VESTIBULAR DISORDERS ASSOCIATION

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Computer Monitors and Digital Televisions

Visual Sensitivity from Vestibular Disorders Affects Choice of Display

Visual sensitivity from vestibular disorders can be exaggerated when a person uses a computer monitor or watches television. Certain types of displays—and certain ways a person might use them—can be more problematic than others. These are discussed in the following introduction to terminology associated with three common display technologies: cathode-ray tube (CRT), liquid crystal display (LCD), and plasma. To help readers navigate the technical jargon, key points aimed at assisting people with vestibular disorders are flagged with the symbol at left.

Basic terminology
Televisions and computer monitors share similar technologies, but they apply them in different ways. These differences are based on the brain's ability to process information from a distance (televisions) as opposed to up close (computer monitors).

Display size is expressed by two types of measurement: screen size and display-aspect ratio. *Screen size* is measured diagonally across the viewable screen (for LCD and plasma displays) or across the viewable screen plus the outside casing (for CRT displays). Viewing distance is an important consideration in selecting a television's screen size. A very large television placed in a small room can be problematic for a person with a vestibular disorder because the screen will dominate the visual field so much that any movement on the screen may create the illusion that it is actually the viewer who is moving.

Display-aspect ratio (not to be confused with "screen-aspect ratio," see pg. 3) characterizes a display's width relative to height. Traditional computer and television displays have a display-aspect ratio of 4:3 (sometimes expressed as the fractional amount of 4/3 = 1.33). Wide-screen displays have a 16:9 aspect ratio (or 16/9 = 1.77), and thus provide added viewing area (see Figure 1).

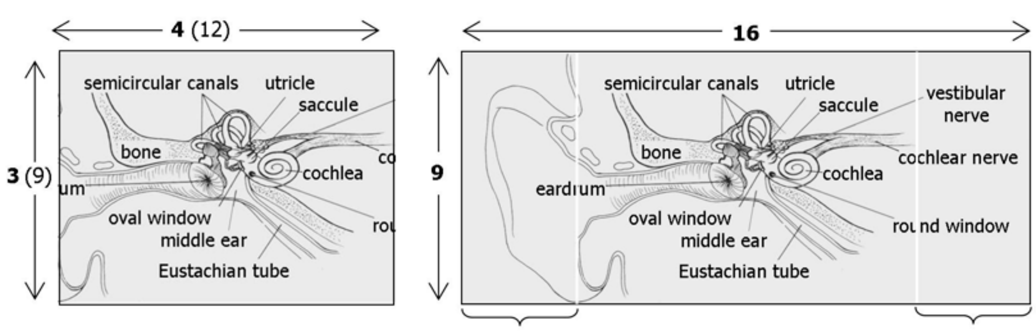
A wide-screen computer monitor with a screen size ranging between 19 and 22 inches is especially helpful for a person with a vestibular disorder who writes and edits documents. This screen allows two full-size pages to be displayed side by side, thus reducing the amount of scrolling required. It also allows two separate documents to be compared side by side—a helpful feature when a person is moving or copying a block of text or data from one document to the other. The ability to view both documents simultaneously eliminates the steps involved in minimizing and maximizing windows in order to jump between documents. This helps a person avoid potential errors caused by the concentration problems that sometimes accompany vestibular disorders.

Flat screen and **flat panel:** A *flat screen* monitor is a modified CRT monitor flattened to reduce the distortion associated with traditional CRT screens. However, flat screen monitors do have some distortion, unlike *flat panel* monitors used for LCD and plasma displays, which generally have no distortion.

Digital and **HDTV signals:** Digital television (DTV) signals are transmitted as a stream of digital data represented by patterns of ones and zeros. Guidelines have been established for defining the quality of DTV signal transmissions. These range from the lowest level, standard definition digital (SDTV), to the highest level, high definition digital (HDTV) signals. SDTV signals are more compressed and picture definition is not as sharp as HDTV signals.

Pixels: The human brain has the ability to compile thousands of individual visual elements into an image. On this basis, televisions and computer monitors produce images by fusing many small dots called pixels (from "picture-elements"). Each pixel contains a tiny red, green, and blue triad.

Resolution and **dot pitch:** Image sharpness is determined by the *resolution* (the number of pixels contained in a display) and the *dot pitch* (the distance between the pixels). The smaller and closer the pixels are to one another, the more realistic and detailed the picture appears. An image will become grainy and uncomfortable for a person with a vestibular disorder to view if the pixels are too far apart because each one becomes noticeable as an individual element.



Standard Display   Wide Screen Display

Figure 1: Aspect ratio for standard and wide screen displays.

Screen size and viewing distance are factors that affect the brain's ability to interpret specific resolutions without graininess or blurring. For example, the low-resolution picture in Figure 2 isn't clear when seen at reading distance, but it resolves when viewed from far enough away for the brain to assemble the dots into a recognizable image.

This difference in viewing distance is the reason why computer monitors require higher resolution levels than televisions, and it is why most televisions used as computer monitors do not produce high-quality images. The difference in resolution levels also affects how on-screen movement is represented. Motion on television is created using gradual transitions in color, intensity, and pattern. When a computer display changes from one page of text to the next or reflects moving text as it is inserted, the movement is more abrupt, and thus requires a higher resolution to remain clear.

Resolution is expressed as the number of pixels displayed horizontally and vertically. For example, the resolution for most CRT displays is 640 x 480. The lowest HDTV resolution is 1280 x 720, sometimes referred to as "720" (which refers to rows of pixels). For a television screen size less than 50 inches, a person might not notice a difference between low HDTV resolution and high HDTV resolution (1920 x 1080 or "1080").

Screen-aspect ratio (as opposed to "display-aspect ratio," defined above) is an optional computer setting that allows a user to adjust the operating system properties so that they impose a different computer-screen resolution from the *native resolution* (the resolution set by the manufacturer). LCD picture quality will suffer if a person configures it to use a non-native resolution. This is because, unlike CRT monitors, LCD technology scales images to accommodate any variation from the native resolution.

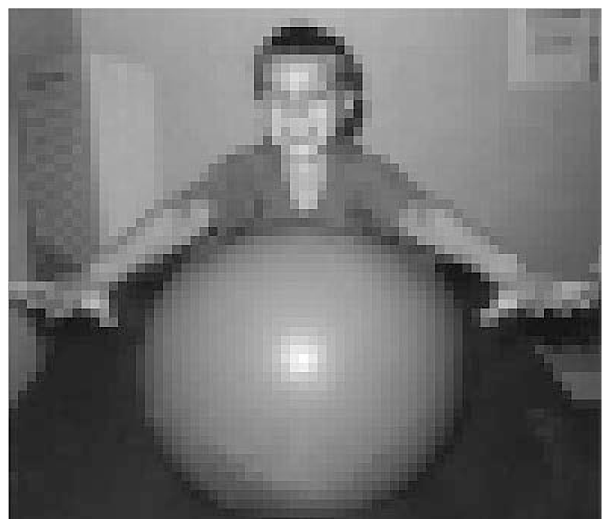


Figure 2. This low-resolution picture resolves into a sharper image when viewed from a distance.

Photo of pediatric vestibular rehabilitation session courtesy of Atlanta Ear Clinic, Atlanta, Georgia.

Refresh rate and **frame rate:** The number of times a complete image is drawn on the screen per second is called the *refresh rate.* This is not the same as the *frame rate,* which signifies how often the image being displayed is repeated per fraction of a second before it is changed.

The rates that produce the most visually comfortable display depend in part on whether the screen is a television or computer monitor. This is because the human eye is most sensitive to flicker in its peripheral vision (the edges of the field of view). Thus, low refresh rates in computer monitors, which are viewed up close, will produce a noticeable screen flicker because the display fills a larger proportion of a person's field of vision than televisions.

Progressive scans and **interlaced scans:** These terms refer to how a picture is formed. Their related technologies take advantage of the brain's ability to integrate gradual transitions seen by the eye while an on-screen image is painted. *Progressive scans* form a picture by painting one row of pixels at a time, in sequential order. *Interlaced scans* form an image in two phases. During the first phase, even-numbered rows are drawn; during the next phase, odd lines are drawn. The eye integrates the two images to create a single interlaced image (see figure 3). Interlacing is said to help improve problems with flickering caused by lower refresh rates. However, many people with vestibular disorders find interlaced scans uncomfortable.

Aliasing and **anti-aliasing:** Interlacing introduces a visually disturbing distortion called *aliasing*, an interline "twitter" that appears under certain circumstances. For example, a television character's black-and-white-striped shirt will appear to buzz if it is viewed on an interlaced low-resolution television display. This disturbing twitter with busy and high-contrast patterns is a familiar concept for people with vestibular disorders—they experience similar distortions even when they are not looking at a television or computer monitor! For example, many people find it uncomfortable to see sunlight streaming through partially closed Venetian blinds.

The process of *anti-aliasing* was developed as an attempt to minimize the distortion caused by interlacing. Anti-aliasing reduces twitter by blurring details and decreasing picture resolution. This adaptation introduces other problems. It is somewhat analogous to the strategies used by a person with a vestibular disorder who dons sunglasses or dims room lights in an attempt to reduce visual contrast.

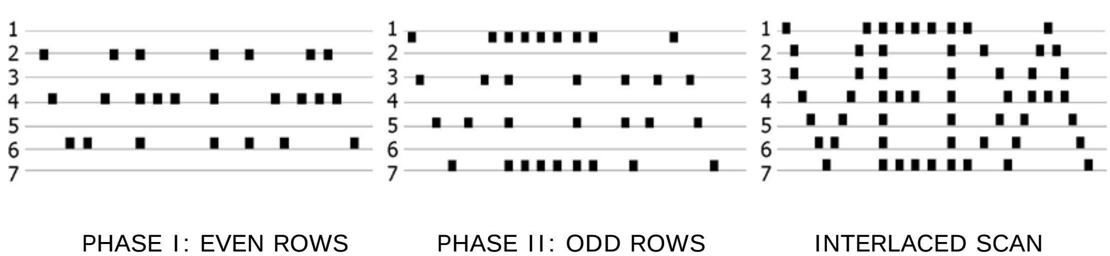


Figure 3. An interlaced scan forms an image with alternating rows of pixels.

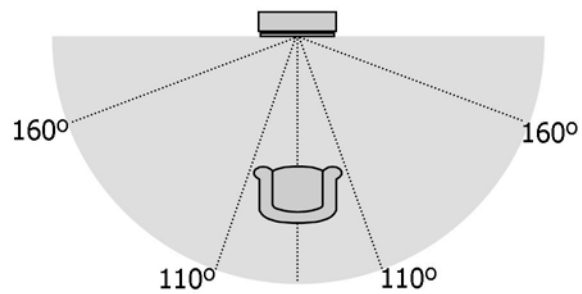
Contrast ratio and **brightness:** The *contrast ratio* is a comparison of the number of white pixels and black pixels (e.g., 500:1). *Brightness* is a measurement of the amount of light produced by the monitor. It is expressed in units called *nits* (candelas per square meter). A very high brightness level is not necessarily good because it reduces the viewing angle (see below) and can be uncomfortable to watch, especially if the display is used in a darkened office or television room. For a person with a vestibular disorder, a comfortable brightness is 300 nits or lower (for computer monitors) and 450 nits or lower (for televisions).

Viewing angle: The *viewing angle* is the maximum degree of the angle at which the screen can be viewed from the sides (horizontal angle) and top or bottom (vertical angle) while preserving the clarity and true colors of the image. An acceptable horizontal viewing angle is 110 degrees for a computer monitor oriented to one person and 160 degrees for a television intended to accommodate a group of viewers (see Figure 4).

Types of displays

CRT technology: A cathode-ray-tube (CRT) display forms an image when an electron beam travels across the screen, causing the pixels to glow. CRT televisions and computer monitors are based on analog (not digital) technology. Conventional CRT televisions have 480 lines of pixels that refresh repeatedly, one interlaced row at a time.

Figure 4. The minimum horizontal viewing angle for a computer monitor should be 110 degrees. For televisions, 160 degrees is preferred.



For CRT technology in computer monitors, progressive scans replaced interlacing because visible flickering was obvious at the close viewing distance. In addition, interlaced text appeared ragged when viewed up close (refer to Figure 3) because of imprecision in painting interlaced rows exactly halfway between a preceding scan's rows. However, some manufacturers reintroduced interlacing in CRT computer monitors by combining this technique with very high resolution and a fast refresh rate. This strategy aimed at reducing interlace-imposed flicker. Nevertheless, users of this technology continue to report eye strain and focusing difficulties.

LCD technology: Liquid crystal displays (LCDs) create an image by blocking light. A backlight passes through a layer of pixels, which are formed by liquid crystal molecules, sandwiched between two layers of polarized glass. An electrical current forces the naturally twisted liquid crystal molecules to unwind or coil tighter, thereby changing the amount of light that passes through the glass to the viewer's eyes.

LCD technology uses a progressive scan and thus produces a flicker-free display. It was introduced in monitors for notebook computers and is now also used to make much lighter televisions that swivel.

One of the important parameters to consider in selecting an LCD display is the *response time,* which indicates how much time it takes for the pixels to change colors. A faster response is needed to reduce the problem with *latency* (ghosting of rapidly moving images on television and in computer-video games). Currently, a fast response rate is 3–5 milliseconds (for most computer monitors) and 8 milliseconds (for many large televisions).

Plasma technology: A plasma display forms images with a process similar to LCD technology except that the layer of liquid crystal molecules is replaced by a layer of cells coated on one side with red, green, or blue phosphor and containing inert gases (neon and argon or xenon). The gases heat when charged, emitting a visible color that forms the image with a progressive scan.

Plasma screens have a wider viewing angle and can generate far more colors and darker blacks than LCD screens simply by not activating the phosphors in the dark part of the image. A related advantage of plasma technology is that it is not prone to latency problems (blurred motion), unlike the larger LCD televisions.

However, the image created by plasma displays is generally not as crisp because plasma-screen pixels cannot be made as small as LCD pixels. Plasma displays thus have a lower native resolution than LCDs. In addition, plasma screens are known to have a glare (they will reflect light from a nearby window or lamp) and generally have a higher contrast ratio than LCD screens. These are possible problems for visually sensitive users.

3DTV

Television with 3D capabilities (3DTV) and 3D films require the viewer to wear glasses that can deliver a separate image to each eye to create an illusion of depth and movement. This illusion conflicts with information from the vestibular organs, which signal that the body is still. This is sometimes referred to as visual-vestibular conflict. When the brain attempts to resolve the contradiction, distressing symptoms may result that manifest even more severely if a viewer already has a vestibular disorder. Additionally, other aspects of 3D technology can cause visual problems that are particularly acute for anyone with a vestibular dysfunction.

Modern 3D films are made with a technology called RealD. When watching RealD films at the theater, viewers wear passive 3D glasses that use circularly polarized lenses to deliver a separate image to each eye. Such lenses are polarized clockwise for the right eye and counterclockwise for the left in order to preserve the 3D effect when the head is tilted. Some people with vestibular disorders have reported symptoms of dizziness and vertigo after viewing RealD films although others report having no problems.

By contrast, 3DTV viewers wear active 3D glasses that require a battery to power the lenses, which are actually small LCD screens enclosed in shutters. To create a 3D effect, the shutters rapidly open and close in sync with images from the TV screen so that each eye sees them at a slightly different angle. The shutter movements also result in a sharp reduction in the frame rate that can cause images to noticeably shake. Manufacturers of 3DTVs include product warnings that in addition to causing nausea and dizziness, viewing in 3D mode may also result in motion sickness, disorientation, eye strain, and decreased postural stability.

Shopping tips

The guidelines discussed above can be used to help narrow down a person's choice of a television or computer monitor. However, an important part of the selection process—especially when choosing a television—ultimately involves visiting a store to observe firsthand which displays are most comfortable. This process can be very unproductive for a person prone to sensory overload. A person with a vestibular disorder is easily overwhelmed in appliance stores that have high ceilings, flashy carpets, milling crowds, loud sound tests, and aisles of stacked televisions that are all tuned to the same station. Below are suggestions to help manage the shopping experience:

- Before visiting a store, decide what screen size and type you want. Once in the store, only look at televisions that meet those criteria.
- Wear a visor or baseball cap in the store. This will help minimize overhead distractions such as bright fluorescent lamps and lighted displays mounted on high shelves.
- Wear ear plugs or noise-suppressing headphones.
- If the store provides shopping carts, take one to push around the store, even if you don't intend to collect merchandise in it. Grasping the cart's handle will provide stability as you turn your head to compare televisions.
- Shop at off-peak times, such as when stores first open on weekday mornings.

Summary

A person with a vestibular disorder may find wide-screen LCD technology to be the most comfortable for televisions (especially those with a screen size that is between 15 and 42 inches) and for most sizes of computer monitors. Compared with other displays, LCDs provide crisp, undistorted images, require less energy, are flicker free, have a dimmer screen, and are lightweight enough to provide flexibility in positioning. Factors to consider in selecting the optimum LCD display will depend on the combination of resolution, screen size, response time, contrast ratio, and brightness. Media displayed in 3D should be treated with caution.

This document is not intended as a substitute for professional health care.

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