Assessment of tolerability of ambient light in soft copy diagnosis.

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Purpose

Picture archiving and communication systems (PACS) have found great success in the fields of X-ray computed tomography (CT) and computer-generated graphics. In recent years, liquid crystal display (LCD) has replaced the cathode ray tube (CRT), which has been used since the invention of PACS.

PACS-specific LCD monitors are frequently used in such diverse medical settings as patient exam rooms, consultation rooms, conference rooms, and nurses' stations. The illumination and ambient light in each of these places is different. Ambient light influences the diagnostic performance of radiological images, especially mammography, because the ambient light is reflected by the LCD monitor, which increases the intensity of the darker aspects of the examined images. Increased ambient light similarly decreases the diagnostic capabilities of clinicians using PACS.

However, the image observation in the state that I do not regulate even if there are the image observation that I used light-box for at the same time and the image observation in the room without-like light facilities,-like light facilities in the real clinical spot tends ambient light not to be considered, and it is very likely that I do a diagnosis in the environment where I came off from a guideline. Therefore, in this study, we measured the influence of ambient light and the luminance response of an LCD monitor used in a medical care setting, and established guidelines for the consideration of ambient light in the clinical setting.
Methods and Materials

Devices

1. LCD monitor

RadiForce RX320 (RX320) (NANAO Corporation, Ishikawa, Japan)
   • 3 megapixel colour display
   • Primary monitor for medical care

FlexScan S2100M (S2100M) (NANAO Corporation, Ishikawa, Japan)
   • 2 megapixel colour display
   • Secondary monitor for general-purpose medical care

2. Measurement instrument

Luminance meter: LS-100 (Konica Minolta, Tokyo, Japan)

Illuminance meter: T-10 (Konica Minolta, Tokyo, Japan)

3. Illumination machinery

Two 20-W inverter-type fluorescent lamp lights

Slide transformer: RSA-5 (Tokyo Rikosya)

The voltage was coordinated by a slide transformer, and the illumination at the monitor front was coordinated

4. Others

Monitor quality control application software: RadiCS (NANAO Corporation, Ishikawa, Japan)

Monitor indication sample: JIRA BN8(1-18), JIRA TG18-QC pattern

Measurement environment and methods

1. Measurement environment

For the purposes of this research, we constructed a darkroom in the medical facility. To do this, we covered the surfaces of the darkroom in blackout curtains, and covered the
LCD monitor table with a comparable blackout cloth (see Figure 1(Fig. 1 on page 6) for experimental schematic). We then prepared the experimental device as described in Haijo Jung, et al, with the focus distance of the luminance meter set at 1,150mm from the LCD monitor. We subsequently positioned the luminance meter 1,300mm away from the monitor, as described in Shiiba, et al.

The distance of the fluorescent lamp considered width when we made a monitor vertical and adopted direct image few state that included it to the monitor and 50cm that it seemed. Next, we installed the device, which made an inverted fluorescent lamp of 20W-like light possible with a slide transformer as ambient light two sets of one set before a monitor. In addition, we installed a light shield behind the fluorescent lamp so that there would not be any fluorescent light in the direct luminance meter. We positioned the illuminance meter in front of the monitor's center and regulated the voltage of the slide transformer to become the illumination of the aim before the luminance measurement. We removed this device at the time of the luminance measurement.

2. Condition of the monitors

RX320

- Maximum luminance: LmaxR, 400(cd/m$^2$)
- Minimum luminance: LminR, 0.7(cd/m$^2$)
- Gradation characteristic: calibrated based on DICOM Part 14 GSDF

S2100M

- Maximum luminance: LmaxS, 195(cd/m$^2$)
- Minimum luminance: LminS, 1.0(cd/m$^2$)
- Gradation characteristic: calibrated based on DICOM Part 14 GSDF

We started an experiment since we used RadiCS before an experiment entirely and performed an unchangeableness examination and confirmed a thing without the hindrance.

3. Method of measuring the reflection

- Using the 20W lamps, we set 11 levels of environmental light (0, 5, 10, 20, 50, 100, 150, 200, 250, 500, 700lux).
- We measured monitor front of the power supply off state-centered luminance with luminance meter. We measured the luminance three times and averaged these measurements for a final mean result.
- We was less than condition (Lmin/1.5 of AAPM TG18 and demanded illumination to satisfy less than Lmin/4).
4. Method of measuring the luminance response

We displayed a JIRA BN8 test pattern on the LCD monitor, and measured the test pattern’s brightness in the varying 11 levels of ambient light described above. We subsequently evaluated the luminance response for each light level.
Images for this section:

Fig. 1: The experiment schematic view which we watched from the top.

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Results

1. Reflection (Figure 2)

We show the measurement results of the reflection of the two monitors in Figure 2. The vertical axis represents reflection (Lamb; cd/m²), and the horizontal axis represents illumination E(lux). Either monitor showed a graph in proportion to which went along approximately 0. As for each approximation curve, RX320 was expressed in a linear equation of $y=0.001x+0.0007$. S2100M was expressed in a linear equation of $y=0.0011x-0.0008$.

We set the monitor to its lowest brightness for this experiment,

- Recommended lowest brightness(Lmin) $\times 1.5 \times$ environmental brightness(Lamb)
- Ideal lowest brightness (Ideally) $\times 4 \times$ environment brightness (Lamb)

The environmental brightness must be a smaller value than Lmin/1.5, the value of Lmin/4, to satisfy the abovementioned guideline.

The light green area of Figure 2(Fig. 2 on page 10) shows the range where the environmental brightness shrinks to less than Lmin/4, and the lightly pink range shows the range where the environment brightness shrinks to less than Lmin/1.5. The yellow is lightly a range more than the rated values. These ranges are all different from one another because RX320 0.7 is different from 1.0 in S2100M, the lowest brightness setting. The illumination of the upper limit that the green frame satisfies Lmin/4 of the number is shown on the horizontal axis, and the red frame showing the illumination of the upper limit to satisfy Lmin/1.5. Lmin/4 of RX320 was 174lux, and Lmin/1.5 was 466lux. Lmin/4 of S2100M was 228lux, and Lmin/1.5 was 607lux. Thus, the illumination of the ambient light to satisfy the rated value was less than 607lux in 466lux, S2100M in RX320.

2. Luminance Response (Figures 3, 4)

Here we show the graph of the contrast response at three levels of representative illumination in the half in a thing of figure 3,4. The vertical axis shows a JND Index on $L/L$ for a JND, the horizontal axis Illumination (lux) was measured in the lower half and Luminance Response (k#), a value of brightness ratio (LR')

- RX320(Lmax, 400/Lmin, Luminance Response of 0.7)#Figure 3# (Fig. 3 on page 10)

The number shown in the red frame shows a thing beyond the AAPM TG18 guideline value. At the level of to 250lux, k# was in the range of $\pm 10\%$, but illumination exceeded
-14%, -18%, and a guideline value when our measurement was more than 500. When the illumination changed from 0 to 700lux, the contrast ratio became 286.3 and approximately 1/2 from 552.1.

- S2100M(Lmax, 195/Lmin, Luminance Response of 1.0)#Figure 4# (Fig. 4 on page 11)

The number shown in the yellow frame shows a thing beyond the AAPM TG18 guideline value (Primary). With regard to the illumination, k# was in the range of ±10% at the time of to 250lux, but, like RX320, it exceeded -12%, -18% and a guideline value of Primary in more than 500. However, we must consider that this monitor is a secondary monitor, and the ±20% range that is a recommended value of secondary monitors do not exceed this guideline. The contrast ratio was not able to satisfy 111.4 neighbors, guideline value LR'# 250 of Primary from 227.7, either.

1. Reflection

In the darkroom environment, the reflection and the illumination showed the approximation curve of the straight line to go along approximately 0. We hypothesize that this is caused by a lack of influence by the direct light of the fluorescent lamp. We similarly hypothesize that the degrees of the approximation curve are affected by the properties of the LCD monitor's surface panel. I think that it is desirable I do the brightness measurement at the time of the monitor introduction from these, and to install it.

When the lowest brightness was high, the reflection of the permission value was similarly high, but the brightness ratio shrank. It is necessary that we understand the relationship between these brightness levels at the initiation of the experiment, as this luminance may change depending on the monitor.

2. Luminance Response

In the darkroom environment, both monitors surpassed a tolerance level of more than 500lux. A significant deviation arose in the 250-500lux range. We suggest that clinicians must be careful in using LCD monitors in this range of ambient light. S2100M was louder ambient light, but reputation case was possible, but LR' shrank because the smallest brightness rose (but the standard of AAPM satisfied it). Use at a high brightness level is possible, and RX320 can raise the setting of the lowest brightness, but, on the other hand, this causes the contrast ratio to become small. As a result, we hypothesize that the balancing the monitor brightness with the contrast ratio and adjusting the ambient light will help clinicians to observe low-contrast images.

Because the darkroom bottom was an experiment under the darkrooms which made the outskirts that covered the surroundings with black cloth black, there are few reflections
of black cloth equivalent to the wall and thinks about the reflection to the monitor from the outskirts by the illumination that extremely little.

Here, we tested only two monitors made by the same manufacturer; thus, we expect that our results will not apply equally to all monitors. In addition, it is thought that the results are different with regard to the different surface treatment even if the display part is the same throughout the experiment. Future avenues of research will include similar luminescence examination involving LCD monitors from multiple manufacturers.

In addition, by the real use, I tend not to be it to a constant value even if I install it in the same device for the same period. Therefore, I think that it is desirable I keep the degree width that is the clinical spot, and to manage. I want to examine in future how much width is necessary.
Fig. 2: The measurement result of the reflection of two monitors.

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Fig. 3: RX320; The graph of the contrast response in three kinds of representative illumination in the half in a thing of figure 3. The vertical axis shows JND Index on #L/L for a JND, the cross axle. Illumination (lux) which I measured in lower half and Luminance Response (k#), a value of brightness ratio (LR').

Red field means that the value do not satisfy AAPM TG18 guideline.

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**Fig. 4:** S2100M; The graph of the contrast response in three kinds of representative illumination in the half in a thing of figure 4. The vertical axis shows JND Index on $\Delta L/\Delta L$ for a JND, the cross axle. Illumination (lux) which I measured in lower half and Luminance Response ($k\delta$), a value of brightness ratio ($LR'$).

Yellow field means that the values do not satisfy AAPM TG18 guideline as primary monitor. But they satisfy the guideline as secondary monitor.
Conclusion

We examined the influence that ambient light had on the reflection of an LCD monitor used for medical care, a luminance response. There was a tolerance level for ambient light to satisfy a guideline, and this level was different for each of the tested monitors. Thus, we conclude that ambient light must be carefully considered when PACS is used in a clinical environment.
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