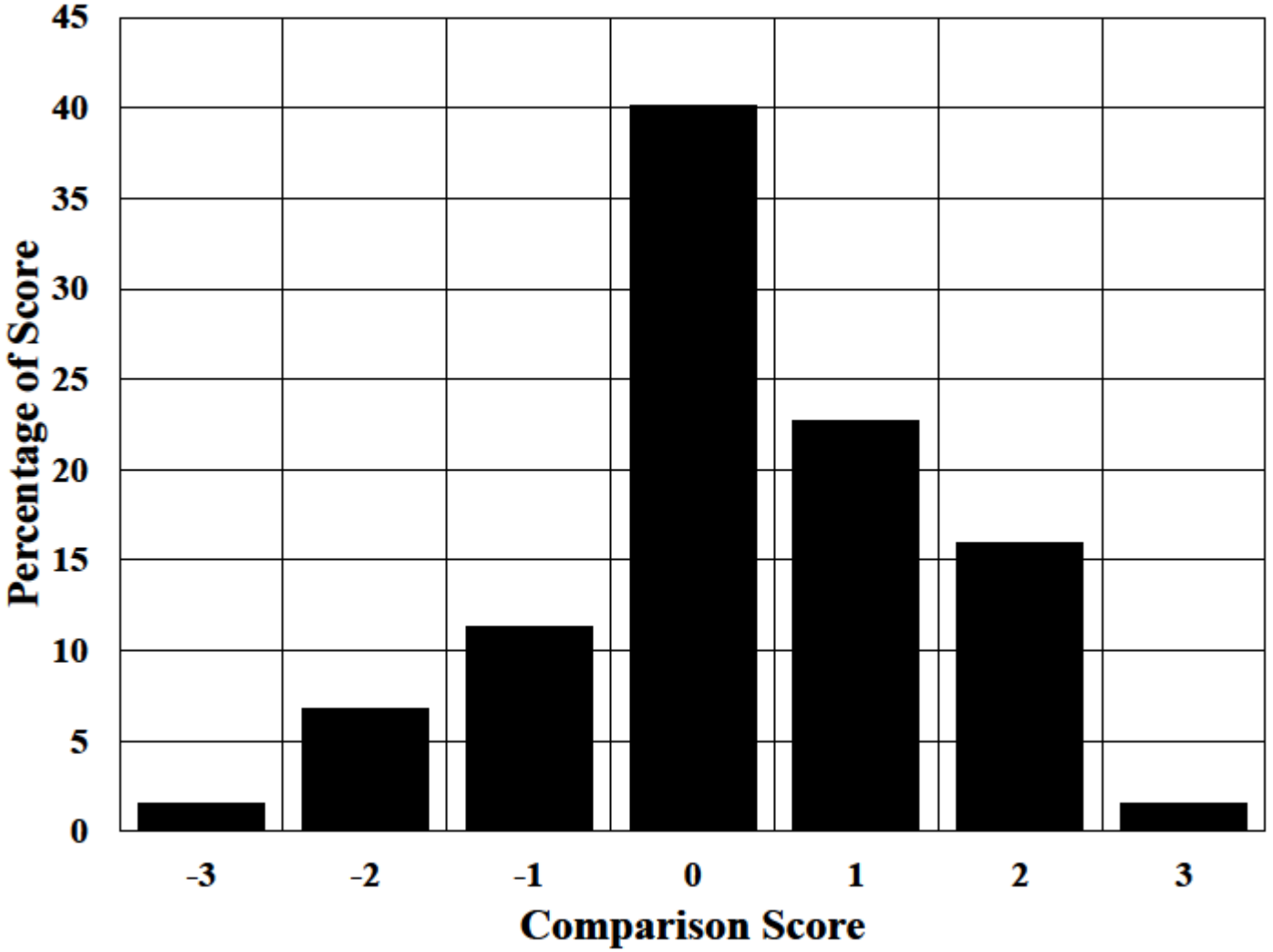
# Angular resolution degradation



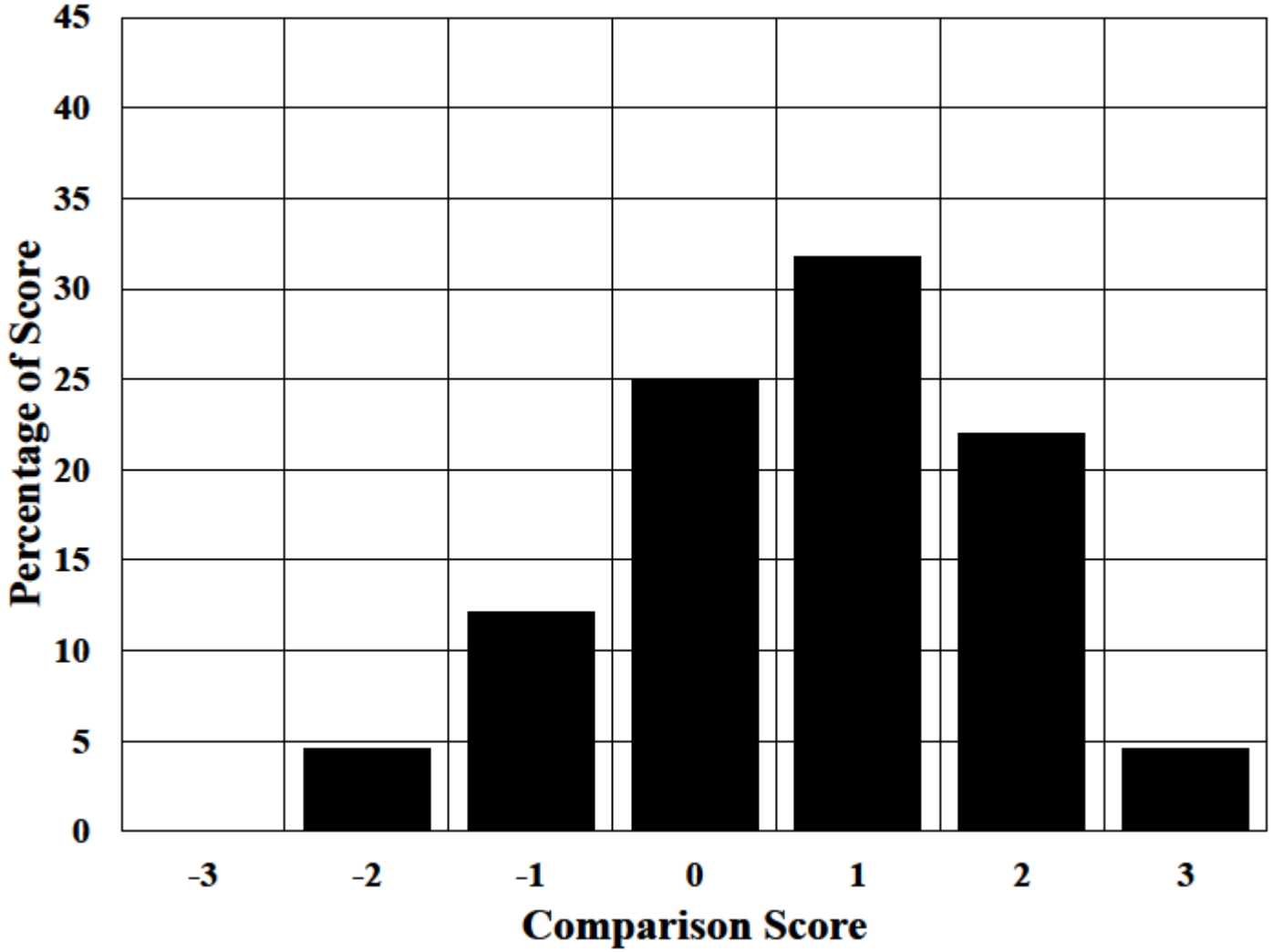
# Angular resolution degradation



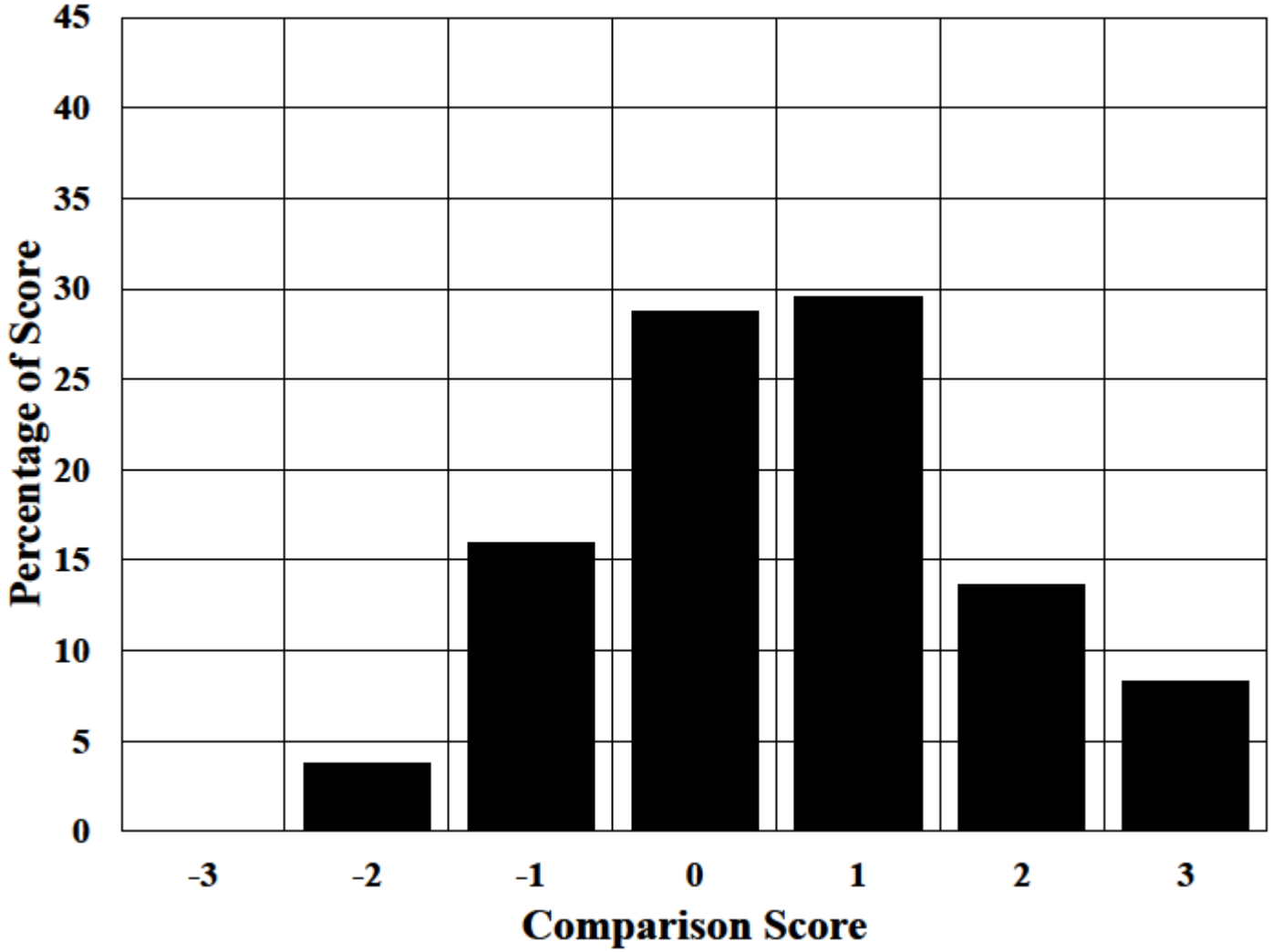
# Results: 135 views

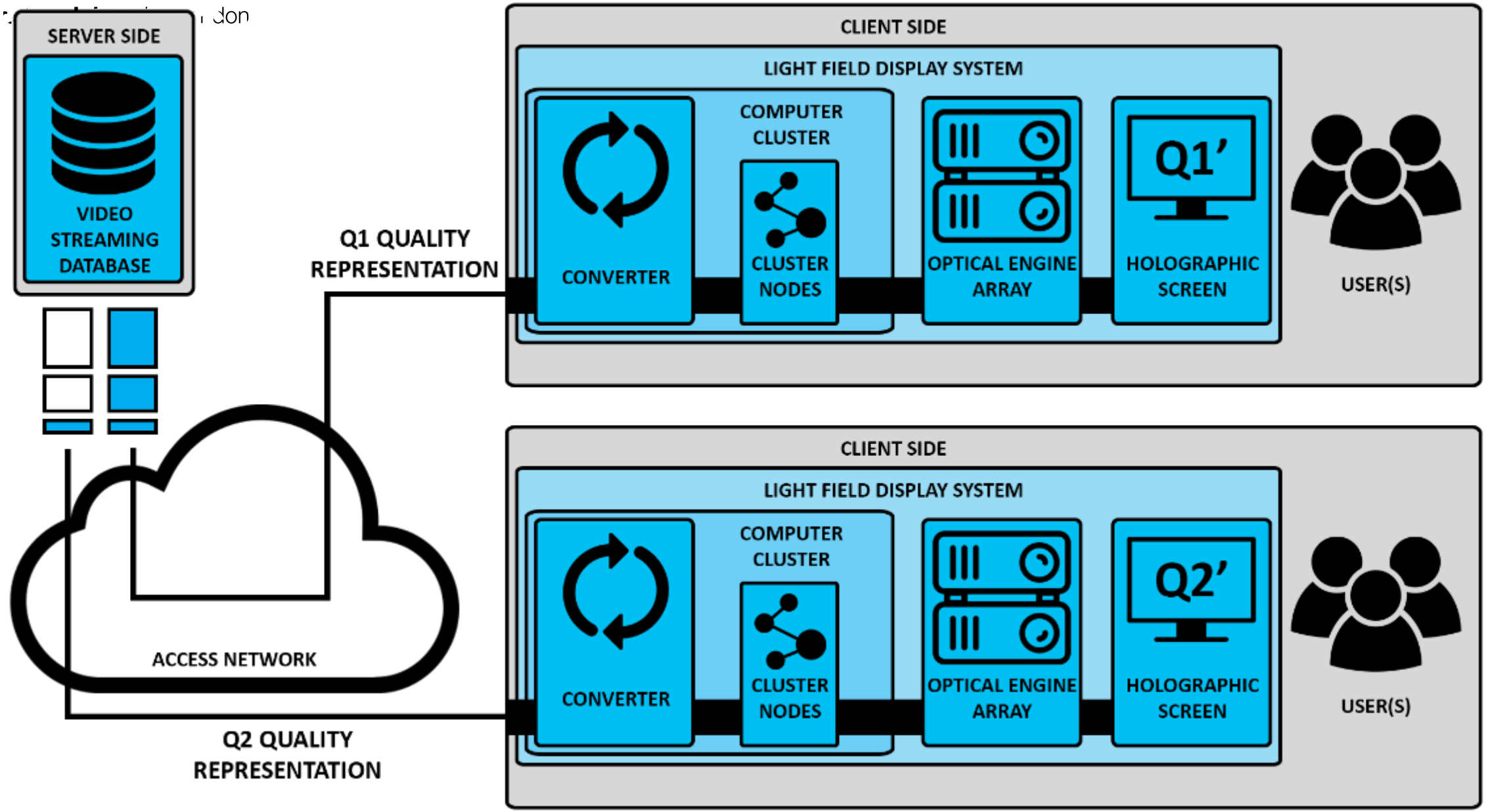


# Results: 45 views



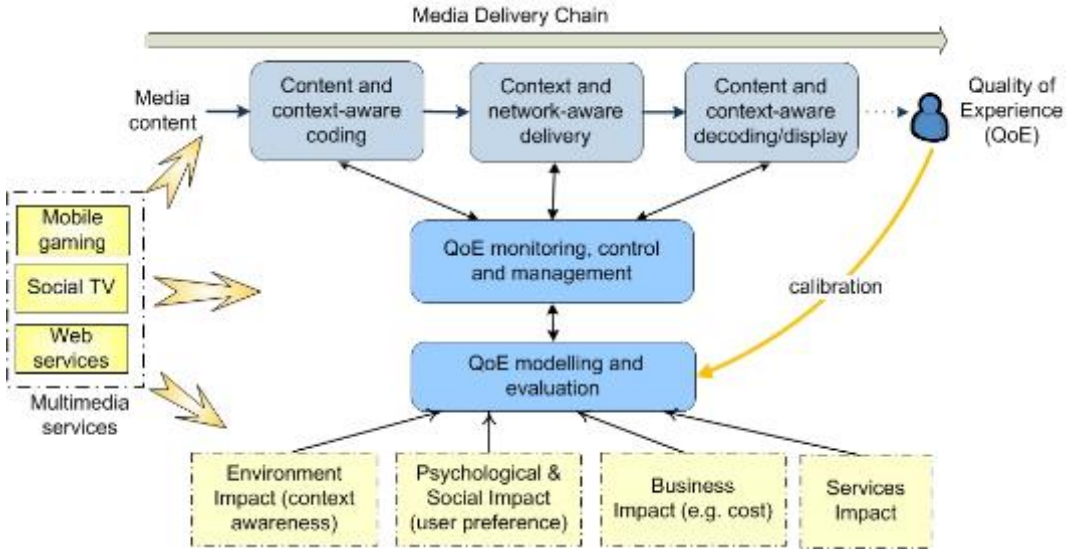
# Results: 30 views






PA Kara, A Cserkaszky, MG Martini, A Barsi, L Bokor, T Balogh, "Evaluation of the Concept of Dynamic Adaptive Streaming of Light Field Video", *IEEE Transactions on Broadcasting*, Vol. 64, no. 2, June 2018, pp. 407 – 421.

We acknowledge the support of European Union's Horizon2020 Programme under grant agreement No. 643072 (QoE-NET)



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# HFVE: Collaboration

**Please send a mail to**
**m.martini@kingston.ac.uk**
**to be included in the group list**