

# Is Dynamic Visual Search Performance Sensitivity to the Visual Fatigue and Comfort of LED TV? A Comparative Experiment of Eight LED TVs

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**Abstract.** A comparative experiment was conducted to make clear whether dynamic visual search performance is sensitivity to the visual comfort of LED TVs by testing dynamic visual search performance and visual fatigue of eight LED TVs. 16 ordinary man from 18 to 45 years old were paid to participate in the experiment. And all subjects were arranged to doing the dynamic visual search task when velocity was 5°/s. Each participant took the same dynamic visual search tasks on the eight LED TVs in the experiment. The search time and accuracy of each participant were recorded. The results shows that there is significant difference about the accuracy and dynamic visual search time in the course of 5°/s movement velocity between different LED TVs. And there is corresponding mode of comfort, satisfaction, the subjective fatigue feeling between different LED TVs. Those results revealed that dynamic visual search performance was sensitive to visual fatigue and comfort under the situation of 5°/s movement velocity. The obtained results could be a reference for evaluating the quality of LED TVs for a specific visual search task.

**Keywords:** Dynamic visual search task · Visual fatigue · Comfort · LED television

## 1 Introduction

With the coming of the information era, the way of information communication has greatly depended on the visual display terminal (VDT). As a kind of visual display terminal, LED television is essential in our daily life. With the continuous innovation of the display industry technology, the television products are constantly upgrading, but, it is not easy to buy the suitable televisions for consumers' different goals. Generally, the consumers might watch movies, watch the games, surf the internet and do many other activities, however, these complex activities might be related to dynamic visual search performance of LED

TVs. Therefore, how to choose a more comfortable and efficient LED TV is important to the consumers, particularly to the ball fans and game enthusiasts, etc.

This study intends to investigate the effect of watching visual displays by dynamic visual search task paradigm and subjective survey. The study is expected to provide indicators to evaluate the efficiency of LED televisions. According to ISO international standard [1] about the user performance test methods for electronic visual displays, we adopted a dynamic visual search task paradigm [2] to evaluate the fatigue degree of LED TVs. We had tested the dynamic visual search task performance, user experience and the visual fatigue degree of 8 LED televisions, which provide the reference for the consumers, fans and gamers buying televisions. The specific evaluation indicators include the effectiveness, efficiency, comfortable and satisfaction. The visual fatigue perception scale developed by Sheedy [3] was used to evaluate the eye and mental fatigue degree.

## 2 Method

### 2.1 Participants

Sixteen ordinary users from 18 to 45 years old (8 male and 8 female, mean age = 31.56) were recruited and paid to participate in the experiment. Among them, the participants under the age of 25 were accounted for 18.8 %, 25 years old–40 years old were accounted for 68.7 %, and the participants over the age of 40 were accounted for 12.5 %. All had normal or corrected-to-normal visual acuities and healthy physical conditions, without ophthalmic diseases. They did not have any history of neurological and mental diseases. And all well-rested participants were arranged to doing the dynamic visual search tasks on eight LED television by the turn that was random in Latin square design.

### 2.2 Experiment Design

A within-subject factorial design was used in this experiment. The independent variable of the experiment is TV types which include eight LED TVs. In this experiment, the dynamic visual search performance, visual fatigue were measured to assess and compare which LED TV is better. The subjective questionnaire was used to investigate the visual fatigue after performing the dynamic visual search task. Participants reported their perception and evaluations by filling in a questionnaire. All the questions in the questionnaire were measured by a hundred-point scale from none to strongly serious (0 = “none” and 100 = “strongly serious”).

### 2.3 Apparatus

Experiments were conducted in a laboratory environment which simulated home condition. It was installed in the laboratory in the Institute of Human Factors and Ergonomics lab in China National Institute of Standardization. The dynamic visual search tasks are displayed on the 8 LED TVs. We selected 8 46–48 in. (1 in. = 2.54 cm)

LED TVs as test samples from the market. The image mode of all the LED televisions sets exactly the same standard mode.

## 2.4 Procedures

After arriving at the laboratory, participants signed the informed consent and completed a general survey about their demographic information. The participants were asked to sit into the simulator to get ready for the test. Then we had a visual acuity and diopter measurements for the participants. After that, the participants were asked to follow their own natural state to do the dynamic visual search task when velocity was  $5^\circ/\text{s}$ , which is near to the velocity of ball games. Before the experiment, participants were asked to relax 10 min or more, and told the testing process and requirements. Before the experiment, the height of the table and display position were adjusted to make the participants' eyes and display center on a line. The viewing distance is about 300 cm. The experiment task is search a circular ring from dynamic circle matrix [4]. After dynamic visual searching, the participants were required to fill out the visual fatigue questionnaire. The same procedures have done on each LED TVs. Each participant spent about four hour finishing the experiment for two times.

## 2.5 Data Analysis

The changes value of dynamic visual search and visual fatigue were analyzed by IBM SPSS 20 Statistics software (IBM-SPSS Inc. Chicago, IL). The method of repeated-measure ANOVA analysis is applied to the response accuracy data and response time.

# 3 Results

## 3.1 The Basic Luminance Information of LED Televisions Samples

The basic luminance information of 8 LED televisions samples is as follows (Table 1).

**Table 1.** The basic luminance information of 8 LED televisions samples

Samples	Screen size	Physical resolution	Refresh rate	Luminance
1	47	$1920 \times 1080$	60 Hz	$2.44\text{E} + 0.1 \text{ cd/m}^2$
2	46	$1920 \times 1080$	60 Hz	$7.94\text{E} + 0.1 \text{ cd/m}^2$
3	46	$1920 \times 1080$	60 Hz	$2.00\text{E} + 0.2 \text{ cd/m}^2$
4	48	$1920 \times 1080$	60 Hz	$1.20\text{E} + 0.2 \text{ cd/m}^2$
5	47	$1920 \times 1080$	60 Hz	$5.51\text{E} + 0.1 \text{ cd/m}^2$
6	46	$1920 \times 1080$	60 Hz	$1.01\text{E} + 0.2 \text{ cd/m}^2$
7	47	$1920 \times 1080$	60 Hz	$2.53\text{E} + 0.2 \text{ cd/m}^2$
8	47	$1920 \times 1080$	60 Hz	$2.02\text{E} + 0.2 \text{ cd/m}^2$

Note: The luminance values were tested in the same place of the sane laboratory at the same light intensity running under the visual search task and the LED TVs were set up the standard mode value during the luminance determination process.

### 3.2 Comparison of the Visual Search Task Performance on 8 LED TVs

The visual search task performance is mainly including two aspects, one is the response accuracy data, which demonstrates the effectiveness of visual search task; the other is the average search time, reflects the efficiency of visual search task. The results show that the whole performance of samples 4 is better than others, while whole performance of samples 5 is less than others (See the Table 2).

**Table 2.** Comparison of visual search effectiveness and efficiency of 8 LED TVs

Samples	Visual search accuracy data	Average visual search time	Comfortable degree	Satisfaction
1	4.31	76.32	45	50
2	8.07	65.08	61	60
3	6.00	81.56	51	54
4	10.13	46.58	66	67
5	5.67	86.09	38	42
6	8.25	51.68	54	56
7	6.60	94.36	55	58
8	6.06	54.74	62	65

A repeated-measure ANOVA analysis was conducted to compare the effect of the eight types of LED TVs on participants' search effectiveness, search efficiency, comfortable degree and satisfaction.

The results shows that there is a remarkable difference between the visual search effectiveness of eight LED TVs ( $F = 3.532$ ,  $p < 0.01$ ). The planned comparisons revealed that the visual search effectiveness of sample 4 and 6 is remarkably higher than that of sample 1, 5 and 7 ( $ps < 0.05$ ), and the visual search effectiveness of sample 2 is significant higher than that of sample 1 ( $p < 0.05$ ), and the visual search effectiveness of sample 4 is significant higher than that of sample 8 ( $p < 0.05$ ).

The results shows that there is a remarkable difference between the visual search efficiency of eight LED TVs ( $F = 2.212$ ,  $p < 0.05$ ). The planned comparisons revealed that the visual search efficiency of sample 4, 6 and 8 is remarkably higher than that of sample 5 and 7 ( $ps < 0.05$ ).

The results shows that there is a remarkable difference between the comfortable degree of eight LED TVs ( $F = 4.050$ ,  $p < 0.01$ ). The planned comparisons revealed that the comfortable degree of sample 4 is remarkably higher than that of sample 1, 3 and 5 ( $ps < 0.05$ ), while the comfortable degree of sample 5 is remarkably less than that of sample 2, 4, 6, 7 and 8 ( $ps < 0.05$ ).

The results shows that there is a remarkable difference between the satisfaction of eight LED TVs ( $F = 3.448$ ,  $p < 0.01$ ). The planned comparisons revealed that the satisfaction of sample 4 is remarkably higher than that of sample 1, 3 and 5 ( $ps < 0.05$ ), while the satisfaction of sample 5 is remarkably less than that of sample 2, 4, 6, 7 and 8 ( $ps < 0.05$ ).

### 3.3 The Subjective Visual Fatigue Feelings After Completing Dynamic Visual Search Task on 8 LED TVs

Participants' perception about the visual fatigue after completing dynamic visual search task on 8 LED TVs was measured by nine items (see Table 3). It is demonstrated in Table 3 that there is more serious visual fatigue feelings of samples 5 on almost all items except for dryness, while there is less visual fatigue feelings of samples 4 on almost all items except for irritation and tearing. It means the result of the subjective report is in accord with dynamic visual search.

**Table 3.** Comparison of the subjective visual fatigue feelings after completing dynamic visual search task on 8 LED TVs

Samples	Burning	Ache	Strain	Irritation	Tearing	Blur	Double vision	Dryness	Headache
1	21.75	25.81	28.75	31.31	17.19	33.63	30.75	27.88	18.00
2	20.63	21.38	26.13	17.44	11.44	23.31	25.19	29.06	14.94
3	26.50	25.13	30.63	26.19	16.50	29.13	27.25	32.94	20.94
4	16.44	14.50	21.88	19.75	11.06	20.56	18.13	20.44	9.69
5	28.31	31.00	36.44	27.56	18.19	38.13	31.50	28.81	21.50
6	23.88	25.81	28.06	25.25	14.94	28.88	24.88	27.13	17.94
7	21.69	28.31	26.56	26.13	13.38	26.81	25.69	23.63	17.06
8	18.75	18.81	25.63	19.44	10.88	28.44	21.94	23.94	12.38

## 4 Discussion and Conclusion

The study investigated the visual fatigue and comfort of LED TVs. It compared the eight LED TVs, to figure out which was better. A compare test was designed and an experiment was conducted to fulfill the study goals. The study indicated that there are significant difference between the eight LED TVs. Those results revealed that dynamic visual search performance was sensitive to visual fatigue and comfort under the situation of 5°/s movement velocity. The obtained results could be a reference for evaluating the quality of LED TVs for a specific visual search task (i.e., the safety check and the soccer game etc.).

**Acknowledgement.** The authors would like to gratefully acknowledge the support of the National Key Technology R&D Program of the Ministry of Science and Technology (2013BAK04B03 and 2014BAK01B03), Quality inspection industry research special funds for public welfare projects (201310095) and China National Institute of Standardization through the "special funds for the basic R&D undertakings by welfare research institutions" (552013Y-3078, 522015Y-3991).

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