SUBLIMINAL FLICKER Part I:
Computer screens, TV's and Flicker Sensitivity

by Richard Conrad, Ph.D. Revised 05/04/09

Subliminal: *below the threshold of conscious perception; inadequate to produce conscious awareness but able to evoke a response.*

The light emitted from computer screens and TV's is not steady, but has flicker. This is true for all monitors, of all types. The flicker is usually invisible, at least to the conscious mind. Flicker is invisible when it consists of pulses or waves of light that repeat one after the other so rapidly that they appear to fuse together into steady light. Our flicker fusion frequency (the frequency above which we no longer consciously see flicker) ranges from about 25 to 55 Hz (Hz means times per second). Flicker fusion frequency varies with the person, with the intensity and color of the light, and also depends on where the light falls on the retina. Optic nerve signals proportional to flicker at frequencies far above the conscious flicker fusion frequency do reach our brain from the eye (as shown by EEG and other studies). **Any invisibly flickering light that affects the brain is what I call subliminal flicker.**

Subliminal flicker from computer and TV screens is at a particular frequency or frequencies. It is analogous to a tone, for example a loud hum or a dial tone, that goes on and on incessantly in your ear and very quickly causes irritation. Subliminal flicker can have effects on the brain and body in a similar manner. A significant percentage of people who have chemical sensitivities are also sensitive to subliminal flicker, sometimes severely so. **The symptoms caused by flicker can include any of the following:** a feeling of being unable to focus on the screen, disorientation, confusion, attention deficit/brain fog, irritability, headache, migraine, eye or neck pain, dizziness, queasiness, or an uncomfortable feeling down through the chest. An extreme sensitivity to subliminal flicker is probably due to prior neurological damage.

In some cases subliminal flicker affects us and produces its symptoms by inducing partial complex seizures in a particular area of the brain. Sometimes sensitization to particular flicker frequencies develops over time. The degree of effect of subliminal flicker depends on many factors, which include:
1. the **frequency** of the optical flicker - slow flicker/low refresh rate is worse for most people; in computers the flicker frequency is set by the vertical refresh rate of the screen (the higher the refresh rate the better), and in TV's depends on whether interlaced ("i") or progressive ("p") scan is used - "i" has more low frequency flicker than "p", so "p" is best (computers use the equivalent of "p", see the paragraph on "TV flicker" near the end of this article);
2. the **brightness** of the light coming from the screen (brighter is worse);
3. the **angle** that the edges of the screen makes with the eye, which is a function of the ratio of the size of the screen to the distance between eye and screen (the periphery of the retina is more sensitive to flicker than the center of the retina), this means that the larger the screen and/or the closer you are to it, the worse the effect of the flicker;
4. the percent modulation of the flicker (the “depth” of the waves); and

5. the color of the light (a complex subject, use trial and error).

The screen can appear steady, and yet while looking at it, neurological symptoms develop either immediately or after watching it for a period of time. Sound familiar? Instead of being due to the wrong eyeglasses, or to the screen glare or poor posture that most ophthalmologists and optometrists attribute computer screen symptoms to, these symptoms are usually due to subliminal flicker (or for some people, due to any combination of subliminal flicker, EMF from the computer or monitor, and chemical offgassing from the monitor). A sensitivity to fluorescent room lighting (see Subliminal Flicker Part II) makes it likely that you also have some sensitivity to subliminal flicker from your monitor.

A method to determine whether symptoms are due to subliminal flicker, to EMF or to offgassing is as follows. First, with your computer screen on (and set so that it does not go into a dark/sleep mode) sit at your normal working position with a dark towel placed over the face of the screen so that you cannot see any light from it. Be sure not to obstruct any ventilation openings. You could pass the time by reading a book or talking to a friend (but not on the phone because this could introduce another EMF variable). If the towel eliminates the symptoms, then you know that they were due to subliminal flicker. If it does not, the next step would be to either wear a good activated carbon mask, or to exhaust from the room all offgassing vapors that could possibly be coming off the monitor. If that does not cure the problem, the culprit is most likely a sensitivity to EMF from the monitor, computer, and/or keyboard and mouse. To determine the worst source of EMF, the next step could be to remain sitting at your workstation with the computer on (and not in sleep mode) but with the monitor off. Next, with the computer and monitor on, sit in the same position but with the keyboard and mouse pushed away from you, etc. Be sure to change only one variable for each experiment.

The old fashioned cathode ray tube (CRT) type of monitor has much more subliminal flicker and potentially more EMF and offgassing than the new liquid crystal display (LCD) monitors, but one can adjust the frequency of the CRT flicker to be so fast that it has less effect on the brain. In your system software settings, set the vertical refresh rate (of the signal that the computer sends to the CRT monitor) to as high a frequency as it will allow. (The video graphics card and the resolution setting (and the particular CRT monitor) will limit the maximum vertical refresh rate that can be set - the lower the resolution setting, the higher the allowed vertical refresh rate.) The minimum for long-term comfort for normal people is between 72 and 85 Hz. A flicker sensitive person may have to set the frequency even higher. Sometimes it is necessary to buy a faster video graphics card for the computer and/or a faster CRT monitor in order to accomplish this.

In the case of a CRT monitor the flicker has approximately 90% modulation (i.e., the light intensity is 9 times brighter at its highs than at its lows). It is like a strobe light flashing in your face. Even though the screen may be comfortable at for example a 90 Hz refresh rate, attempts to rapidly proofread text on such a screen will sometimes result in missing typographical errors. This is because the screen will be almost dark

between its flashes of light, and as the eye scans quickly across a line of text, a character or word at the location that the eye is scanning past in a dark moment can be missed. Thus it is more accurate to proofread from a printout than from a CRT screen. This is yet another reason to raise the vertical refresh rate of a CRT monitor as high as possible. For more discussion of minimizing flicker from CRTs, go to http://www.displaymate.com/flicker.html.

LCD monitors are a whole different story. The propaganda on the street says that LCDs (Liquid Crystal Displays) have no flicker and that the light from a LCD screen could never bother anyone. Wrong! It is true that the percent modulation of the flicker of LCDs is on the order of only about 1%, as compared to 90% in a CRT, but for a flicker sensitive person, even 1% can be devastating if it is at a frequency of less than 85 Hz. The vertical refresh rate and therefore the flicker frequency of most LCDs is fixed at the rather low frequency of 60 Hz. This is true whether the LCD is in a stand-alone monitor, a laptop or a projector. The native 60 Hz frequency does not change even when the monitor is fed input signals from the computer that have higher refresh rates. The specifications given for these monitors are misleading because they list refresh rates accepted, not displayed.

Even worse, some LCDs also have a significant amount of 30 Hz flicker due to the way the pixels are refreshed (see footnote). Additionally, in many LCDs that are 15" diagonal and less, "dithering" is used to generate the illusion of more colors while using fewer signal channels. Dithering is a method of alternating back and forth between two colors, for example a light and a dark green, to produce the impression of a medium green. Dithering introduces additional low frequency flicker.

If a particular LCD monitor that is 17" or larger does not solve your problem, try other brands - it is a crap shoot (until someone at Consumer Reports becomes flicker sensitive and starts to report comparative measurements taken with a photodetector and a spectrum analyzer). You may do better with a CRT monitor running at a very high refresh rate, provided that you can tolerate or adequately shield its EMF and radio frequency (RF) emissions. (Although LCDs usually have less low frequency EMF than CRTs, they can have as much or more RF emissions.) Don't waste money on "EMF neutralizers" or "shielding diodes" etc. Based on my reading the marketing literature of these devices, and on my background in the workings of EMF, my opinion is that the only way they could work is via a placebo effect. See my article "EMF Scams".

Make sure that you are not experiencing image jitter in addition to flicker. Jitter can occur from improper synch settings, or from using a video cable between the computer and the monitor that is either faulty, not well shielded, or is too long. DVI cables transmit a more stable video signal than do VGA cables, especially over longer distances, but they radiate more EMF than a VGA cable does.

To reduce the effects of screen flicker: one can sit further away from the screen and/or experiment with the color of the text, background and buttons, etc. Sometimes increasing the room brightness can help. In the case of CRT monitors, set the vertical refresh rate as high as possible. In some CRTs the flicker in the blue has a greater %

modulation than the other colors, and so sometimes decreasing the amount of blue on a CRT screen can help. Decreasing the screen brightness always helps to reduce the effects of flicker, but unfortunately in most LCD monitors any setting of brightness below the maximum level introduces considerably more EMF emissions because of the chopping mechanism that is used to dim the backlight. Therefore better methods of reducing the brightness of a LCD screen would be to wear sunglasses, or to place a transparent anti-glare/E-field shielding filter in front of the screen. (No filter can reduce the percent modulation of the flicker). The herb *bilberry* and for the author also the supplement *carnosine* taken before being exposed to flicker can reduce sensitivity to flicker significantly. (Carnosine is a dipeptide found naturally in the body; the one available from www.integratedhealth.com is the best I have found.)

You are probably wondering if the new LCDs that are backlit by LEDs (Light Emitting Diodes) have less subliminal flicker and/or less EMF than the fluorescent tube backlit type. The answer is no. The flicker rate is determined by the vertical refresh rate of the pixels, and is not caused by the backlight. Concerning EMF, the LED backlight is usually operated in a pulsed mode by a very electrically noisy/EMF-producing power supply similar to the one that runs fluorescent backlights. Also, the EMFs in LCDs come not only from the backlight power supply, but also from the main power supply, the electronics circuit board, and from the front of the screen itself due to the high frequency of the addressing and refreshing of the individual liquid crystal pixels. An EMF filter placed in front of an LCD screen can only reduce the emitted fields slightly because the EMFs leak through and around the filter plate. A true very low EMF monitor is very difficult and expensive to achieve. Greater distance from the screen reduces EMF exposure. (Note that the plasma type of screen has been reported to have extremely high EMF emissions.)

Monitors that have a vertical refresh rate of 120 Hz and even 240 Hz, a welcome recent development: Flicker at 120 Hz is so fast that it has little effect on the brain. Mitsubishi, NEC and Sharp (and probably others) now have new LCD TV's that have a vertical refresh rate of 120 Hz, and may also be usable as computer monitors. Samsung has 61" and 67" DLP TV's that refresh at 120 Hz. Note that a refresh rate of 120 Hz is not always a guarantee that there is no flicker at lower frequencies, since electronic engineers sometimes use various tricks to adjust brightness or color that introduce lower frequencies. But 120 Hz is a good start. They are using 120 Hz because it enables faster gaming and/or 60 Hz stereovision (don't use the stereo feature, or you will be running at 60 Hz per eye). Some of the latest HDTV's refresh at 240 Hz! Make sure you have a 30 day money back guarantee so you can try out your choice. And watch out for the EMF emissions of these large monitors.

A data projector can be employed as a monitor by projecting from a distance onto a rear projection screen. This removes the EMF source much further away from the user, but most projectors have far more intense EMF emissions than does a direct view LCD monitor due to their high-wattage lamp switching-type power supplies. LCD projectors have the same flicker problems as direct view LCD monitors. DLP type projectors, with the possible exception of the very highest speed color wheel types, are not suitable because they have a large amount of subliminal flicker and various types of flicker

motion artifacts. (For some persons DLP may be satisfactory for TV use, but not for text, data or CAD use). A very few (not all) of the LCOS projectors flicker only at 120 Hz. These can potentially solve flicker, EMF, and offgassing problems for some people, but such setups are custom and expensive. I have designed and am using as my monitor a special LCD projector with low EMF electronics. It utilizes a dither-free LCD projection panel that I drive at an actual displayed vertical refresh rate of 85 Hz (in the case of the LCD type display, 85 Hz is a high enough frequency to avoid the effects of subliminal flicker on the brain). I may soon be able to build this projector for others on a custom basis.

TV flicker: TV video displayed on a TV or computer screen usually has a frame rate of 30 Hz. The TV video data can be displayed via either an interlaced ("i") or progressive ("p") scan. On older TV's the scan is a fixed 480i. This interlaced scan is a combination of 30 Hz and 60 Hz vertical refresh rates; a summed vertical resolution of 480 horizontal lines, displayed as sequential sets of the odd field (240 odd lines) alternating/interlaced with the even field (240 even lines). The total field rate is 60Hz, and the frame rate is 30 Hz (a frame, or complete image, is made up of an odd field followed by an even field). Newer TV's and DVD players provide the option of a progressive scan setting, for example 480p, where the odd and even field data are both stored for a short time and then displayed as integrated into a single frame, with a display rate of 60 Hz achieved by displaying each frame of data twice in a row.

Progressive scan TV has less flicker than interlaced, and thus 480p has less flicker than 480i. Higher resolution settings are often also available, including 720p, 1080i, and 1080p. They provide high definition (HD) TV with clearer picture and more visual detail. The best is 1080p. In the case of 1080i, although it interlaces odd and even fields, the lines are so close together that the subliminal flicker is often not effectively worse than progressive scan. Motion artifacts (due to fast motion across the screen such as a football player running, etc.) are another problem, which is best solved by the TV's that have the newest and best processors. DLP-type TV's tend to have more flicker and motion artifacts, but the newest ones that refresh at 120 Hz might be satisfactory. LCD TV's and LCD TV projectors that refresh at 120 or 240 Hz and run at 1080p generally have the least flicker and are the best visually (EMF can still be a big problem). For additional methods of reducing TV flicker, follow the principles outlined in the paragraph above that begins with: “To reduce the effects of screen flicker”.

FOOTNOTE: In most current LCD panels, each pixel is refreshed 60 times a second. In other words, each pixel is hit by a very brief voltage update 60 times a second. (Some of the newest LCD TV's refresh 120 or 240 times per second.) The brightness of a particular pixel is proportional to the voltage across it at the moment, independent of the polarity of this voltage. The voltage that the pixel feels at any one moment is the voltage output of its capacitor which stores the voltage between updates. Capacitors leak over time, and in one-sixtieth of a second this leakage causes a droop in the voltage of between 1/2% and 1%. This is the cause of the 60 cycle flicker of LCD panels. Furthermore, the updates are not all of the same polarity; if they were, the liquid crystals would begin to pile up against one side of the pixel cell and the image would stick. Alternate updates are of alternate polarities, that is, one update is a positive

voltage, the next is a negative voltage, the next is positive, etc. If the input image data does not change, the update voltages should all be of the same voltage magnitude/level no matter whether they are positive or negative. But even for non-changing image input data, alternate polarity refreshes are often not of exactly the same voltage levels. This is due to imbalances in the driving electronics, including the fact that the resistances of the transparent conductive surfaces on each side of the pixel cells are not homogeneous. This alternating imbalance results in an unpredictable amount of 30 Hz flicker.

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