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A Study of the Effect of Color Photostimulation from a Cathode-ray Tube (CRT) Display on Photosensitive Patients: The Effect of Alternating Red–Cyan Flicker Stimulation

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Summary: *Purpose:* In an attempt to establish evidence for developing better guidelines for the production of animation programs that would not induce photosensitive seizures in Japan, we evaluated the effects of red flicker, alternating red/cyan (complementary color to red) flicker stimuli, and of contrast between the red and cyan frames from a cathode-ray tube (CRT) display in photosensitive patients.

Methods: We studied 35 photosensitive patients. They were exposed to seven types of flicker. The first three types were alternating red/cyan flicker (R/C) with the luminance of cyan set at three different levels, high, equal, and low luminance (65, 20, and 16 cd/m^2, respectively) relative to the red (20 cd/m^2). The following four types were red, cyan, yellow, and magenta flicker stimuli. EEGs were recorded while the patients watched these stimuli on a CRT display.

Results: Rates of photoparoxysmal response (PPR) provocation were 11.4, 13.7, and 14.0% with high-, no- and low-contrast R/C flicker, respectively, and 3.7% with red flicker. The differences between red and each of the other R/C flicker stimuli were all statistically significant ($p<0.05$, 0.01, 0.01). No significant differences were found between the effects by each of the three levels of contrast in alternating R/C flicker ($p > 0.05$).

Conclusions: These findings suggest that alternating R/C flicker is more provocative than simple red flicker, and that contrast between frames of different colors may play some role in the effects of alternating flicker stimuli from a CRT display in photosensitive patients. Therefore, caution against the use of the combination of red and cyan, in addition to the red flicker stimulus, should be included in any guidelines drawn up to prevent photosensitive seizures. **Key Words:** Photosensitivity—Photoparoxysmal response—Color photostimulation—Pure red color—Cathode-ray tube.

On December 16, 1997, an incident happened simultaneously in several areas in Japan, in which about 700 individuals (mainly young children, low teens) developed acute symptoms, such as convulsions and loss of consciousness, while viewing a popular TV animation program, "Pocket Monster" (broadcast by TV Tokyo) (1). Subsequent studies suggested a possibility that most of these symptoms were photosensitive seizures that were provoked by approximately 12-Hz alternating red/blue inversion frames that lasted about 4 s during the second half of the program (2,3). In response to this development, the Japan Broadcasting Corporation (Nippon Hoso Kyokai (NHK)) and the National Association of Commercial Broadcasters in Japan jointly prepared "Guidelines for picture techniques involved with animation programs, et cetera" (hereafter abbreviated to the "Guideline"; Table 1) (4). This guideline advises that "pure red color" should not be used and that the brightness change must not exceed 20%. Here pure red color is specified as red with the longest wavelength without including a green or blue wavelength component among the three primary colors for television signals.

For a photoparoxysmal response (PPR) provoking effect of the red flickering light stimulation, Takahashi et al. (5,6) before, and Harding (7) after the "Pokemon" incident clearly demonstrated that red color, especially long-wavelength red, plays an important role in triggering PPRs. Based on these reports, a clause specifying that pure red color should not be used was included in the Japanese Guideline.

However, there have been no reports comparing the inversion stimulation caused by a combination of red and another color (like the red/blue inversion frames discussed in relation to the recent "Pocket Monster" incident) and stimulation from a red flickering light. There is also no mention of color combinations in the Japanese "Guideline."

The Japanese "Guideline" states that brightness

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TABLE 1. *Guidelines for picture techniques involved with animation programs*

1. As a general rule, the use of lights or images that flash or flicker >3 times per second should be avoided. Note also the following
   a. Particular caution should be exercised over the use of pure red color
   b. Where the use of flicker at rates >3/s is absolutely necessary, a rate of ≤5/s may be used, provided that the change in image brightness is <20% and that the duration does not exceed 2 s.
2. Brightness inversions of high-contrast images, or scene changes in which the image brightness changes by >20%, should as a general rule be limited to three per s.
3. Regular patterns (such as stripes, spirals, concentric circles, etc.) that occupy the greater part of the screen should be avoided.

changes in frames must not exceed 20%. This is based on a Guideline promulgated by the Independent Television Commission (ITC) of Great Britain, based on the experience of Harding, in which there was intermittent photic stimulation (IPS) of high brightness from a strobe light (8). Although several studies have looked at the PPR-provoking effect of the grating pattern made by the changes in brightness contrast (9,10), no detailed clinical investigations have examined the PPR-provoking effect of the inversion color frame by the differences in brightness contrast. To establish more precise measures to prevent photosensitive seizures, it is necessary to investigate photic stimulation with a low brightness that will simulate a normal television-viewing environment. For the past several years, we have been conducting special EEG study on photosensitivity by using a cathode-ray tube (CRT) display (11). This study was conducted to establish the effect of colors and brightness contrast on the provocation of PPRs and to confirm the validity of the Guideline.

SUBJECTS AND METHODS

Subjects

Thirty-five patients (17 male and 18 female subjects, aged from 6 to 34 years; mean, 15 years and 5 months) who had photosensitivity and were being treated at the outpatient department of Tokyo Women's Medical University hospital were selected. They all had developed PPR [i.e., the development of diffuse spike and waves (type 4 of PPR by Waltz et al.) (12)] during photic stimulation, which was caused by IPS from a strobe light in a standard EEG test. At the time of study, 20 (57%) were being treated with antiepileptic drugs [AEDs; 17 with valproate (VPA) alone, one each with a combination of VPA and phenobarbital (PB), VPA and clonazepam (CZP), and carbamazepine (CBZ) alone]. Among these, 13 watched the aforementioned television animation program, "Pocket Monster," and eight (61.5%) experienced some symptoms, which were generalized seizure in three, partial seizure in two, a loss of consciousness (suspected complex partial seizure) also in two, and headache in one.

Referring to the Harding et al. (13) classification of photosensitivity, each subject was assigned to one of the following four groups based on his or her clinical symptoms (Table 2).

A. Seizures occurred only after some form of photic stimulation: nine patients (25.7%);

B. Seizures occurred after some form of photic stimulation, and also spontaneously: 14 patients (40%);

C. Only spontaneous seizures occurred, but photosensitivity discovered by IPS in EEG testing: six patients (17.1%); and

D. No obvious seizure symptoms, but photosensitivity accidentally discovered by EEG testing: six patients (two discovered from a detailed diagnosis of conditions related to headaches and three with a history of febrile convulsions; one a dizygotic twin of a patient in group A; 17.1%).

Methods

For imaging with stimulation, a VESA-BIOS Extension was used, and the image appeared on 21-inch CRT display (Iiyama-8521E). Simultaneously, EEG recordings were made by using a 21-channel EEG apparatus (EEG-44210, Nippon Koden) according to the International 10-20 system. For the test, each patient was instructed to sit in a dark room 1 m from the display and focus both eyes on the center of the display. Under these conditions, the visual angles were 22 degrees horizontally and 17 degrees vertically.

Four colors—red, cyan (a complementary color of red, i.e., a mixture with blue and green), yellow (a mixture with red and green), and magenta (a mixture with red and blue)—were used for stimulation. To prepare each color,

TABLE 2. *Clinical features of subjects in each group*

Group	n	Gender (M/F)	Age mean (range)	No med/ med	No. of cases by AEDs
A	9	5/4	14 yr 6 mo (9 yr 2 mo–20 yr 1 mo)	6/3	VPA 3
B	14	7/7	17 yr 3 mo (7 yr 6 mo–25 yr 10 mo)	1/13	VPA 11; VPA + PB 1; VPA + CBZ 1
C	6	3/3	20 yr 8 mo (10 yr 4 mo–34 yr 9 mo)	2/4	VPA 3; CBZ 1
D	6	2/4	9 yr 7 mo (6 yr–18 yr 10 mo)	6/0	
Total	35	17/18	15 yr 5 mo (6 yr–34 yr 9 mo)	15/20	

Med, medication; AEDs, antiepileptic drugs; PB, phenobarbital; VPA, valproate; CBZ, carbamazepine.

64 levels of each RGB were combined. The brightness setting of each frame was adjusted by luminosity, based on the amount of the radiant energy determined by a Minolta (Osaka, Japan) spectral radiometer (CS-1000). Before the test, the actual brightness was confirmed by using a Minolta color difference meter (CS-100).

The peak wavelengths for each color were 620 and 705 nm for red; 450 and 530 nm for cyan; 530 and 620 nm for yellow; and 450 and 620 nm for magenta (Fig. 1). Stimulation was applied in the following sequence:

1. Red/cyan inversion stimulation (alternating repetition of red and cyan);
2. Red flickering stimulation (alternating repetition of red and black);
3. Cyan flickering stimulation (alternating repetition of cyan and black);
4. Yellow flickering stimulation (alternating repetition of yellow and black); and
5. Magenta flickering stimulation (alternating repetition of magenta and black).

To examine the effect of the brightness contrast of the frame for red/cyan inversion stimulation, cyan was set at three brightness levels [16 cd/m^2 (low contrast), 20 cd/m^2 (no contrast), and 68 cd/m^2 (high contrast)] and used for inversion with red that had the brightness set at 20 cd/m^2. The brightness of the other colors was set at that for red (20 cd/m^2) equally.

The temporal frequency for each stimulation was at four levels (3, 10, 20, and 30 Hz) for each type of stimulation. Duration of inversion and flickering stimulation were set at 10 s each, with intervals of 10 s. The test was conducted while the patient was under close observation. The stimulation was immediately interrupted if a clinical symptom or a PPR was elicited. For the latter, the test was first interrupted, and then if an EEG recovery was confirmed, the next stimulation was applied. If some symptoms again developed, the test was terminated at that point. In this study, type 4 of PPR by Waltz (10) was defined PPR, whereas types 1 to 3 of PPR of the same classification were evaluated separately as "focal PPR."

To establish the effect of color and brightness contrast, the rates of PPR provocation in the previously described color stimulation test were compared.

Before the test, the purpose and details of the test were explained thoroughly to the test subjects and their parents, and an informed consent was obtained from all. For the statistical analyses, Fisher's Exact probability test was used. The two-sided level of significance was set at <0.05.

RESULTS

During the test, only one patient complained of discomfort simultaneous with the development of PPR, and the test was interrupted. The test did not provoke convulsive seizures in any of subjects.

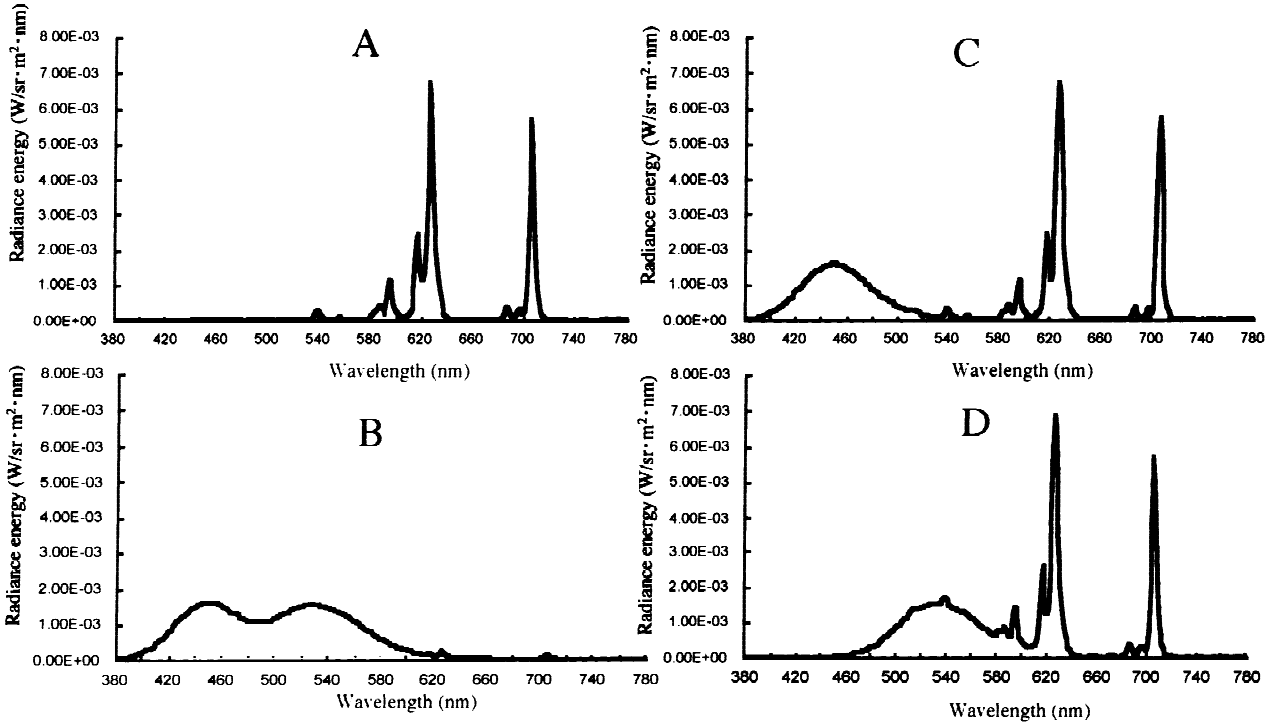

FIG. 1. The spectral output of the red **(A),** cyan **(B),** magenta **(C),** and yellow **(D)** from a cathode-ray tube. The red has two sharp peaks at 620 and 705 nm. The cyan, which is the mixed wavelength of blue and green, has two peaks at 450 and 530 nm. The magenta and yellow have the mixed wavelength of red and blue, red and green, respectively.

Comparison of the rates of PPR provocation for each color stimulation (Figs. 2 and 3)

The PPR provocation rates for the total number of stimulations were 11.4% (16 of 140 times) from red/cyan inversion (high contrast), 13.7% (19 of 139 times) from red/cyan (no contrast), 14.0% (20 of 136 times) from red/cyan (low contrast), and 3.7% (five of 136 times) from red flicker (red/black). When focal PPR was included, the rates increased to 20% (28 of 140 times), 20.1% (28 of 139 times), 20.6% (28 of 136 times), and 5.9% (eight of 136 times), respectively. The PPR provocation rate from the stimulation by red/cyan inversion was significantly higher than that from red flicker alone at each brightness contrast ($p < 0.05$, 0.01, and 0.01, respectively). The inclusion of focal PPR produced similar results ($p < 0.001$ for all).

No PPR was provoked by stimulation of flickering of cyan, yellow, or magenta. When limited to focal PPR, the incidence from cyan, yellow, and magenta was 1.5% (two of 136 times), 1.5% (two of 136 times), and 0.7% (one of 136 times), respectively.

All the patients were subjected to each color stimulation at four frequency levels (3, 10, 20, and 30 Hz). The number of patients with PPR provocation by even a single stimulation was 22.9% (eight of 35 cases) with red/cyan (high contrast); 28.6% (10 of 35 cases) with red/cyan (no contrast), 26.5% (nine of 34 cases) with red/cyan (low contrast), and 11.8% (four of 34 cases) with red flicker. When focal PPR was included, the rates increased to 40% (14 of 35 cases), 42.9% (15 of 35 cases), 41.2% (14 of 34 cases), and 20.6% (seven of 34 cases), respectively. Stimulation from red/cyan inversion frame provoked PPR in a number of the subjects, but even when focal PPR was included, the difference from the number reacting to red flickering light alone was not significant.

Among the four developing PPR with stimulation from red flickering alone, three developed PPR, also with stimulation from red/cyan inversion. Only one produced PPR from red flickering alone.

Comparison of the rates of PPR provocation for each temporal frequency

The PPR provocation rates for the total number of red/cyan and red flicker stimulations were 1.4% (two of 138 times) at 3 Hz, 14.5% (20 of 138 times) at 10 Hz, 13.8% (19 of 138 times) at 20 Hz, and 13.9% (19 of 137 times) at 30Hz. When focal PPR was included, the rates increased to 2.2% (three of 138 times), 19.6% (27 of 138 times), 21.0% (29 of 138 times), and 24.1% (33 of 137 times), respectively. The PPR provocation rate at 3 Hz was significantly lower than that at 10, 20, and 30 Hz ($p < 0.01$ for all). The inclusion of focal PPR produced similar results.

The number of patients with PPR provocation was 5.7% (two of 35 cases) at 3 Hz; 28.6% (10 of 35 cases) at 10 Hz, 22.9% (eight of 35 cases) at 20 Hz, and 28.6% (10 of 35 cases) at 30 Hz. If focal PPR was included, the rates increased to 8.6% (three of 35 cases), 34.3% (12 of 35 cases), 34.3% (12 of 35 cases), and 45.7% (16 of 35 cases), respectively.

Flicker stimulation at 10, 20, and 30 Hz was therefore significantly more provocative than that at 3 Hz.

Comparison by brightness contrast on the inversion frames with red/cyan inversion stimulation

As stated earlier, the rates of PPR provocation for the total number of stimulations were 11.4% for high contrast, 13.7% for no contrast, and 14.0% for low contrast. There were no significant differences among these figures ($p > 0.05$). Similar results were obtained even when focal PPR was included ($p > 0.05$).

The rates of patients with PPR in the total number of the subjects were compared by the brightness contrast. They were 22.9% for high contrast, 28.6% for no con-

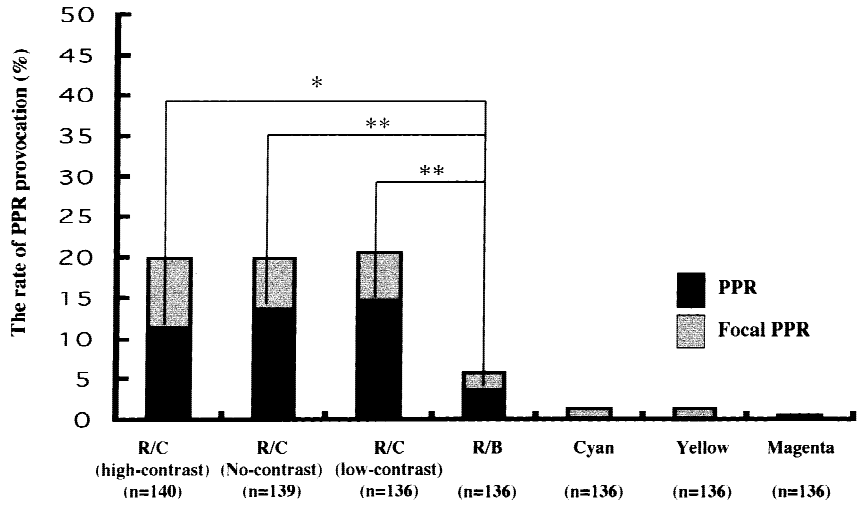

FIG. 2. Photoparoxysmal response (PPR) rate estimated from the total number of stimuli in each group. PPR rate accounted for 11.4% by high contrast red/cyan (R/C) flicker (16 of 140 times), 13.7% by no-contrast R/C flicker (19 of 139 times), 14.0% by low contrast R/C flicker (20 of 136 times), and 3.7% by red/black (R/B) flicker (five of 136 times). The differences between the R/B and each R/C flicker stimuli were all statistically significant (*$p < 0.05$, **$p < 0.01$), although they were not found between each of the three levels of contrast in alternating R/C flicker ($p > 0.05$). No PPR was provoked by cyan, yellow, or magenta flicker stimuli.

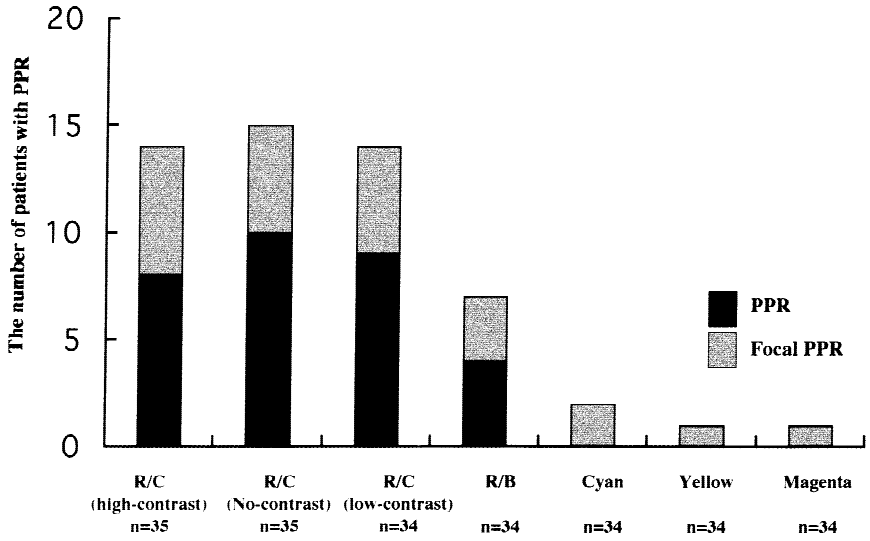

FIG. 3. Photoparoxysmal response (PPR) rate estimated from the number of patients in each group. PPRs were provoked in eight patients (40%) by high-contrast R/C flicker, in 10 patients (42.9%) by no-contrast R/C flicker, in nine patients (41.2%) by low-contrast R/C flicker, and in four patients (20.6%) by R/B flicker. There were no significant differences in the number of patients who had PPRs induced by each R/C and R/B flicker ($p > 0.05$). No patient had PPRs with cyan, yellow, and magenta flicker.

trast, and 26.5% for low contrast. There were no statistically significant differences ($p > 0.05$). It was concluded that there was no difference in the rates of PPR caused by brightness contrast of the frame when red/cyan inversion stimulation was applied.

Comparison of PPR provocation rates in each group (Figs. 4 and 5)

The PPR provocation rates were compared among the aforementioned groups (A through D) when the patients were subjected to stimulation from red/cyan inversion (the stimulation that produced the highest rate of PPR provocation). The PPR provocation rates for the total number of stimulations for groups A, B, C, and D were 20.4% (21 of 103 times), 11.9% (20 of 168 times), 9.7% (seven of 72 times), and 9.7% (seven of 72 times). The rate of PPR provocation was highest for group A, but the differences between it and other groups were not significant (A/B, $p = 0.0798$; A/C, A/D, $p = 0.0629$).

When focal PPR is included, the rates increased to 25.2% (26 of 103 times), 22.6% (38 of 168 times), 16.7% (12 of 72 times), and 11.1% (eight of 72 times) for groups A, B, C, and D, respectively. The rates were slightly higher in groups A and B. Significant differences were found between groups A and D and groups B and D ($p < 0.05$ for both).

The rates of patients with PPR in each group were 66.7% (six of nine cases) for group A, 28.6% (four of 14 cases) for group B, and 16.7% (one of six cases) for both groups C and D. Again, the number of patients with PPR

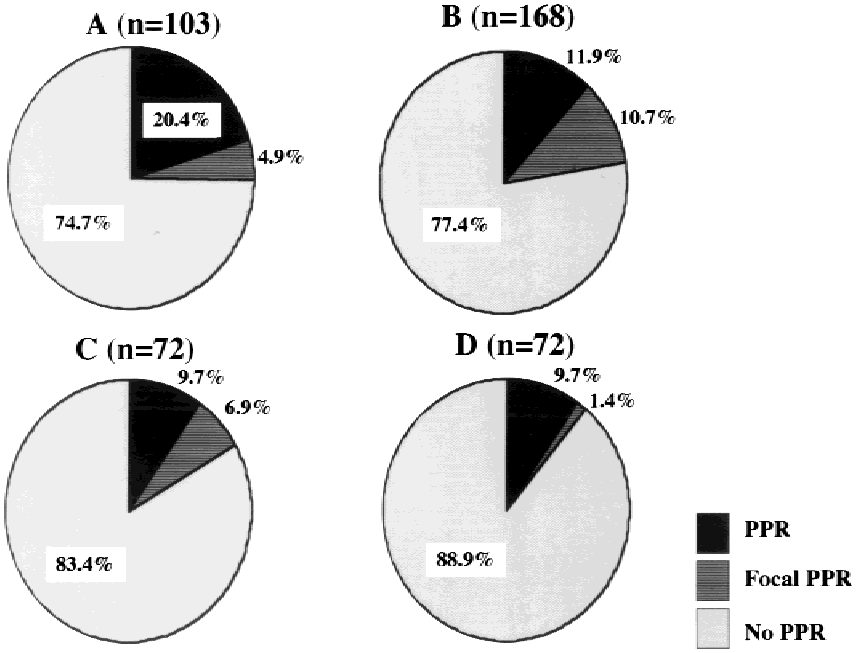

FIG. 4. Comparison of the rate of photoparoxysmal response (PPR) provocation in the total stimuli by alternating R/C flicker in each group. The rate of PPR provocations in group A was higher than that in other group, but the differences were not statistically significant. The rate of PPR provocation including focal PPR was 25.2% in group A, 22.6% in group B, 16.7% in group C, and 11.1% in group D. There were statistically significant differences between group A and D ($p < 0.05$), and between groups B and D ($p < 0.05$).

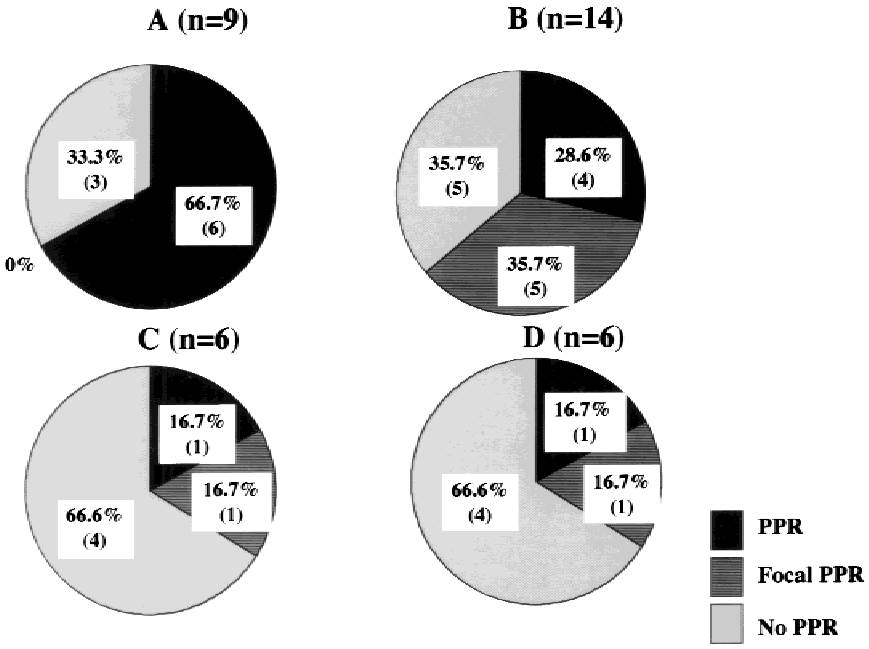

FIG. 5. Comparison of the number of patients who had photoparoxysmal responses (PPRs) and focal PPRs by the total R/C flickers in each group. The rate of PPR provocations including focal PPRs in groups A and B were higher than those in groups C and D, but the differences were not statistically significant.

was greater in group A, but the differences were not significant (A/B, $p = 0.1023$; A/C and A/D, $p = 0.1189$).

When those patients with focal PPR were included, the rates increased to 66.7% (six of cases), 64.3% (nine of 14 cases), 33.3% (two of six cases), 33.3% (two of six cases) for groups A, B, C, and D, respectively. The number of cases in which PPR was provoked was high in group A and B, but the difference from groups C and D was not significant. The number of patients with only focal PPR was greatest in group B (35.7%, five of 14 cases).

Difference in PPR provocation rates related to medication

In the test using red/cyan inversion, the PPR provocation rate in the group of patients who had been treated with AEDs was compared with that of the group of patients who had not been treated. The PPR provocation rate for the former was 8.3% (20 of 240 times), whereas that of the latter was 20.5% (35 of 171 times). The PPR provocation rate of the latter was significantly higher ($p < 0.001$). Even when focal PPR was included, the provocation rate for the untreated group was higher than that of the treated group: 25.1% (43 of 171 times) for the former versus 16.7% (40 of 240 times) for the latter, with a statistically significant difference ($p < 0.05$) between them. The rates of patients with PPR were 20% (four of 20 patients) for the treated group and 53.3% (eight of 15 patients) for the untreated group. The number of those with PPR in the untreated group was greater than that of the treated, but there was no statistical significance in the difference ($p = 0.0713$). If those with focal PPR alone were included, the rate of patients with PPR or focal PPR in the treated group was 50% [those with focal PPR only, 30% (six of 20 cases)], and that in the untreated group was 60% [those with focal PPR only, 6.7% (one of 15 cases)]. The two groups showed about equal percentages of patients with PPR or focal PPR, although there were more with focal PPR only in the treated group.

DISCUSSION

There had been several controversial reports on the effects of colors on photosensitive epilepsy even before the "Pocket Monster" incident. Takahashi et al. (5) (6) studied the effect of stimulation with red flickering of low luminance by using a strobe filter and found that the stimulation of red is more provocative than that of other colors. Based on the result, they called attention to the danger of stimulation by red light. Harding et al. (13), on the other hand, claimed that there is no significant difference between the PPR-provoking effects of red flickering and those of green, blue, or white flickering. However, Harding (7), in a recent study after the "Pocket Monster" incident, suggested that the red that they had used in their prior studies had a relatively short wavelength with a peak at 580 nm. He conducted an EEG study on six patients with photosensitive epilepsy using red/blue inversion images of the "Pocket Monster" and monochromatic (white and black) images with identical brightness (7). Because PPR was provoked only by the alternating red/blue inversion frames, he concluded that long-wavelength red with a peak that exceeded 600 nm (especially the "deep red" that is generated from televi-

sion signals) plays an important role in triggering PPRs. As a mechanism for this phenomenon, Harding explained that long-wavelength reds stimulate only the red cones on the retina, not those sensitive to green or blue, thus yielding no inhibitory mechanism inherent in the latter (monocone stimulation). He also added the fact that red cones are the most numerous of the three types (4,000,000 in a single eye). Conversely, Binnie et al. (14) also provided a similar hypothesis based on the silent substitution method.

In our study, PPR was induced only by flickering and inversion stimulation that included red light, whereas no PPR was provoked by any of the other colors (cyan, yellow, or magenta). Like the data reported earlier (5,6), these findings indicated that long-wavelength reds that are generated by a CRT display are more provocative than other colors. It also was suggested that long-wavelength reds play an important role in some photosensitive individuals with chromatic sensitivity (15).

We further investigated the effect of the combinations of red with other colors, because the triggering factor in the "Pocket Monster" incident was actually the inversion image of a combination of red and blue. Tobimatsu et al. (15) conducted a study of individuals who had experienced seizure symptoms during the "Pocket Monster" incident, comparing incidences of PPR between those exposed to red/blue inversion and to black/gray inversion stimuli. They found that a red/blue inversion stimulus is significantly more provocative of PPR than is a black/gray inversion stimulus. To account for this result, they postulated that the red/blue inversion stimulus has a stronger stimulatory effect on the visual field than a stimulus from red or blue alone, because the inputs from the red and blue cones among the retinal visual cells are not in an antagonistic relationship at the cerebral cortex level.

Conversely, Takahashi, et al. (5,16) used red flickering with blue light in the background and found that the PPR-provoking effect from the stimulus by red flickering is suppressed by this background.

If one compiles the findings by Harding (7), Tobimatsu (15), and Takahashi (16), one may readily reach to a conclusion that when red/blue stimuli are repeated alternately, blue augments the stimulus caused by red; but when they are applied simultaneously, they antagonize each other's action.

It has been shown that green is a color that is in a physiologically antagonistic relationship with red at the cerebral cortex level in a monkey (17). In a study of clinical patients with photosensitive epilepsy, a stimulus with a red/green grating pattern of isoluminance did not provoke any epileptic EEG patterns (9). In another study, similar stimuli did not affect for the amplitude or latency of visually evoked potentials (VEPs) (18). The grating used in these studies was composed of red and green that were simultaneously perceived by the visual system. This stimulatory condition is different from that in which a red/green-inversion stimulus is used (i.e., red and green were applied alternately to stimulate the visual system). Therefore it is difficult to compare the effect on the cerebral cortex between the two different stimulatory conditions, although they had same color combinations. Harding (19) reported that a long-wavelength red interspersed with blue frames is more provocative than equiluminant green frames (19), although the details of data in this study have not been presented.

In this study, the most significant PPR-provoking effect was produced by the red/cyan-inversion stimulus. Here cyan is a so-called complementary color of red in which the wavelengths of blue and green, two of the three primary colors of television signals, are mixed. According to the conventional concept of the antagonistic relationship of colors transmitted to the cerebral cortex, the wavelength component of green contained in cyan has an antagonistic effect on the stimulus from red. To the contrary, it was found that cyan further augmented the stimulus by red. The induced color-contrast effect is cited to explain this phenomenon (20). Due to lateral inhibition, color perception is affected by a color that is adjacent to the original color. For example, when one stares at blue, the sensitivity to blue is reduced in the adjacent area, while the sensitivity to yellow increases; and if one gazes at red, the sensitivity to green increases. Such a contrast effect is called a spatial or induced contrast and is caused by the presence of a certain color that induces a contrasting color in an adjacent area. A marked induced-contrast effect is produced when a complementary color is paired (20).

According to this theory, when two complementary colors are paired, they alternately stimulate the visual system, such as the red/cyan-inversion stimulus in this study, producing a most significant induced-contrast effect. Thus red and cyan act in such a way that each color augments the sensitivity to the other, and the stimulatory effect is amplified in comparison with the stimulatory effects produced by a single color.

Further study is needed to determine the individual effects on red of the blue and green wavelength components constituting cyan. It is necessary to conduct comparative studies on inversion stimuli by using combinations of red/cyan, red/blue, and red/green.

For the study on the effects of brightness contrast, IPS evaluation using a highly luminous strobe light showed that the PPR provocation rate increased as brightness was increased in steps (21). In this study, however, no difference in PPR provocation was recognized despite the difference in the brightness contrast. It was believed that the major cause for this result was the relatively low brightness of red and cyan and the strong stimulatory

effect brought about by the combination of these two colors, regardless of their brightness.

When the PPR provocation rate for each clinical group was compared, the rate for group A was found to be the highest. The result was probably because many of the patients had not been treated with AEDs (66.7%, six of nine cases), rather than the dominance of individuals in this group with chromatic sensitivity.

In the comparison between the treated and untreated groups, it was found that the PPR provocation rate was lower and the ratio of focal PPR was higher in the former. This supports the result of Harding et al. (22) that VPA is effective as a therapeutic agent for photosensitive epilepsy.

In summary, for effective prevention of photosensitive symptoms caused by viewing television images, caution against the use of red/cyan or red/blue inversion stimuli (i.e., in the details of color combinations) should also be included in the current Japanese "Guideline" that prohibits the use of deep red flickering. It is believed that this addition will lead to the prevention of second "Pocket Monster" incident.

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