Effect of TV's physical controls on psychological dimensions for still image quality evaluation.

Hae-Yeon Kim*, Jeong Weon Wu*, Sun-Hee Cho*, Ju-Mi Lee*, Na-Keung Lee*, Soo-Keun Shin**
Ewha Color Design Research Institute, Ewha Womans University, Seoul, Korea, Monitor4U Inc** Seoul, Korea*

Abstract

The purpose of this study is to find out changes in the psychological dimensions that evaluate the image quality of TV still images as to the various levels of the TV's physical controls (e.g. contrast, brightness, hue (tint), saturation (color), color temperature and gamma). Results of factor analysis on all of the psychophysical data showed that there are slight differences in psychological dimensions according to each TV program's scenes. Psychophysical test was performed with 5 scenes for the evaluation of the image quality of an LCD-TV, using the evaluation scales for each TV programs. Five scenes from major TV programs - the news, history drama, sports, soap drama, and documentaries - were selected, and TV physical controls with 3~5 levels were used to produce a total of 120 different still pictures. These still images were then shown to 24 male and female university students in their twenties.

The resulting factor analysis on all of the psychophysical data showed that there are slight differences in psychological dimensions according to each TV program's scenes. Psychological dimensions can be roughly divided into 3 categories – SSE (the scene-specific emotion), Sensation, and Pleasant-Unpleasantness. Changes in the color according to changes in the set levels of each TV physical controls showed that each program's scenes had different effects on the psychological dimensions. Maximization of the dynamic range was particularly found also to maximize all psychological reactions for all TV program scenes. Changes in saturation and hue led to different reactions in the 3 psychological dimensions for all scenes. On the other hand, changes in gamma and color temperature resulted in a weak reactions of psychological dimensions, and the reaction varied according to the scenes.

Introduction

Customers' decision has been considered as an important factor in judging image quality. Satisfaction in image quality is judged by the TV watchers other than the TV objective specs. Various scenes can be presented when judging the image quality and each scene arouses different emotions.

Psychologists are emphasizing the importance of emotion in making their decision. For example, Zajonc (1980) has said that emotion reaction is the first response which is caused automatically and after that the information process occurs. There are definitely different emotions depending on different scenes, and emotion is an important psychological dimension affecting the judgment for image. While in previous studies only the objective perceptual properties were used in judging image quality, we introduce scene-dependent emotion as an important psychological dimension.

The following preparatory studies were performed in advance before the main study part is pursued. Firstly, the important scenes for TV were surveyed by customers. After that, adjectives describing each scene were selected in terms of judging image quality. We have obtained the psychological dimension used in judging image quality depending on the scene by the results of the adjective scale experiment. The image quality judgment for most of the scenes is done by SSE (the scene-specific emotion), sensation, and pleasant-unpleasant dimension.

The aim of this study was to find how TV physical controls variable of the TV affects the psychological dimension for each scene.

Preparatory Studies

Setup Selection adjectives as an image quality scale

Through brain storming, previous studies and using the dictionary, 200 adjectives for judging image quality for still images were selected. Five hundred university students in their 20s' were asked to decide the suitability of the adjectives in judging image quality on a 7 point scale. Using cluster analysis the adjectives were categorized into 10-12 clusters by their similarity. The representing adjectives were selected for each cluster and they were different for each scene.

Image quality experiment to find Psychological Dimension

An experiment of judging image quality was to find the psychological dimension. Three images were selected for each scene which showed similar emotions for the experiment. Therefore, 15 images were presented to the participants to be judged randomly. As results of factor analysis, 7 point scale of 10-12 adjectives was used as to judge the image quality. Excluding the documentary, the other scenes image quality judgment could be sorted into 3 psychological dimensions using factor analysis (principle component analysis and varimax rotation). The psychological dimensions of image quality for TV scenes are SSE(Scene-Specific Emotion), Sensation, and Pleasant-Unpleasantness. Especially, SSE (Scene-Specific Emotion), which shows unique emotions effected by scenes, was different for each scene. [Table 1] lists the psychological dimension and adjectives that represent each scene.

Experimental method

Setup

Subjective image quality evaluation was performed in a standard test room using a 40-inch LCD-TV (Samsung's 2007 Bordeaux TV, LN40R81BD). This TV has a pixel resolution of 1366×768, and vertical frequency of 60Hz. Its backlight system was a normal CCFL BLU that covers 72% of the color reproduction range of the original NTSC (1953). The participants evaluated the TV still pictures from a distance of 2.5m. The room was illuminated at 400-600lx, which is a typical viewing condition at home in Korea. A large screen with N5 gray color was installed behind the TV, in order to minimize any possible fatigue over the eyes, as well as to give adequate contrast between the screen and the background.

Table1: Psychological dimension & adjectives

TV still images	SSE	Sensation	Pleasant-Unpleasant
News	calm simple live natural sophisticated	refined colorful bright vivid	stimulus dynamic
Documentary	approaching live strong intense cool dynamic	soft natural abundant vivid	
Sports	active strong live dynamic	colorful vivid bright	soft natural harmonic
Soap drama	intense splendid sensuous active stimulus	bright vivid refined	natural soft delicate
History drama	strong courageous dynamic tense live	colorful attractive bright vivid	soft natural harmonic

Test still images

5 still images were selected for the experiment of this study. These images included scenes that represent major TV programs - the news, dramas, sports, and documentaries. Each scene was selected based on a survey with the question which scenes were most memorable among the programs for the given category: A war and a love scene were selected for dramas; an anchor's reporting scene for the news; a goal shooting scene in a soccer game for sports; and a lion's hunting scene for documentaries.

Figure 1. Test Images

Procedure

Twenty four male and female university students in their twenties participated in the psychophysical experiment. All the participants passed the Ishihara color blind test prior to the experiment. While changing the setting with 3~5 levels of 6 physical controls (contrast, brightness, saturation(color), hue(tint), color temperature, and gamma) of TV that affect the image quality, participants were asked to evaluate on a scale of 7(1 to 7) the conformity of adjectives to the above 5 still images. The adjectives were collected separately for each scene.

[Table2] shows 6 physical controls and set levels of TV for the experiment. For each of the 6 physical controls, 3 to 5 levels were applied, resulting in a total of 24 combinations for each still image. Since 5 images were used, a total of 120 different still images were reproduced on a TV screen, and these 120 still images were presented randomly to the participants, who were then asked to evaluate the adjectives for each of the scenes. Participants were asked to judge the conformity of 10~12 adjectives to each scene, which sums up a total of 1,200 questions for 24 participants.

Participants received instructions prior to the experiment and were able to rest their eyes for a minute after the evaluation of each still image. They performed the evaluation for 40 still images per session and there was an interval of a week for each session, requiring a total of 3 weeks to complete the experiment. The order of the questionnaires were also randomized for the participants evaluating 10~12 adjectives of each still images.

Table2: TV Physical Controls Level

Physical controls of the TV	Level
Contrast	40, 80, 100
Brightness	10, 30, 50, 70, 90
Saturation	30, 40, 50, 70,90
Hue	G90-R10, G70-R30, G50-R50 G30-R70, G10-R90
Temperature	Warm2, Standard, Cool2
Gamma	-3, 0, +3

Physical Controls of the TV and Physically Controlled Variables

Contrast Control

The range of contrast control for the TV used in this experiment was from 1 to 100. An increase in contrast showed no significant effect on the dark colors, but the brightness increased significantly for lighter colors. The higher the contrast, the brighter and more vivid the screen becomes.

Brightness (Black Level) Control

The range of brightness control for the TV used in this experiment was from 1 to 100. An increase in brightness would lead to a similar rate of increase in brightness for all levels of colors and the entire screen would brighten up to a certain level.

But beyond that point, the bright colors would saturate, no longer brightening up, and dark colors would be over-brightened, weakening the contrast.

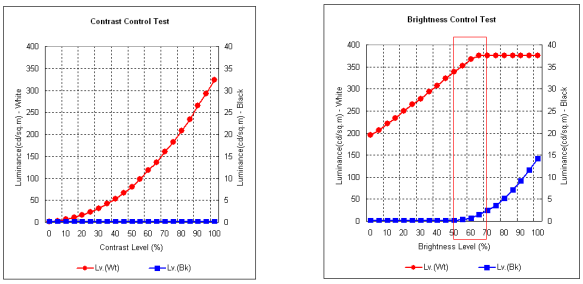

Figure 2.Contrast, Brightness control

Saturation(color) Control

The range of saturation control for the TV used in this experiment was from 1 to 100. Up to a certain point, an increase in saturation would lead to an increased color reproduction range. But beyond that point, the color reproduction range will no longer show any changes, and the colors will be saturated to show exaggerated colors.

Hue(Tint) Control

The range of hue control for the TV used in this experiment was from Green'0' - Red'100' to Green'100' - Red'0'. When the hue is changed beyond a certain level, the screen would show excessive tones of yellow or pink color.

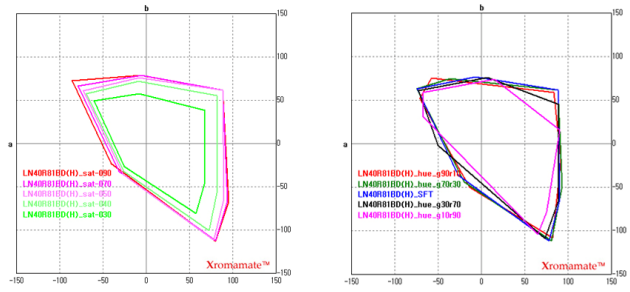

Figure 3.Saturation, Hue control

Color Temperature Control

The range of color temperature control for the TV used in this experiment was one of the 5 options, Warm2, Warm1, Standard, Cool1, or Cool2. We selected Warm2, standard and Cool2 for the experiment, and the actual color temperatures measured were 6941K, 9774K and 16784K respectively. Increase in color temperature leads to a cooler and clearer image, and lower temperature to a lighter and warmer image.

Gamma Control

Increase in gamma leads to stronger and sharper, but darker colors in general, while lower gamma leads to lighter and brighter, but washed-off colors. In case of the TV used in this experiment, the gamma actually measured was 2.2 for level named 'standard', 1.9 at level +3, and 2.6 at level -3.

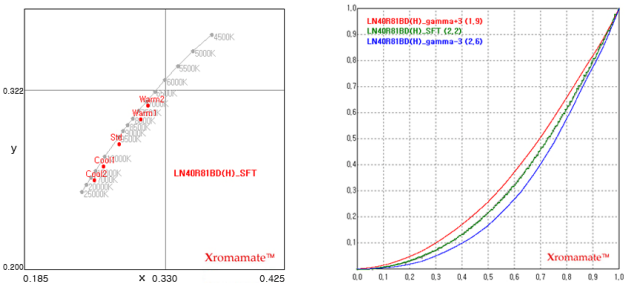

Figure 4.Color Temperature, Gamma control

Experimental results

The reactions of the participants by the image quality judgment scale for each scene, regarding to the TV physical controls variable, were the dependent variable for the statistic analysis. The average reaction of the adjectives in the psychological dimension was used because the aim of this study was to inspect the changes on the psychological dimension. ANOVA was used in order to find the verification of the interaction between psychological dimension and TV physical controls variables. The following are the results of the ANOVA and the changes of the psychological dimension according to the physical controls variables.

As an example for color saturation in news scene, the effect of the color saturation level and psychological dimension was highly significant. The effect of the interaction between color saturation and psychological dimension was highly significant ($F(8, 184) = 32.512$, $p = .000$).This was the main hypothesis of this study. [Figure 5] show that different color saturation levels affect the 3 psychological dimensions differently. Hue, color temperature, contrast, and brightness showed interaction with the physical controls variables and psychological dimension. However, gamma showed none ($F(4, 92) = 1.994$, $p = .102$). As shown in the figure the gamma difference affects the same for all three psychological dimensions.

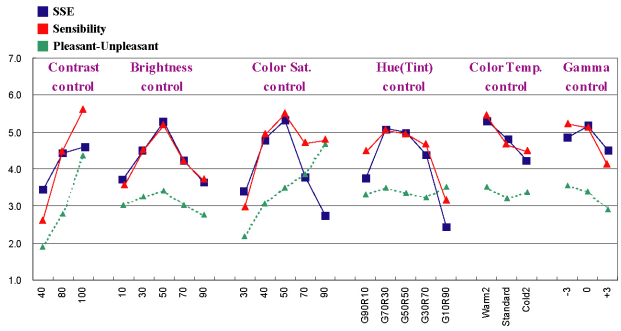

Figure 5.news & TV controls

[Figure 6] is the results for documentary scene. That shows the changes of the psychological dimension by the level of physical controls variables. The brightness, color saturation, and hue showed interaction with the psychological dimension. However, contrast, gamma, color temperature has not showed any interaction.

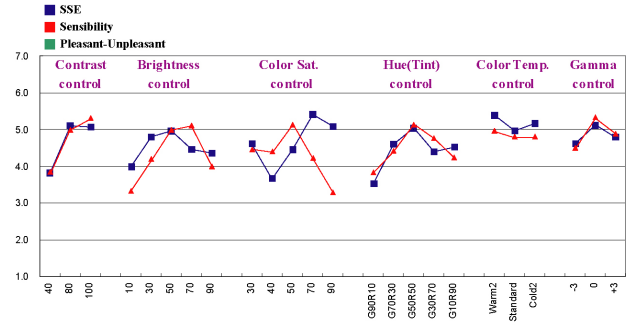

Figure 6.Dacumentary & TV controls

The effect of the color temperature (F (2, 46) = 1.715, p = .191) and gamma (F(2, 46)=1.347, p = .270) was not significant for the sports scene.

[Figure 7] shows that there is no reaction when changing the level of two physical controls variables. However contrast, brightness, color saturation and hue shows large differences in different levels.

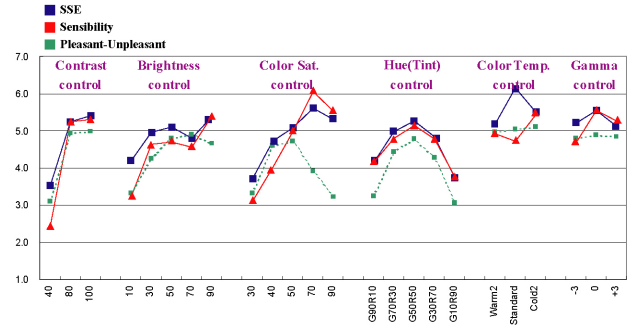

Figure 7.Sports & TV controls

[Figure 8] is for the love scene in a soap drama. Emotion level has increased as the contrast level increases and brightness, color saturation, hue show the highest in the middle point

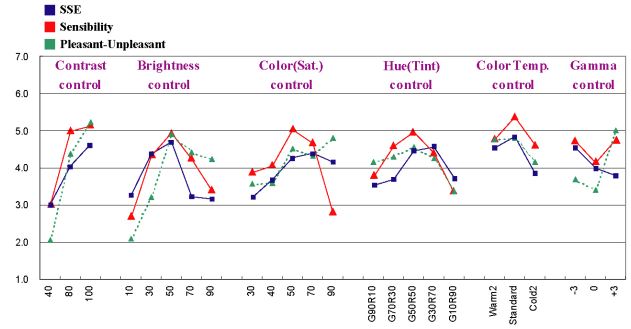

Figure 8.Soap drama & TV controls

In the history scene every effect, excluding gamma, was highly significant. In terms of interaction between the psychological dimensions and the gamma was highly significant. [Figure 9] shows that the increase of contrast increases the emotion level then saturates and brightness, color saturation, and hue show the highest in the middle level. The lowest level show the best reaction of the color temperature

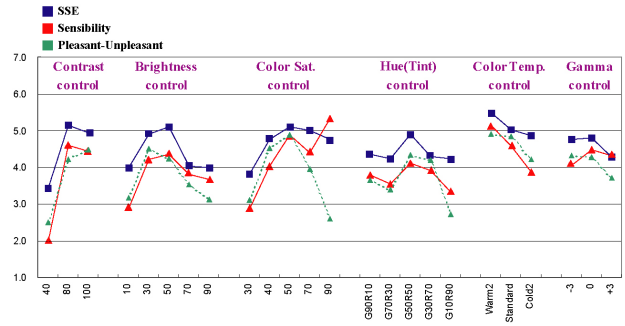

Figure 9.History drama & TV main control

Conclusion

Traditionally, brightness and contrast controls of TVs are used to adjust the black level and white level respectively. It has been known in the display industry that when these controls are properly adjusted, the dynamic range of the TV is maximized. And then this maximum dynamic range gives the most brightness and best contrast. The experiments we have conducted also support this idea in terms of the psychological reaction. The participants' psychological reaction showed most strong reaction with the optimum black level and the maximum white level, which resulted in the maximum contrast ratio for the TV, as depicted in [Figure 10]

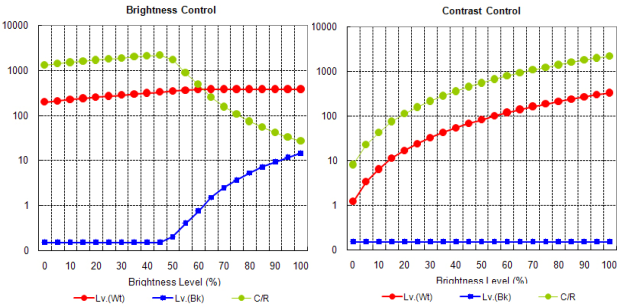

Figure 10.Dynamic range

The experiment on saturation(color) and hue(tint) controls of the TV showed that the participants' psychological reaction was most stimulated by the balanced hue and saturation for the 5 most typical scenes of TV broadcasting. Excessive level of hue (tint) gives yellowish or pinkish tone and resulted in poor psychological reaction. Deficient or excessive color also degraded the image quality in psychological dimension aspect. Therefore balance or harmony was the most important attribute for these controls. So despite of their importance in color appearance, changes in gamma and color temperature showed little emotional reactions in all the 5 typical scenes. This result indicates that participants, in average, are far less sensitive to changes in gamma or color temperature than other controls of the TV, when watching a typical TV program through a single TV set in a typical viewing condition. This result also implies that we may have to re-establish some part of the traditional image quality criteria in terms of psychological dimension aspect. Further studies are scheduled to be conducted to investigate the relationship between psychological dimension and other image quality parameters

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