Effect of display resolution on physiological and psychological state while viewing video content

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Abstract

We experimentally evaluated the effect of display resolution on physiological and psychological state while viewing video content at 4K and 2K on a 65-inch 4K TV. Four kinds of video content (two types of scenic material and two types of material with movement and action) were used. Each program comprised two minutes of 4K and two minutes of 2K content. The results showed that the scores for “presence,” “impact,” “realism,” “quality” and “precision” when viewing 4K scenic content were significantly higher than those for 2K content. Significant differences were also observed between NIRS, an index of autonomic nervous system activity, during viewing tests of 4K content and that for 2K content; and between heart rate, an index of sympathetic nervous system activity, during viewing tests of 4K content and that for 2K content. Our results suggest that viewing material at 4K causes psychological elation, a surge in brain activity and calming of autonomic nerve activity, although the effects varied with type of content.

I. INTRODUCTION

Bigger and higher-definition screens and longer TV viewing times due to changing TV viewing styles, which are becoming more diverse due to broadening content, such as video games and web pages in addition to conventional TV programs, make it increasingly necessary to consider the effects of these changes on visual fatigue and health. To develop TVs that minimize visual fatigue and be able to propose optimum TV viewing conditions, these factors need to be investigated in addition to the conventional focus on image quality and presence.

Stress levels in modern life continue to rise and are taking their toll both physiologically and psychologically. Contact with the natural world, however, has been noted to cause physiological and psychological relaxation; and several studies have been carried out on the physiological and psychological relaxation effects of “forest bathing” and viewing rose blooms [1]. The “harder” side of high-definition TV technology, such as for 4K TV and 8K TV, continues to progress, but there is a growing need to focus on “softer” aspects, such as on qualities that favor human vision and health by not only minimizing visual fatigue but also reducing stress, and studying how increasing image quality and presence are related to these qualities. We therefore explored and evaluated the effects of display resolution on subjects’ physiological and psychological state while they viewed video content.

II. EXPERIMENT

Participants: Eight subjects in their 20s
Display device: 65-inch 4KTV (Panasonic TH-L65WT600)

The following items were investigated.
(1) Participants’ psychological state, reported on a scale of 3 to -3 for 24 items including “stressed-relaxed,” “presence-no presence,” “comfortable-uncomfortable,” and “like-dislike.” These psychological items were additionally defined in the light of the results of pilot experimental interviews and those of our prior study.
(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), 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) β/α, 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.

The results showed significantly higher scores for “presence,” “impact,” “realism,” “clarity” and “feeling of invigoration,”...
when viewing 4K nature scenic content than when viewing 2K content. The results for “presence,” “impact” and “realism” are shown in Figure 1.

![Figure 1. Subjective assessment scores at 4K and 2K when viewing nature scenes. Higher scores indicate more positive evaluations. *: p < 0.05 X-axis: resolution for each subjective assessment Y-axis: Subjective assessment score](image1)

When viewing urban scenes, the score for “feeling of invigoration” for 4K content was significantly higher than that for 2K content, and the scores for “precision,” “impact,” and “quality” for 4K content tended to be higher than those for 2K images. On the other hand, the results showed the scores for “presence,” “feeling of invigoration,” “realism,” “clarity,” “feeling of depth” and “quality” when viewing 4K food material content to be significantly higher than those for 2K content. Moreover, the scores for “feeling of invigoration” and “impact” when viewing 4K material content (jewels, watches, glass and fur, etc.) were significantly higher than those for 2K content, and the scores for “precision,” “feeling of depth” and “sharp focus” for 4K content tended to be higher than those for 2K.

A paired t-test was performed to statistically analyze the influence of the high-resolution 4K displays on physiological indices while viewing different types of content. The results showed that NIRS (total cHb), representing nervous system activity, during viewing tests of 4K nature scenic content, was significantly higher than that for 2K content (Figures 2 and 3).

![Figure 2 Time line of NIRS (total cHb) at 4K and 2K when viewing nature scenes. NIRS baseline set to that at the start of viewing. X-axis: timeline when viewing nature scenes Y-axis: NIRS (total cHb) at 4K and 2K](image2)

In Figure 2, the time variations in NIRS were averaged over all eight participants. In Figure 3, NIRS was indicated as the mean integrated NIRS value per second for the eight participants during the viewing test.

Heart rate (HR), representing sympathetic nervous system activity, was significantly lower during the 4K nature scenic content viewing tests than for identical 2K content (Figure 4).

![Figure 4 Heart rate (HR) during viewing test for nature scenes at 4K and 2K *: p < 0.01 X-axis: resolution (4K or 2K) Y-axis: heart rate (HR)](image4)

Blinking rate during viewing tests for 4K nature scenic content tended to be lower than that for 2K. The results also showed heart rate (HR) during the 4K viewing tests for food to be significantly lower than that for 2K content. On the other hand, when viewing the two other types of content, no significant difference was observed between any of the physiological indexes for 4K or 2K images.

Our results suggest that content viewing at 4K can cause participants to experience psychological elation, a surge in brain activity, and reduced autonomic nervous activity [2], although the effects varied somewhat according to type of content.

REFERENCES
