Do I Really Need To Worry About Millisecond Timing Any More?

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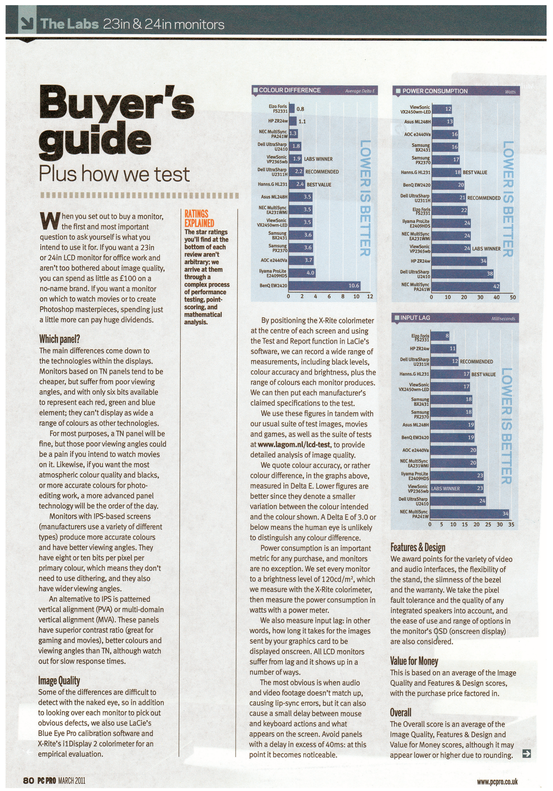
Some Background

Psychologists are, and have always been, concerned about millisecond timing accuracy if one traces back to the development of the tachistoscope by Wundt (c.1875). In many areas contemporary researchers regularly make use of commercial and custom written software to administer paradigms. Increasingly they use complex multimodal stimuli interacting with hardware which would have been unimaginable a few years ago. It is common to see studies where conditional differences are in the order of tens of milliseconds. Some less.

We discuss whether some modern equipment is actually worse than that of 136 years ago? Has experimental rigour worsened in the last decade even? Can anything be done from a practical standpoint?

The Problem

Researchers often remain blissfully unaware just how much impact their choice of hardware and software can have on their studies. With conditional differences in the 10's of milliseconds reported in the literature. Tests of paradigms running in situ can reveal alarming variations in what the experimenter believed was happening and what actually did happen! These range from visual stimuli that cannot be displayed on time due to differing display technologies through to response time errors caused by using standard keyboards and mice.



The Labs 23in & 24in monitors

Buyer's guide

Plus how we test

When you set out to buy a monitor, the first and most important question to ask yourself is what you intend to use it for. If you want a 23in or 24in LCD monitor for office work and aren't too bothered about image quality, you can spend as little as £100 on a no-name brand. If you want a monitor on which to watch movies or to create Photoshop masterpieces, spending just a little more can pay huge dividends.

Which panel?

The main differences come down to the technologies within the displays. Monitors based on TN panels tend to be cheaper, but suffer from poor viewing angles, and with only six bits available to represent each red, green and blue element; they can't display as wide a range of colours as other technologies.

For most purposes, a TN panel will be fine, but those poor viewing angles could be a pain if you intend to watch movies on it. Likewise, if you want the most atmospheric colour quality and blacks, or more accurate colours for photo-editing work, a more advanced panel technology will be the order of the day.

Monitors with IPS-based screens (manufacturers use a variety of different types) produce more accurate colours and have better viewing angles. They have eight or ten bits per pixel per primary colour, which means they don't need to use dithering, and they also have wider viewing angles.

An alternative to IPS is patterned vertical alignment (PVA) or multi-domain vertical alignment (MVA). These panels have superior contrast ratio (great for gaming and movies), better colours and viewing angles than TN, although watch out for slow response times.

Image Quality

Some of the differences are difficult to detect with the naked eye, so in addition to looking over each monitor to pick out obvious defects, we also use LaCie's Blue Eye Pro calibration software and X-Rite's i1Display 2 colorimeter for an empirical evaluation.

RATINGS EXPLAINED

The star ratings you'll find at the bottom of each review aren't arbitrary: we arrive at them through a complex process of performance testing, point-scoring, and mathematical analysis.

By positioning the X-Rite colorimeter at the centre of each screen and using the Test and Report function in LaCie's software, we can record a wide range of measurements, including black levels, colour accuracy and brightness, plus the range of colours each monitor produces. We can then put each manufacturer's claimed specifications to the test.

We use these figures in tandem with our usual suite of test images, movies and games, as well as the suite of tests at **www.lagom.nl/lcd-test**, to provide detailed analysis of image quality.

We quote colour accuracy, or rather colour difference, in the graphs above, measured in Delta E. Lower figures are better since they denote a smaller variation between the colour intended and the colour shown. A Delta E of 3.0 or below means the human eye is unlikely to distinguish any colour difference.

Power consumption is an important metric for any purchase, and monitors are no exception. We set every monitor to a brightness level of 120cd/m², which we measure with the X-Rite colorimeter, then measure the power consumption in watts with a power meter.

We also measure input lag: in other words, how long it takes for the images sent by your graphics card to be displayed onscreen. All LCD monitors suffer from lag and it shows up in a number of ways.

The most obvious is when audio and video footage doesn't match up, causing lip-sync errors, but it can also cause a small delay between mouse and keyboard actions and what appears on the screen. Avoid panels with a delay in excess of 40ms: at this point it becomes noticeable.

Features & Design

We award points for the variety of video and audio interfaces, the flexibility of the stand, the slimness of the bezel and the warranty. We take the pixel fault tolerance and the quality of any integrated speakers into account, and the ease of use and range of options in the monitor's OSD (onscreen display) are also considered.

Value for Money

This is based on an average of the Image Quality and Features & Design scores, with the purchase price factored in.

Overall

The Overall score is an average of the Image Quality, Features & Design and Value for Money scores, although it may appear lower or higher due to rounding.

COLOUR DIFFERENCE (Average Delta E) — LOWER IS BETTER

Eizo Foris FS2331	0.8	
HP ZR24w	1.1	
NEC MultiSync PA241W	1.3	
Dell UltraSharp U2410	1.4	
ViewSonic VP2365wb	1.9	LABS WINNER
Dell UltraSharp U2311H	2.2	RECOMMENDED
Hanns.G HL231	2.2	BEST VALUE
Asus ML248H	3.3	
NEC MultiSync EA231WMi	3.5	
ViewSonic VX2260wm-LED	3.5	
Samsung B2243	3.6	
Samsung PX2370	3.6	
AOC e2449Vw	3.7	
Iiyama ProLite E2409HDS	4.0	
BenQ EW2420	10.4	

POWER CONSUMPTION (Watts) — LOWER IS BETTER

ViewSonic VX2260wm-LED	17	
Asus ML248H	17	
AOC e2449Vw	18	
Samsung B2243	18	
Samsung PX2370	18	
Hanns.G HL231	19	BEST VALUE
BenQ EW2420	20	
Dell UltraSharp U2311H	21	RECOMMENDED
Eizo Foris FS2331	22	
Iiyama ProLite E2409HDS	24	
NEC MultiSync EA231WMi	24	
ViewSonic VP2365wb	29	LABS WINNER
HP ZR24w	34	
Dell UltraSharp U2410	38	
NEC MultiSync PA241W	42	

INPUT LAG (Milliseconds) — LOWER IS BETTER

Eizo Foris FS2331	9	
HP ZR24w	11	
Dell UltraSharp U2311H	13	RECOMMENDED
Hanns.G HL231	17	BEST VALUE
ViewSonic VX2260wm-LED	17	
Samsung B2243	18	
Samsung PX2370	18	
Asus ML248H	19	
BenQ EW2420	19	
AOC e2449Vw	20	
NEC MultiSync EA231WMi	20	
Iiyama ProLite E2409HDS	23	
ViewSonic VP2365wb	23	LABS WINNER
Dell UltraSharp U2410	24	
NEC MultiSync PA241W	34	

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Research shows that using standard peripherals for response timing can be a mistake.

Opinion

Jeremy Laird

THE TECHNOCRAT

What started out as a small whine – a barely audible fizzing whisper in the background – has now become an unmistakable rushing noise. Soon it will be a deafening roar. I speak of the air rapidly escaping from the 3D bubble, and by that I'm referring to stereoscopic 3D, not 3D graphics rendering.

Of course, you wouldn't know it from the relentless onslaught of 3D-enabled products. Whether it's tablets with 3D cameras or smartphones with lenticular screens, the sheer momentum of 3D freight train will keep pushing new gadgets and devices down the product-release track for a while yet.

But never mind bursting bubbles and runaway rail vehicles, the point is that the 3D revolution is over before it's really begun. By all accounts, sales of 3D-capable HDTVs are already on the wane. Meanwhile, even the marketing might of Hollywood can't convince punters that 3D movies are the next big thing. On the whole, 3D movies have tanked. Even when they do score, reports suggest moviegoers prefer the 2D version of 3D movies at a rate of two to one.

Still, there's at least one unanticipated benefit for the PC platform in the form of improved LCD monitor image quality. All the 3D hype and hoopla might just have been worth it after all. The problem with PC monitors, you see, is a lack of technical progress and choice. Yes, really. The huge array of panels at your local PC store, all plastered with stickers proclaiming unimaginable feats of image rendering, is an illusion. Take a closer look and you'll soon discover that the LCD monitor market has largely concentrated around a very narrow set of specifications and technologies. Put simply, almost every remotely affordable monitor has a TN panel with a native resolution of 1,920 x 1,080 pixels. TN panels are the cheapest, but also offer the poorest results by every image quality metric save pixel response. Meanwhile, that 1080p native resolution may be plenty for £100 worth of 22in screen, but it's a lot less satisfactory extended to 24in and beyond.

As it happens, the latest 3D-capable monitors don't address any of that. They too are almost exclusively 1080p TN screens in various sizes, but what they do deliver is 120Hz refresh rates – double that of a standard PC monitor. It makes an enormous difference. Find that hard to believe? I'm right with you. Bigging up high-Hz refresh rates is one of the more odious marketing strategies used to flog HDTVs, and the benefits of 200Hz over 100Hz are pretty marginal. Moreover, if you do the maths based on the pixel response of a modern PC monitor, increasing the refresh rate beyond the standard 60Hz seems futile. After all, if the full white-to-black response rate of most LCDs is roughly in the 15ms region, anything above 60Hz ought to be fairly redundant. The LCD panel simply won't be able to respond quickly enough.

Then there's the debate over how many frames per second the human eye can truly perceive. Modern cinema remains at just 24 frames per second. It's true that projectors with triple-shutter blades are commonly used, resulting in 72 images per second, but the number of different images displayed per second remains 24, which is enough for fluid motion.

It's all fascinating stuff, but what I can tell you with absolute certainty is that a 120Hz monitor is a lovely, lovely thing. Suddenly, everything you touch or tweak with the mouse pointer moves more smoothly. Your whole PC feels more responsive. It's an absolutely unmistakable effect, and once you've experienced it for the first time you won't want to go back.

"I can tell you with certainty that a 120Hz monitor is a lovely thing"

Let me be clear about this – I'm not talking about dancing around the virtual battlefield of a popular online game and appreciating the benefits in terms of improved hair-trigger responses. I'm talking about juggling windows on the desktop and scrolling web and document pages - routine stuff we all do every day.

That's all very well, you might be thinking, but slightly smoother computing is no big deal. To which my response would be: try it before you knock it. I personally didn't expect the increase in desktop refresh from 60Hz to 120Hz to be perceptible, much less beneficial. In fact, if it wasn't necessary to run the desktop at 120Hz (rather than merely running certain applications at increased Hz) in order to test some of the latest 3D gubbins on the PC, I likely would not have noticed the difference. But it is, and I duly did. Now I need a new monitor.

To comment and for more columns, visit Jeremy Laird online at ***www.pcplus.co.uk/laird***

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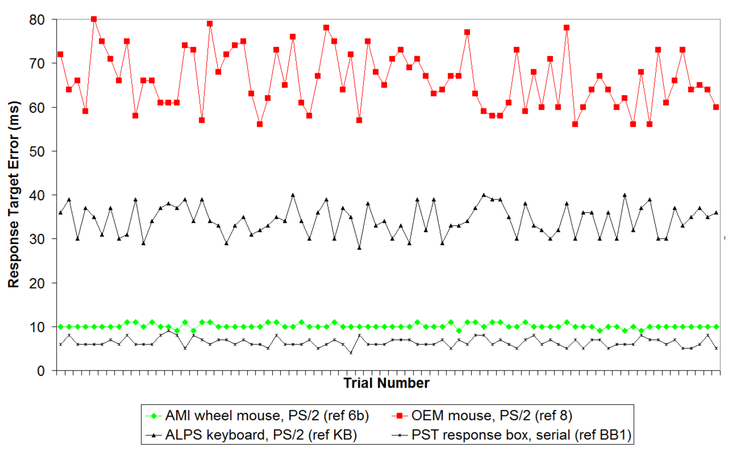
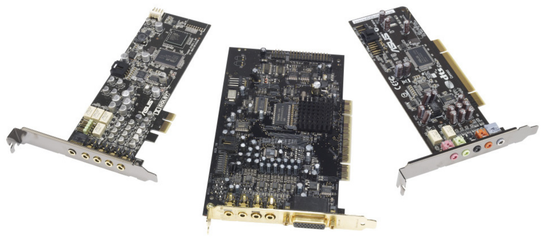
Plant, Hammond and Turner (2004) for example showed response time errors of up to 80ms for some mice and keyboards. Without empirically checking how your devices perform you have little idea how they work in the real world.





What if I use sound as well? Most computers are sold fitted with basic sound cards or with onboard sound processing features built into the motherboard. These are fine for general computer use like word processing or internet browsing, but if you want to use your computer to record or make music a built-in sound card might not be up to the task.

You might hear glitches and pops in the sound when using music software, or your recordings might sound muffled. You might also hear a delay called latency - a gap between playing a note and hearing it come out of your speakers or headphones. This start-up latency can mean that sounds are not played or synchronised when you expect them to be.

Did you know? Sound travels 1130 feet per second at normal temperature, humidity and air pressure. If the speed of sound was 1000 feet per second, it would take 1 ms for sound to travel 1 foot. The same applies to pneumatic headphone tubes in scanner rooms!

We think you'll agree there are more sources of error than the average researcher is willing to acknowledge. Such cumulative errors can mean that statistically significant outcomes may not be so robust or as easily defended as first thought.

The Solution

In common with other scientific disciplines we would like to see researchers quoting they have actively checked their equipment and foresee self-validation as a way forward for today's complex computer-centric studies.

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