No better than a poke in the eye?

Spare a thought for the reader's poor overworked eyes when designing text pages

By Kevin Larson and Jim Sheedy

Every time you design a page of text, what you're really doing is creating a high-stress workout for everyone who might end up reading it.

Reading is a very stressful task. When people read, their eyes need to make roughly four movements every second – that is 15,000 eye movements for every hour they spend reading. At the same time as the muscles controlling eye movement are working so rapidly, other muscles are busy keeping the lens inside the eye constantly focused at the distance of the book, magazine or computer.

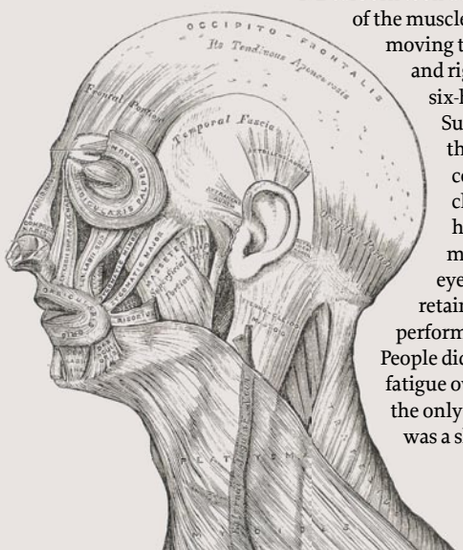
Whew! It is no wonder that fatigue and other eye problems such as nearsightedness became widespread in the twentieth century. In a survey of more than 4000 computer workers, 40.5 per cent reported experiencing eye fatigue symptoms (SOLA Optical).

If you want people to be able to comfortably read the text you design, whether it is in print or on a screen, it is worth taking the trouble to make the eye workout as low impact as possible.

Unfortunately, the current biological understanding of eye fatigue is poor. Asthenopia is the clinical term for it, and it is currently diagnosed by asking patients questions about possible symptoms: Do you have blurred vision? Do you feel ache or pain around the eyes? Do your eyes feel tired at the end of the day? and so on. However, even though the mechanisms of asthenopia are not well understood, some of the causes and fixes are known. For example, we have considerable understanding about the impact of individual diagnosable eye conditions, methods of providing visual corrections, lighting design and workstation arrangement upon eye fatigue.

The ordinary definition of fatigue is easily understood. When somebody says they are fatigued after a long day of playing, working or engaging in physical activity, it means they cannot use their muscles to perform the activity as well as before they became fatigued. Eye fatigue occurs when reading becomes difficult and does not become easier when reading a different topic. So, which muscles get tired during eye fatigue?

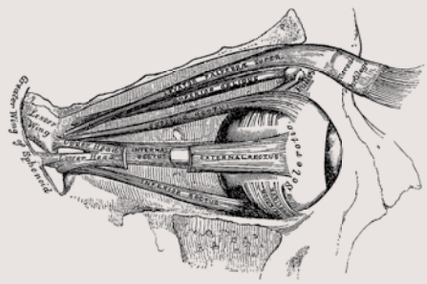
In the 1940s Leonard Carmichael and Walter F. Dearborn took detailed measurements of the muscles responsible for moving the eyes up, down, left and right during multiple six-hour reading sessions. Surprisingly, they found that reading speed and comprehension hardly changed over the six-hour periods, and the muscles that control eye movements also retained constant performance over that time. People did report more eye fatigue over the six hours, but the only measured difference was a slight increase in blink rate from about nine blinks per minute at the beginning to eleven blinks per minute at the end.



1 Muscles around the eye that move them up, down, left, and right
2. Facial muscles including large muscle around the eye responsible for squinting and blinking

You would think these results indicate that we would want to keep blink rates low. However, other studies found that we blink far more often under relaxed conditions than while reading: 22 blinks per minute while relaxed, versus ten blinks per minute while reading a book. A recent study at Pacific University illuminated why blinking is suppressed during reading. Tai and Sheedy found that the eye movement following a blink was far more likely to be a regressive or backward corrective eye movement than one that did not follow a blink.

The muscle that controls blinking is called the orbicularis oculi. It is a large and powerful muscle, which is surprising since it is not responsible for lifting or moving anything. The muscle goes all the way around the eye and also controls squinting. The external fibres of the muscle are more responsible for squinting and the internal ones more for blinking. We focused on this muscle in our studies.



Readers were asked to read under six especially demanding conditions known to cause eye fatigue. These were: reading small text sizes; reading low-contrast gray text; reading with a light source behind the reading material to cause glare; reading from too close a distance, which causes the eyes to point inward towards each other (convergence stress); reading from variable focal distances (accommodative stress); and reading while wearing glasses that simulate an astigmatism (refractive stress). While people were reading under these extra stressful conditions, we measured the activation in the orbicularis oculi muscle with a sensor placed 1.25 cm below the eye. Readers reported eye fatigue after reading with each of these conditions

Size isn't everything

Small text sizes, low contrast, glare and refractive stress all resulted in increased activity in the orbicularis oculi, while convergence stress and accommodative stress did not, though after reading in these two conditions, readers are more likely to report headaches and pain coming from behind the eye. Stressors such as small text size and glare are reported as irritation on the front of the eye.

In a follow-up study, we asked people to read with multiple levels of the small text sizes, low contrast, glare and refractive stress. While readers reported greater amounts of eye fatigue with the more difficult levels (smaller text, more glare etc), we found different reactions to stress from small text size and low contrast from that caused by glare and refraction.

Greater amounts of glare and refractive stress result in steady increases of orbicularis oculi activity and blink rates. Both conditions benefit from squinting, which reduces the effect of glare by acting as a physical barrier to some of the unpleasant light. Squinting also improves blurred vision by increasing the depth of field and hence decreasing blur. The intensity of squinting may cause the increase in blinking.

Reading small text and low-contrast text resulted in constant orbicularis oculi activity across all levels, and the blink rate decreased even at the smallest text sizes and lowest contrast. For these two conditions, which do not benefit from squinting, readers appear to use the orbicularis oculi to avoid blinking. We know that blinking increases the likelihood of being forced to make a backwards eye movement, and it may be that poor text quality amplifies the need to avoid blinking. It is also possible that poor text quality increases cognitive demands for text recognition, which serve to reduce blink rate.

What does this mean for design?

There are three different kinds of eye fatigue, and two are not caused by design. Internal eye problems such as accommodation and refractive problems need to be corrected by eye doctors. Poor environmental conditions such as glare and poor workstation arrangement can be solved with workplace ergonomics. But the third kind of eye fatigue is directly related to typography.

Light grey text on a white background and small text size both lead to an increased orbicularis oculi activity and decreased blinking. These two conditions are related to text quality, and we would expect to find similar indicators of eye fatigue with poor font quality or condensed letter spacing. To reduce this type of eye strain, we need text of the highest possible quality.

Designers usually try to use high quality text when readers are expected to read for any period of time, but using a comfortable text size is not always possible. In print, there is a trade-off between type size and the amount of text that can fit on a page. Nine-point type may be chosen because it is cost-effective, whereas eleven-point would be easier to identify visually and would reduce eye strain. Twelve-point text may be needed for good character definition on computer screens, because readers frequently sit further from a screen than from a printed page, but many web pages specify small font sizes despite the fact that it costs no more to create additional or longer pages. Designers need to argue for larger text sizes to reduce the effects of eye strain.

Of course, there are always times when you do not want someone to read the details . . . Six-point text is very common for legal disclaimers at the bottom of advertising. If your goal is to try to limit the amount of text that gets read, giving your reader eye fatigue is very effective. Try combining tiny text sizes with very light grey text. No one will even try to read it.

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