

# The Effect of a High-Resolution 4K Tablet on Physiological and Psychological State While Viewing Various Types of Content

Kiyomi Sakamoto<sup>1</sup>(✉), Seiji Sakashita<sup>1</sup>, Kuniko Yamashita<sup>2</sup>,  
and Akira Okada<sup>2</sup>

<sup>1</sup> Groupwide CTO Office, Panasonic Corporation, 3-1-1 Yagumo-nakamachi,  
Moriguchi City, Osaka 570-850, Japan

{sakamoto.kiyomi, sakashita.seiji}@jp.panasonic.com

<sup>2</sup> Department of Human Life Science, Osaka City University, 3-3-138 Sugimoto,  
Sumiyoshi-ku, Osaka 558-8585, Japan

{yamasita, okada}@life.osaka-cu.ac.jp

**Abstract.** We experimentally investigated the effects of using a high-resolution 4K tablet on physiological and psychological states while viewing various types of content. The results showed the scores for “precise–coarse,” “feeling of invigoration–no feeling of invigoration” and “enjoyable–boring” when viewing 4K scenic content to be significantly higher than those for 2K scenic content. Moreover, NIRS values, an index of nervous system activity, during viewing tests of 4K scenic content, were significantly higher for 4K content than for 2K content.

**Keywords:** Physiological and psychological measurements · High-resolution 4K tablet · NIRS

## 1 Introduction

Technological progress has led to significant changes in our display-viewing environments. Higher-definition screens, with 4K TV already in production and 8K TV in prospect, and various types of viewing styles, using TVs, PCs and smartphones, make it increasingly important to consider the effects of these changes on human physical and mental health. Our belief that improvements in picture quality and presence should be accompanied by reduced viewer stress and visual fatigue prompted us to investigate the effects of using high-resolution 4K display devices on physiological and psychological state while viewing various types of video content. In a prior study [1], we conducted an investigation of the effects of using a 65-in. 4K TV on the physiological and psychological states, while viewing various types of video content, of eight participants in their 20s. The results showed the scores for “presence,” “impact,” “realism,” “quality” and “precision” when viewing 4K scenic content to be significantly higher than those for 2K content. Significant differences were also observed between NIRS

(near infrared spectroscopic topography) values, an index of nervous system activity, while viewing tests of 4K content and of 2K content. However, further studies using various sizes and types of display will be needed to confirm whether, physiologically and psychologically, 4K viewing is superior to 2K viewing. We therefore explored and evaluated the influence of a high-resolution 4K tablet on psychological state during content viewing.

## 2 Methods

**Subjects:** Ten adults aged in their 20s participated in this experiment.

**Measurements:** The following items were investigated.

- (1) Participants' psychological state, reported on a scale of 3 to -3 for 24 items, included "presence-no presence," "reality-no reality," "high quality-low quality," "relaxed-stressed," "comfortable-uncomfortable," and "like-dislike." These psychological items were additionally defined in the light of the results of pilot experimental interviews and those obtained in our prior study (Table 1).
- (2) NIRS: Brain activity, based on total hemoglobin or oxyhemoglobin, was obtained using NIRS detectors placed on the left and right of the participant's forehead.
- (3) Heart rate (HR) and heart rate variability (LF/HF; level of sympathetic nerve activity): LF/HF is defined as the ratio of the low-frequency band (LF: 0.04–0.15 Hz) to the high-frequency band (HF: 0.15–0.5 Hz) [2, 3], calculated by FFT analysis using the R-R interval based on heart rate variability obtained by electrocardiogram.
- (4) Blinking rate, obtained using an electrooculogram (EOG).
- (5)  $\beta/\alpha$ , calculated from beta and alpha waves obtained using electroencephalogram (EEG) frequency analysis derived from the Cz reference, based on the international 10–20 method.
- (6) Respiration rate (RR), calculated by monitoring a respiratory sensor unit attached to the thorax.

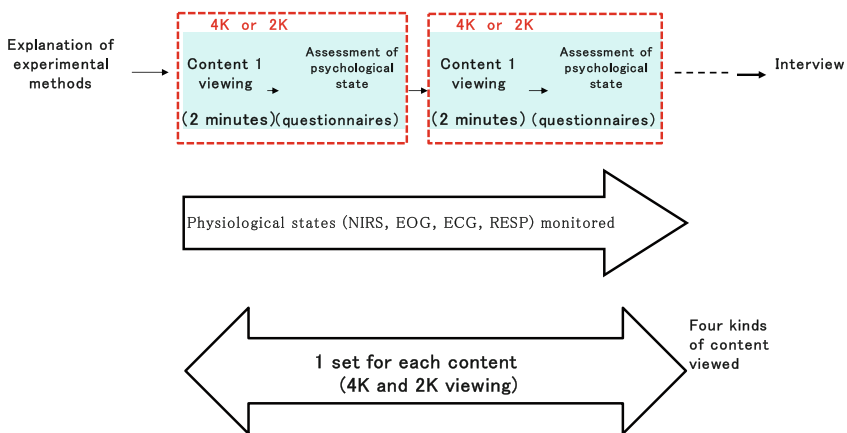
### Apparatus:

- (1) The display device was an A3-size 4K tablet (Panasonic UT-MB5015SEZ).
- (2) The viewing distance was set at 1.5H (45 cm). Screen-to-eye distance was defined in relation to screen height (H). The recommended viewing distance for a 4K TV, defined as 1.5 times the display's height, was 45 cm for the A3 tablet.
- (3) Test room illumination was set at 200 lx to simulate the average light level of a Japanese living room, based on JIS standardization.

**Procedure:** Figure 1 shows the process of the viewing test. The participants viewed four kinds of TV video content (two types of scenic material and two kinds of material with movement and action). Each set comprised 2 min of 4K and 2 min of 2K content. After viewing each program, the participants gave a subjective assessment of their psychological state, on a scale of 3 to -3. One minute of rest time was given before

**Table 1.** Subjective assessment items

Subjective assessment items (including 21 items)
Qualitative assessment of high resolution
“Sharp focus–no sharp focus,”
“Precision–lack of precision,”
“Precise–coarse,”
“Natural–artificial,”
“Looks like a real object–doesn’t look like a real object,”
“Clear–not clear,”
“Realistic–not realistic,”
“Dynamic–static,”
“Feeling of depth–no feeling of depth”
“High quality–low quality,”
Emotional assessment of high resolution
“Presence–no presence,”
“Feeling of invigoration–no feeling of invigoration,”
“Feeling of congruity– feeling of incongruity”
“Impact–no impact,”
“Good–bad,”
“Comfortable–uncomfortable,”
“Enjoyable–boring,”
“Relaxed–stressed,”
“Like–dislike,”
“Aroused–sleepy,”
“No visual fatigue–visual fatigue”



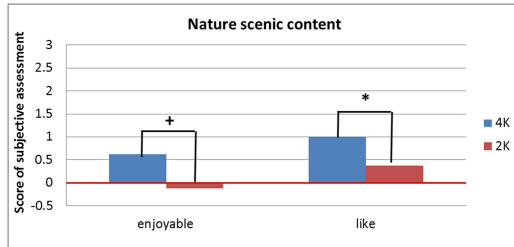
**Fig. 1.** The process of the viewing test using four types of content

viewing each type of content. Physiological indices were monitored while the participants underwent the viewing tests. To eliminate the order effect, the order of the content type or resolution was made unique to each participant. Moreover, the resolution of current viewing content was not informed to the participant, since it might have influenced their evaluation score.

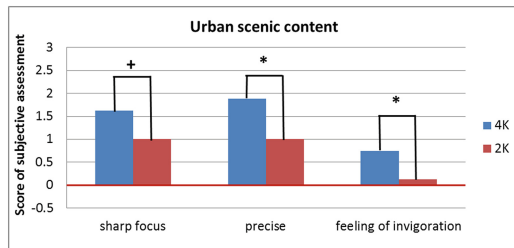
**Statistical analysis:** A paired t-test was performed to statistically analyze the influence of the high-resolution 4K displays on the subjects’ psychological state while viewing different types of content. The level of significance was set at  $p = 0.05$ .

### 3 Results and Discussion

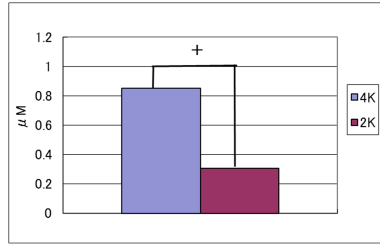
The results showed that the scores for “precise–coarse,” “feeling of invigoration–no feeling of invigoration” and “enjoyable–boring” when viewing 4K scenic content were significantly higher than those for 2K scenic content (Figs. 2 and 3).



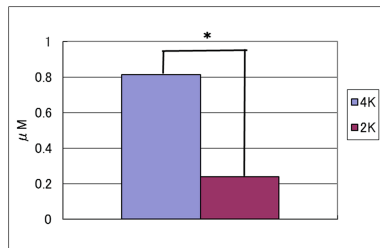
**Fig. 2.** Mean scores of subjective assessments at 4K and 2K when viewing nature scenes. (Eight participants). A higher score indicates a more positive evaluation. \*\*:  $p < 0.05$ , +:  $p < 0.1$ , X-axis (subjective assessments at each resolution), Y-axis (score of subjective assessments)



**Fig. 3.** Mean scores of subjective assessments at 4K and 2K when viewing urban scenes. (Eight participants). A higher score indicates a more positive evaluation. \*\*:  $p < 0.05$ , +:  $p < 0.1$ , X-axis (subjective assessments at each resolution), Y-axis (score of subjective assessments)



**Fig. 4.** NIRS (total Hb) during viewing tests for nature scenes at 4K and 2K. +:  $p < 0.1$ , X-axis: resolution (4K or 2K), Y-axis: NIRS (total Hb)



**Fig. 5.** NIRS ( $\text{O}_2\text{Hb}$ ) when viewing tests for urban scenes at 4K and 2K. \*:  $p < 0.05$ , X-axis: resolution (4K or 2K), Y-axis: NIRS ( $\text{O}_2\text{Hb}$ )

Moreover, NIRS (total Hb), an index of nervous system activity, during viewing tests of 4K nature scenic content, tended to be higher for 4K content than for 2K content (Fig. 4), and NIRS ( $\text{O}_2\text{Hb}$ ) during viewing tests of 4K urban scenic content was significantly higher for 4K content than for 2K content (Fig. 5).

The number of psychological indices which showed a significant difference between 4K viewing and 2K viewing on a 4K tablet was fewer than that for a 65-in. 4K TV. As the psychological evaluation might be influenced by display size, it is possible that a bigger screen created a stronger impression than a smaller one.

However, the data for NIRS using a 4K tablet supported our prior study results with a 65-in. 4KTV [1]. Although the effects varied slightly according to content being viewed and type of screen, our results suggest that viewing at 4K can cause psychological elation and a surge in brain activity.

Further investigations will be needed to gain a more precise picture of the influence on psychological state of high-resolution 4K displays.

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