JVC

White Paper

Advantages of High-Bright Display on Mammography diagnosis

Table of Contents

1. Preface

Fig1. 5MP monochrome mammography display "MS55i2 plus"

Today digital diagnostic imaging is now regarded as the standard practice for radiology. In primary mammography diagnosis using digital imaging displays the required resolution is a 5 mega-pixel (5MP) display with a recommended luminance of 500 cd/m^2. Since the introduction of digital imaging the demand for higher image quality has increased from the previous hardcopy (film) images.

We have developed mammography displays since the cathode-ray tube (CRT) era, always seeking to improve the image quality over many years. In 2017, JVC released the MS55i2 plus (Fig.1) which improves to render increased reproductive image quality with a much higher contrast and brightness than conventional displays.

In this paper, compares the MS55i2 plus which render the luminance at 1,000 cd/m^2 with conventional luminance at 500 cd/m^2, and describes the advantages of MS55i2 plus, in terms of the current demand for high brightness displays.

2. Advantages of High-bright display

In Fig.2 below shows the visual recognition property that compares the display luminance of 500 cd/m^2 to 1,000 cd/m^2 luminance. The vertical axis represents JND's (Just Noticeable Difference) that shows the minimum luminance with which our eyes can recognize.

Compared with 500 cd/m^2, 1,000 cd/m^2 setting display offers more than 100x JND's higher visual resolution. Consequently, it's the visual recognition property that improves to similar JND's (approximately 1,000) of analogue mammography films.

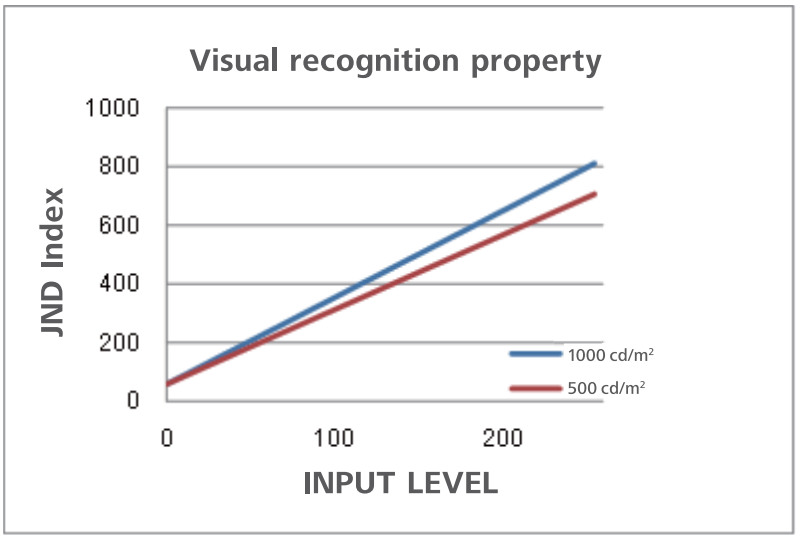


Fig.2 Visual recognition property

2-1. The physical evaluation report of high-bright display

This section explains the improvement of visual recognition property caused by using a higher bright display based on physical data. Fig.3 shows the ACR check-156 mammographic accreditation phantom for an image quality evaluation test. Radiologists evaluates image quality variances as daily system check.

There are placed fibers, simulated micro calcifications, and tumor messes on this slab of phantom like figure 4.

Fig.3 Phantom-ACR-156

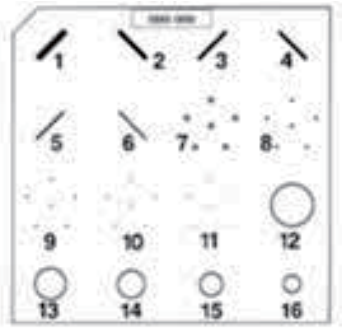


Fig4. Location of the test objects

No.1～No.6：Fibers
No.7～No.11：Micro calcifications
No.12～No.16：Tumors
Other space is filled with Wax and Acrylic equivalent to breast tissue:
50% adipose and 50% glandular

This time, we captured the image of the phantom with a direct-conversion flat panel detector (d-FPD) system, supported by Associate Prof. Shinohara (Associate Professor of Gifu University of Medical Science, Health science department, Radiology course). We displayed the captured image with Image J (Image Processing software) and measured the luminance of the breast-equivalent phantom and imbedded the test object by Spectroradiometer SR-3A, setting up 50 cm far from LCD and setting angle 1 degree. The image displayed on each two monitors, 1) Lmax:Lmin=500 cd/m^2:0.7cd/m^2, 2) Lmax:Lmin=1000 cd/m^2:0.7cd/m^2 and both were set luminance properties DICOM GSDF.

Table 1 shows the luminance which is the result of measurement of each imbedded objects on phantom, JND which is calculated by luminance, and the different values between the breast tissue on phantom and JND. Comparing with different values between the breast tissue on phantom and JND, 1,000cd/m^2 mode is of higher value than 500cd/m^2 mode. This is the efficiency result of high brightness which improves to figure out imbedded objects on phantom. Especially, simulated micro-calcifications are much more visible than the nylon fibrils or tumor messes. That means the 1,000 cd/m^2 enables us to improved initial pick-up more accurately.

Subjects	500cd/m² setting			1,000cd/m² setting		
	Luminance [cd/m²]	JND	JND [Diff]	Luminance [cd/m²]	JND	JND [Diff]
Wax and Acrylic (50% adipose, 50% glandular)	20.15	284.0	—	28.35	321.2	—
Dia/1.56mm, Fiber 1(No.1)	24.45	304.9	20.9	34.94	344.8	23.5
Dia/1.12mm, Fiber 2(No.2)	23.55	300.5	16.5	33.4	339.6	18.4
Dia/0.89mm, Fiber 3(No.3)	22.97	297.9	13.9	32.53	336.7	15.5
Dia/0.75mm, Fiber 4(No.4)	22.3	294.8	10.8	31.53	333.0	11.8
Dia/0.54mm, Fiber 5(No.5)	20.38	285.3	1.3	28.65	322.7	1.5
Dia/0.54mm, micro calcification 1(No.7)	57.94	405.6	121.6	90.08	462.5	141.3
Dia/0.40mm, micro calcification 2(No.8)	49.74	386.6	102.6	76.07	440.4	119.2
Dia/0.32mm, micro calcification 3(No.9)	35.99	348.0	64.0	53.06	394.8	73.6
Dia/0.24mm, micro calcification 4(No.10)	29.53	325.8	41.8	42.88	369.0	47.8
2.00mm thick, tumor 1(No.12)	25.51	309.3	25.3	36.7	350.6	29.4
1.00mm thick, tumor 2(No.13)	23.38	299.8	15.8	33.3	338.9	17.7
0.75mm thick, tumor 3(No.14)	23.15	298.6	14.6	32.9	338.1	16.9
0.50mm thick, tumor 4(No.15)	21.3	289.7	5.7	30.03	327.1	5.9

Table.1 Measurement of the luminance of the breast-equivalent phantom and imbedded test object

Fig.5 is displayed image with 500cd/m², Fig.6 is displayed image with 1,000cd/m². We can see the test objects more visibly displayed on 1,000 cd/m² setting (Fig.6) than displayed on 500 cd/m².

Fig5. 500 cd/m² setting

Fig6. 1,000 cd/m² setting

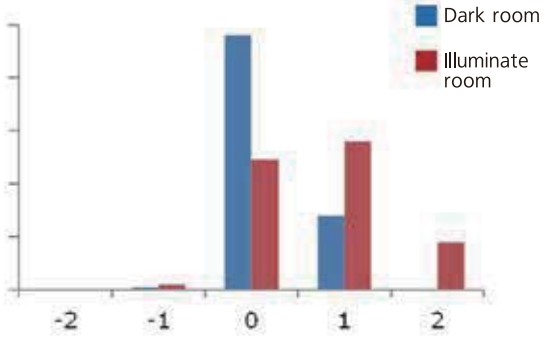
2-2. The clinical evaluation report of high-bright display

Next, we explained the effects of high-brightness display based on the clinical evaluation data.

This content was presented by Radiological Technologist Ms.Hieda (Department of Central Radiology, Kanazawa University Hospital) at the poster session, “Performance evaluation of Super High-bright LCD displays" held on the 27th Meeting of Japan Association of Breast Cancer Screening on November 2017. (Fig.7)

	Dark room	Illuminate room
Average	0.216±0.432	0.720±0.725
Confidence level (95%)	0.140～0.292	0.593～0.847

(n=125) P=9.02e^{-2D} <0.05

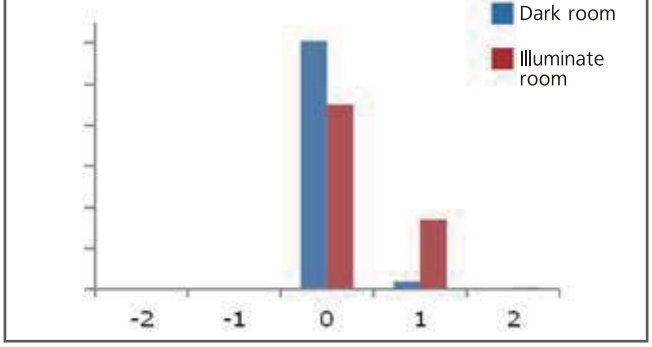


500 cd/m² 1000 cd/m²
Very good ◄—— Same ——► Very good

Mammary gland in-side contrast

	Dark room	Illuminate room
Average	0.031±0.176	0.288±0.472
Confidence level (95%)	0.001～0.063	0.205～0.370

(n=125) P=1.51e^{-9} <0.05

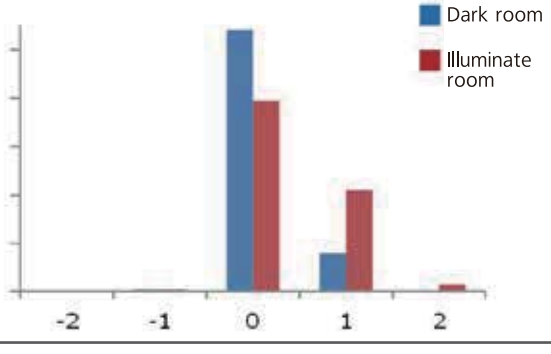


500 cd/m² 1000 cd/m²
Very good ◄—— Same ——► Very good

Mammary gland out-side contrast

	Dark room	Illuminate room
Average	0.120±0.350	0.376±0.549
Confidence level (95%)	0.059～0.181	0.230～0.472

(n=125) P=9.02e^{-2D} <0.05

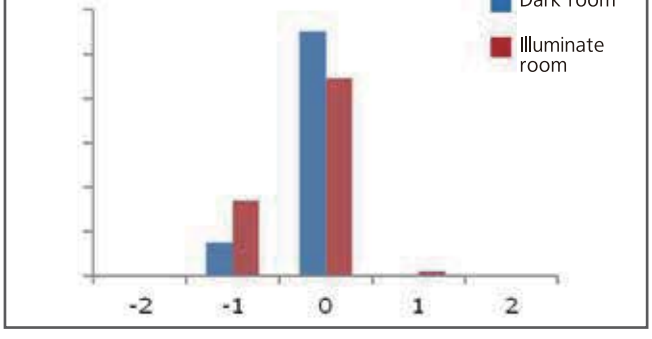


500 cd/m² 1000 cd/m²
Very good ◄—— Same ——► Very good

SHarpness

	Dark room	Illuminate room
Average	-0.12±0.326	-0.26±0.474
Confidence level (95%)	-0.177～-0.063	-0.340～-0.173

(n=125) P=1.47e^{-4} <0.05

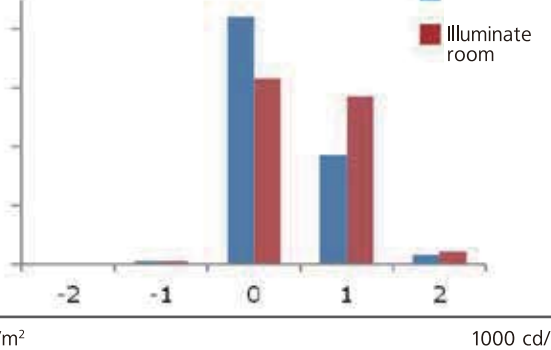


500 cd/m² 1000 cd/m²
Very good ◄—— Same ——► Very good

Noise Power Spectrum (NPS)

	Dark room	Illuminate room
Average	0.336±0.538	0.512±0.577
Confidence level (95%)	0.242～0.430	0.411～0.613

(n=125) P=1.01e^{-6} <0.05

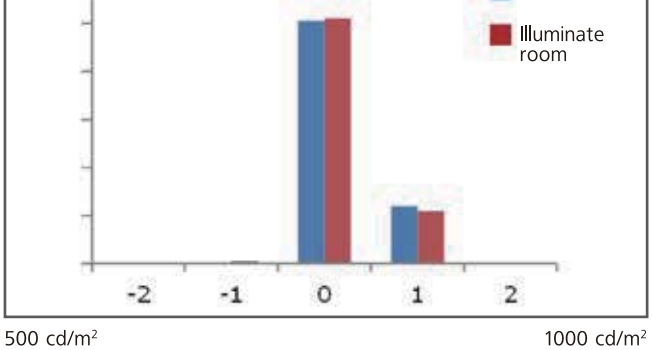


500 cd/m² 1000 cd/m²
Very good ◄—— Same ——► Very good

Existence of micro calcification

	Dark room	Illuminate room
Average	0.192±0.395	0.168±0.396
Confidence level (95%)	0.123～0.261	0.099～0.237

(n=125) P=0.083 <0.05



500 cd/m² 1000 cd/m²
Very good ◄—— Same ——► Very good

Diagnostic capability of micro calcification

Fig.7 performance evaluation of high-bright LCD monitor

In this evaluation, a Radiologist and four Radiological Technologists diagnosed 25 samples of clinical mammography images which included micro-calcifications settings of 500 cd/m^2 and 1,000 cd/m^2 each. They evaluated both displays in terms of 6 items: mammary gland in-side contrast, mammary gland out-side contrast, sharpness, NPS, existence of micro calcification, and diagnostic capability of micro calcification, using a 2-point preference method (+2=very good with 1,000 cd/m^2, +1=good with 1,000 cd/m^2, 0=same, -1=good with 500 cd/m^2, -2=very good with 500 cd/m^2). They scored from two reading environments: A dark room such as reading room (Illuminance of apx. 10 [lx]) and a high illuminate room such as exam room. (Illuminance of apx.100 [lx])

We calculated total scores in each evaluated item within the two reading environments, and subsequently calculated T-test at significant level α=0.05. As a result, 1,000 cd/m^2 setting was superior in all evaluated items except for NPS even difference of reading. Specifically detecting for mammary gland in-side contrast and existence of micro calcification showed remarkable results. In other words, NPS showed to the contrary results due to the other evaluated items which had the opposite characteristics such as sharpness.

From another point of view, the clinical evaluation results suggested the following fact.
In general, diagnostic reading performance declines in high illuminated rooms. However, with a 1,000cd/m^2 setting scored higher in a high illuminated room than a dark room in this clinical evaluation except for the NPS. It suggests that a 1,000 cd/m^2 high-brightness setting enables the readers to diagnose the mammography images without the reduction of diagnostic performance in highly illuminated environments than before. That indicates that high-brightness monitors can defuse the stress of human eyes due to the continual light adaptation otherwise required caused by reading from a 500 cd/m^2 setting in a highly luminated room, and that maybe another advantage with the use of high brightness monitors.

3. Conclusion

The newly developed 5MP monochrome mammography monitor "MS55i2 plus" has a higher brightness (1,000 cd/m^2 setting is equipped) than any other conventional products and increases JND steps to make easier "initial pickup" of disease. It improves the contrast of inside/outside mammary gland, sharpness, existence of micro calcification and diagnostic capability of micro calcification, and realizes the much more efficient mammography of imaging diagnosis.

JVCKENWOOD Corporation

Healthcare Business Division
3-12, Moriya-cho, Kanagawa-ku, Yokohama-shi, Kanagawa, 221-0022 Japan
http://healthcare.jvc.com/