

Evaluation of biological effect on luminance of stereoscopic displays

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Background

- The stereoscopic image has been widely used in a movie, TV, and games.



Stereoscopic image

- provides reality and promotion of understanding.
- provides the fatigue and the evaluation of biological effect is still unknown.



<http://bbs40.meiwasuisan.com/bbs/bin/read/moview/1347527018/150>



Objective

- Study on relationship of 3D parameters and fatigue

| | |
|--------------------------|--------------|
| Viewing distance | Ujike (2008) |
| Stereoscopic disparities | Kooi (2004) |
| Cross talk | Maeda (2010) |



The biological effect on luminance of stereoscopic displays is unknown.

active shutter glasses
polarized glasses
auto-stereoscopic display

Advantages and faults are different by each method and luminance in sight is different in particular.



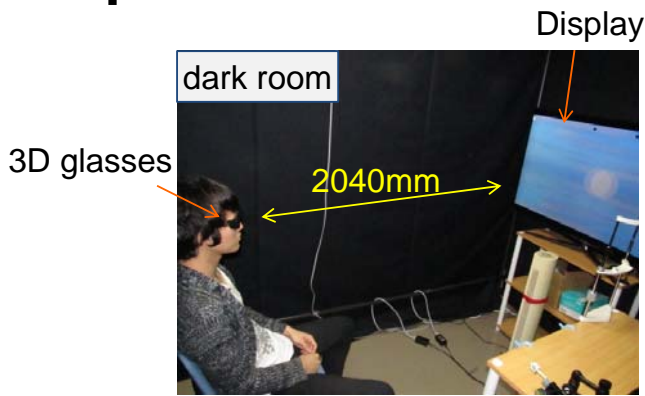
Objective

We evaluate biological effect on luminance of stereoscopic displays by the subjective and objective experiments.

Contents

- Introduction
- Experiments
 - Double stimuli evaluation
 - Single stimulus evaluation
- Experimental results and Discussion
- Conclusion and Future works

Experimental condition



▼ Stereoscopic image



- ▼ Subjects: Twelve healthy people (male 9, female 3, age 20-23)
- ▼ Display: Active shutter glasses technology, 1920 × 1080 pixel
- ▼ Viewing distance: 2040mm (3H)
- ▼ The average luminance of stereoscopic displays: 4-level
(19, 27, 35, 42cd/m²)



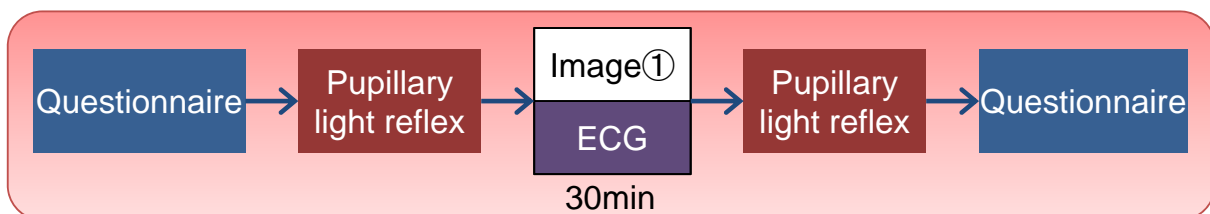
We conducted experiments in a dark room in order to eliminate the influence of environmental light.

Experiments

1. Double stimuli evaluation



2. Single stimulus evaluation



Reproducibility

- ▼ We confirmed experimental accuracy and reproducibility by conducting repetitive experiments.

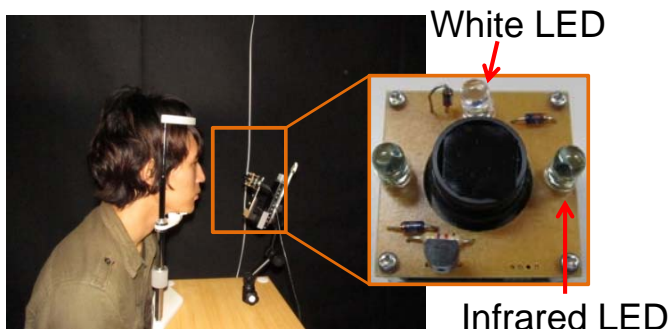
$$R = \sqrt{\frac{(S_1 - m)^2 + (S_2 - m)^2}{2}}$$

R : reproduction error

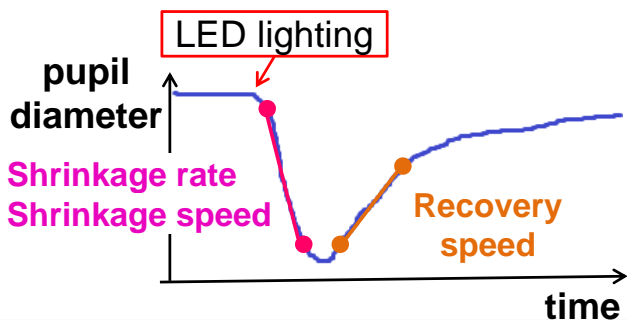
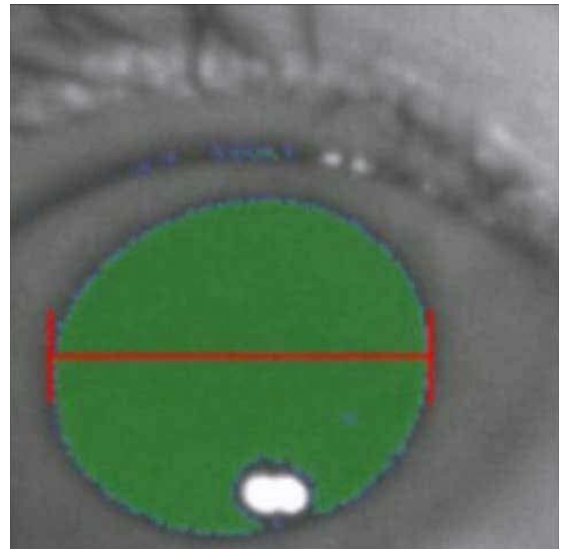
Single stimulus evaluation

Pupil detection

- Pupil detection is conducted by characteristic that infrared reflection of the pupil is low.
- Pupil radius is calculated by image processing.



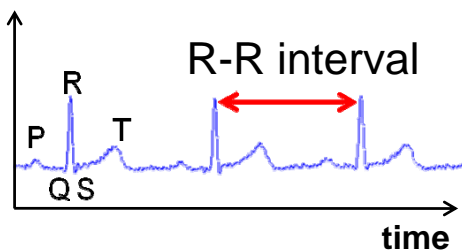
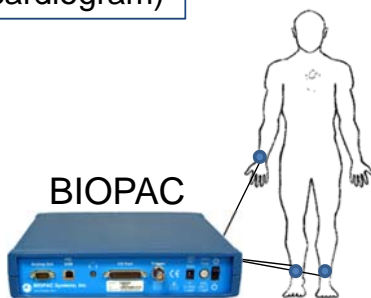
▼ Contraction motion



Single stimulus evaluation

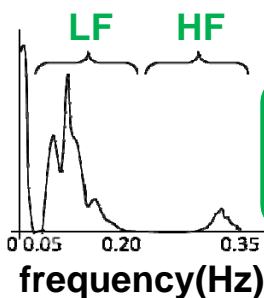
ECG (electrocardiogram)

- An autonomic nerve activity is analyzed by measuring the R-R interval in ECG.



100 of R-R interval samples which extracted in each of before viewing, after viewing, and while viewing.

Method of analysis



LF/HF
An index of autonomic nerve activity

LF/HF High

• stress

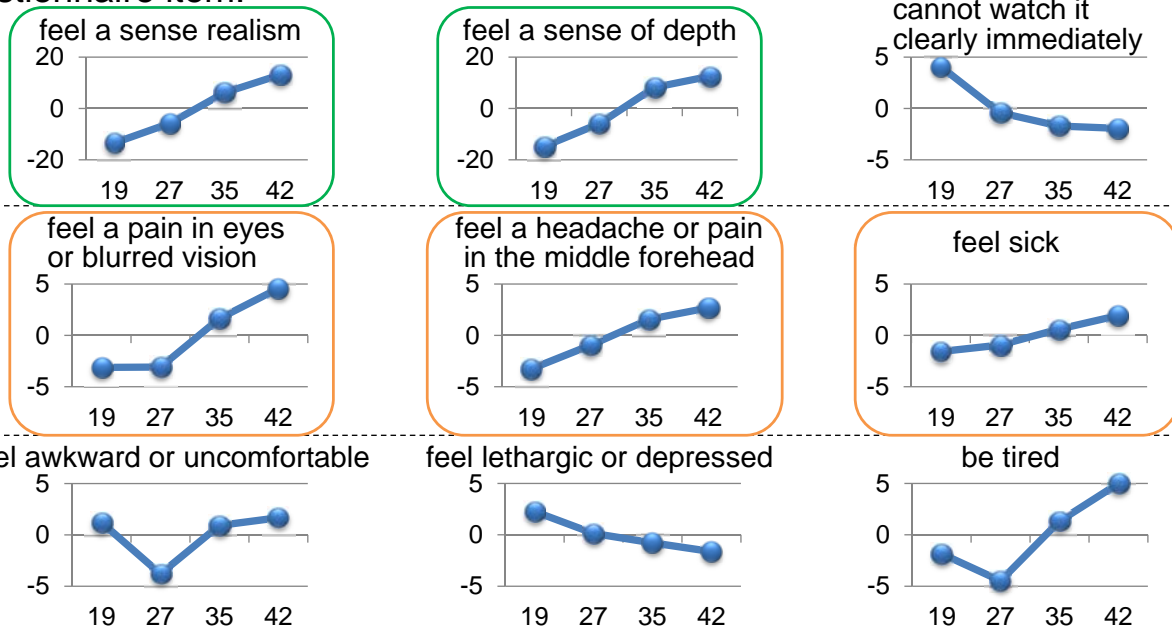
LF/HF Low

• relax

Monitoring change of LF/HF

Experimental results (Double stimuli evaluation)

Significant change related to the luminance of the display was shown in every questionnaire item.



From this result, it was suggested that high luminance of stereoscopic displays increases realism and perception of depth but also increases fatigue.

Experimental results (Double stimuli evaluation)

| Item | All data | R < 7.81 |
|---------------------------------------------------|----------|----------|
| 1. feel a sense realism | ** | ** |
| 2. feel a sense of depth | ** | ** |
| 3. cannot watch it clearly immediately | * | |
| 4. feel a pain in eyes or blurred vision | ** | ** |
| 5. feel a headache or pain in the middle forehead | ** | ** |
| 6. feel sick | * | * |
| 7. feel awkward or uncomfortable | * | |
| 8. feel lethargic or depressed | * | * |
| 9. be tired | ** | ** |

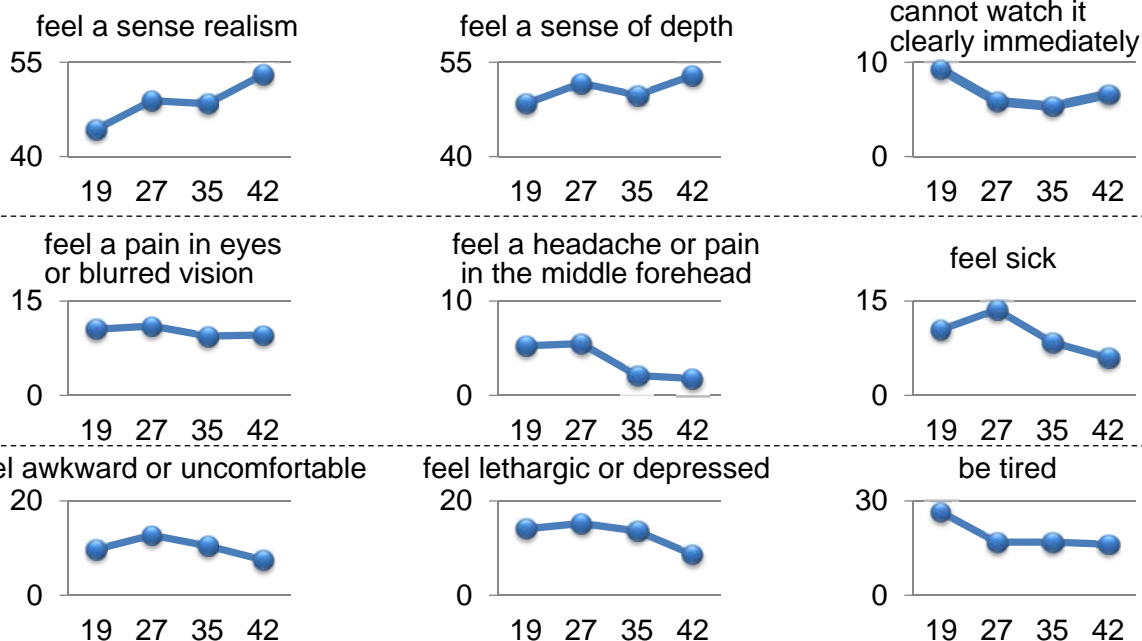
* p < 0.05 ** p < 0.01

Significant change related to the luminance was still shown in almost questionnaire items by extracting data in the criteria of reproduction error.

Because significant difference was shown from the data which has high reproducibility, influence by the luminance was shown.

Experimental results (Single stimulus evaluation)

Significant change related to the luminance of the display was not shown in any questionnaire item.



it seems that change by the luminance is small.

Experimental results (Single stimulus evaluation)

| Item | All data | R < 18.32 |
|---------------------------------------------------|----------|-----------|
| 1. feel a sense realism | | |
| 2. feel a sense of depth | | |
| 3. cannot watch it clearly immediately | | |
| 4. feel a pain in eyes or blurred vision | | |
| 5. feel a headache or pain in the middle forehead | | |
| 6. feel sick | | |
| 7. feel awkward or uncomfortable | | |
| 8. feel lethargic or depressed | | |
| 9. be tired | | ** |

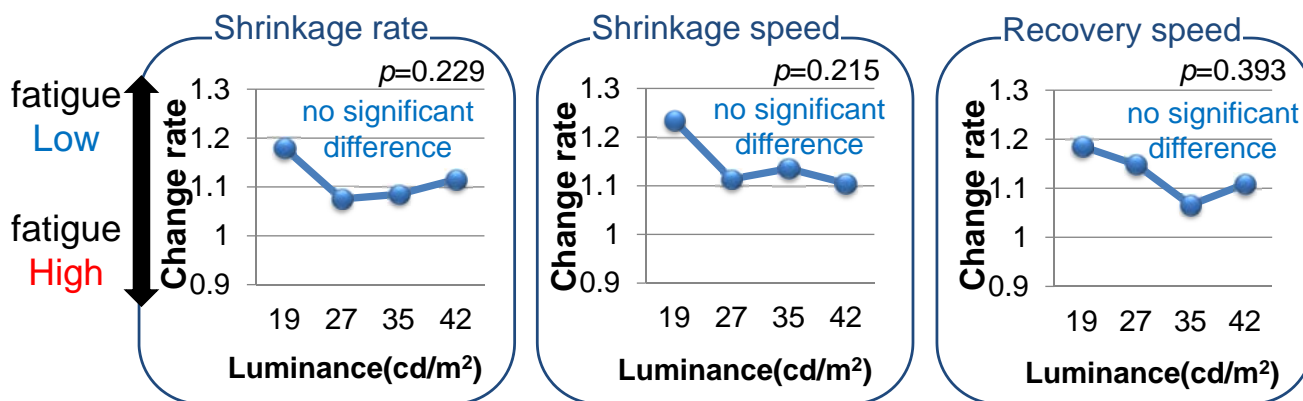
* p < 0.05 ** p < 0.01

By extracting data in the criteria of reproduction error, significant change related to the luminance almost was not shown.

It was found that it was difficult to evaluate biological effect on luminance change of stereoscopic displays by single stimulus.

Experimental results (Pupillary light reflex)

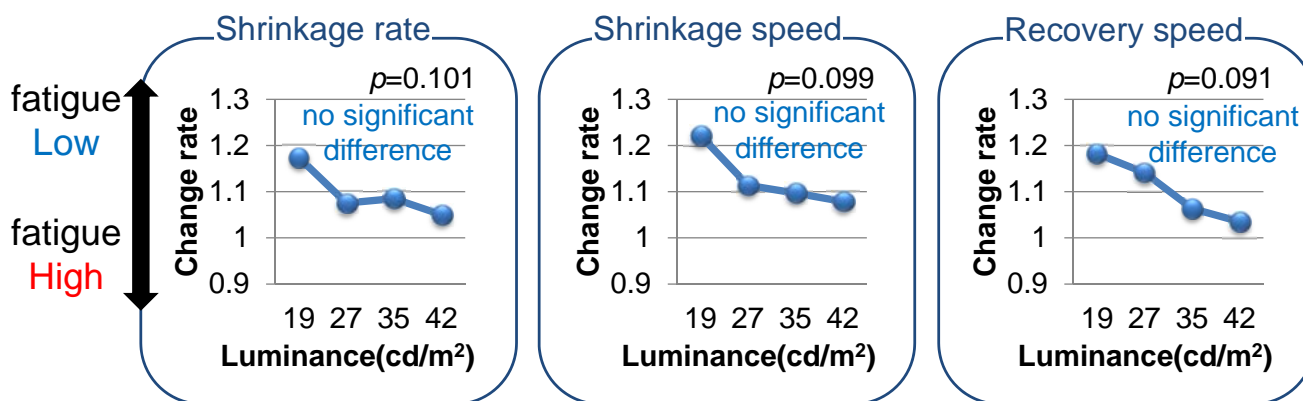
All data



From results of pupillary light reflex, no significant change related to the luminance was shown.

Experimental results (Pupillary light reflex)

R < 0.316

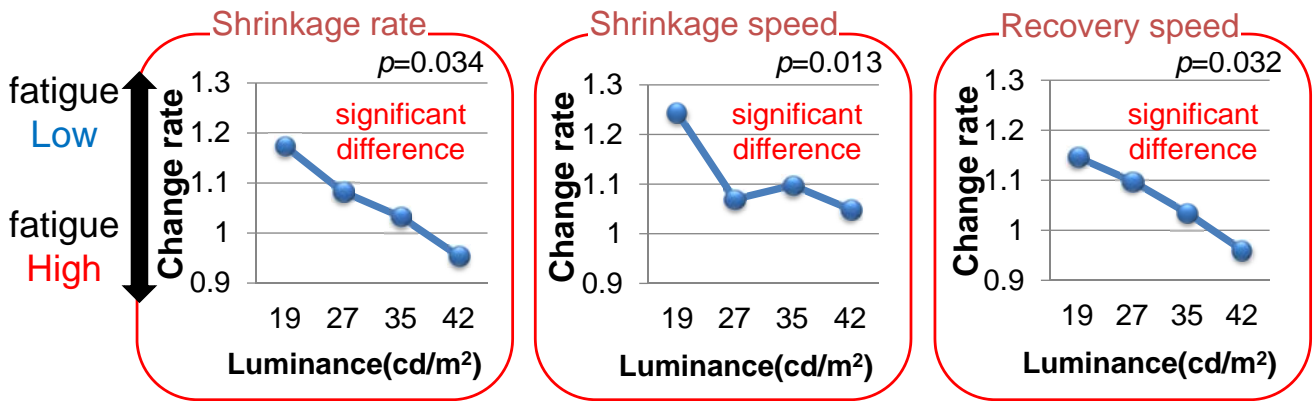


By extracting data in the criteria of reproduction error, no significant change related to the luminance was still shown.

It was found that it is difficult to evaluate biological effect on luminance of stereoscopic displays with these indexes.

Experimental results (Pupillary light reflex)

$R < 0.1$

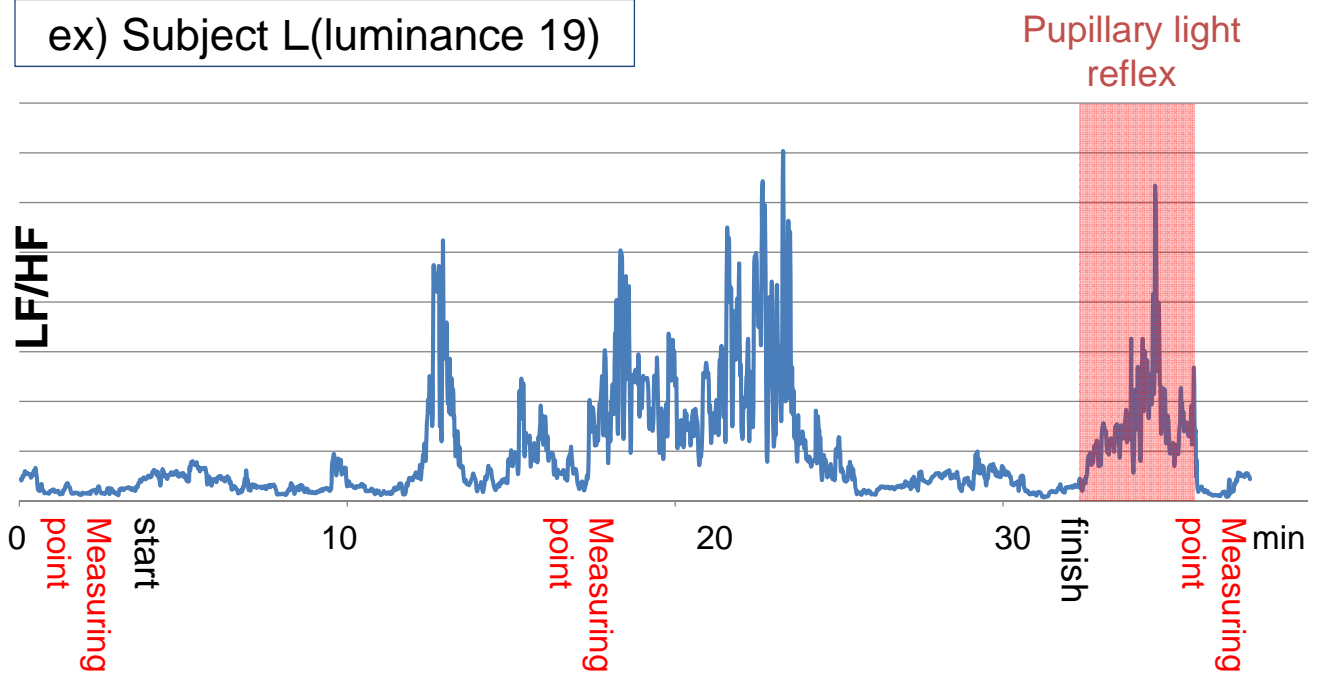


By extracting data in the criteria of reproduction error, significant change related to the luminance was shown.

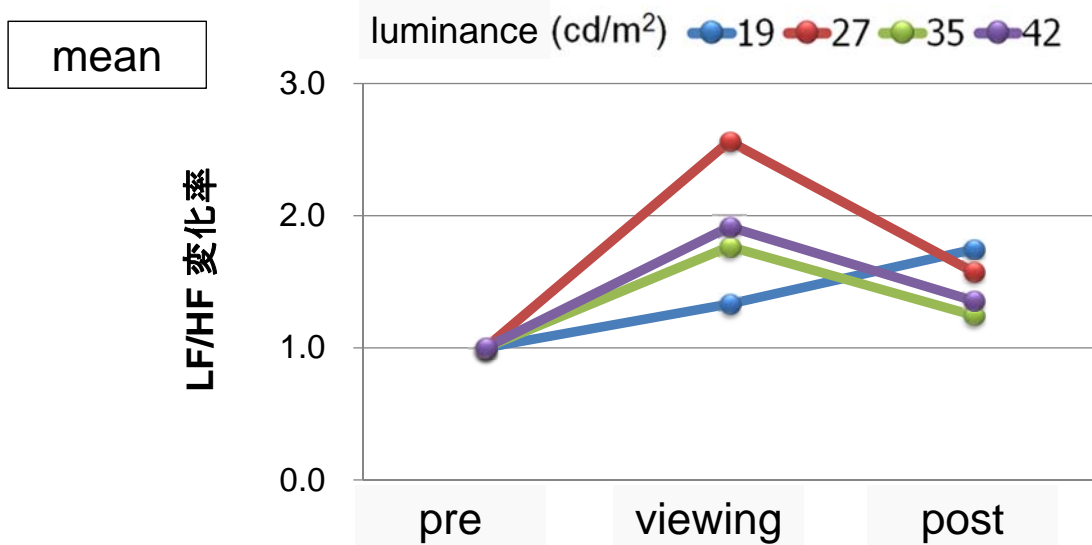
It was suggested that these three indexes have positive correlation with the display luminance.

Experimental results (ECG)

ex) Subject L(luminance 19)



Experimental results (ECG)



Significant change related to the time was shown.
No significant change related to the luminance was shown.

Conclusion and future work

Conclusion

- We presented the subjective and objective evaluation of biological effect by changing the luminance of stereoscopic displays.
- The relationship between fatigue and displaying luminance was shown in both subjective and objective evaluations.

Future Work

- We'll experiment in a parameter different stuff than the luminance and conduct a comparison with 2D images.