Visual fatigue among computer users

a literature review
by Rahul kumar Dhanuk

Introduction of computer during 1970s gave rise to controversial debates about workplace ergonomics, lighting, health and work stress.

User get susceptible to Computer vision syndrome due to long working hours. Their visual ability gets tired and exhausted.

Tsuneto Iwasaki and Shinji kurimoto in their paper, *Eye strain and changes in accommodation of the eye and in visual evoked potential following quantified visual load*, 1988 said:

"Visual fatigue is the fatigue of eye muscles, a sense of pressure in the forehead, headache, blurring, diplopia, dizziness, nausea and vomiting".

Visual task issues: Digital vs Print

Human eyes and brain react well to printed materials having good contrast, but react differently to pixilated screen characters

(made of small dots or pixels which are brightest at the center and diminish in contrast at edges due to poorly defined edges).

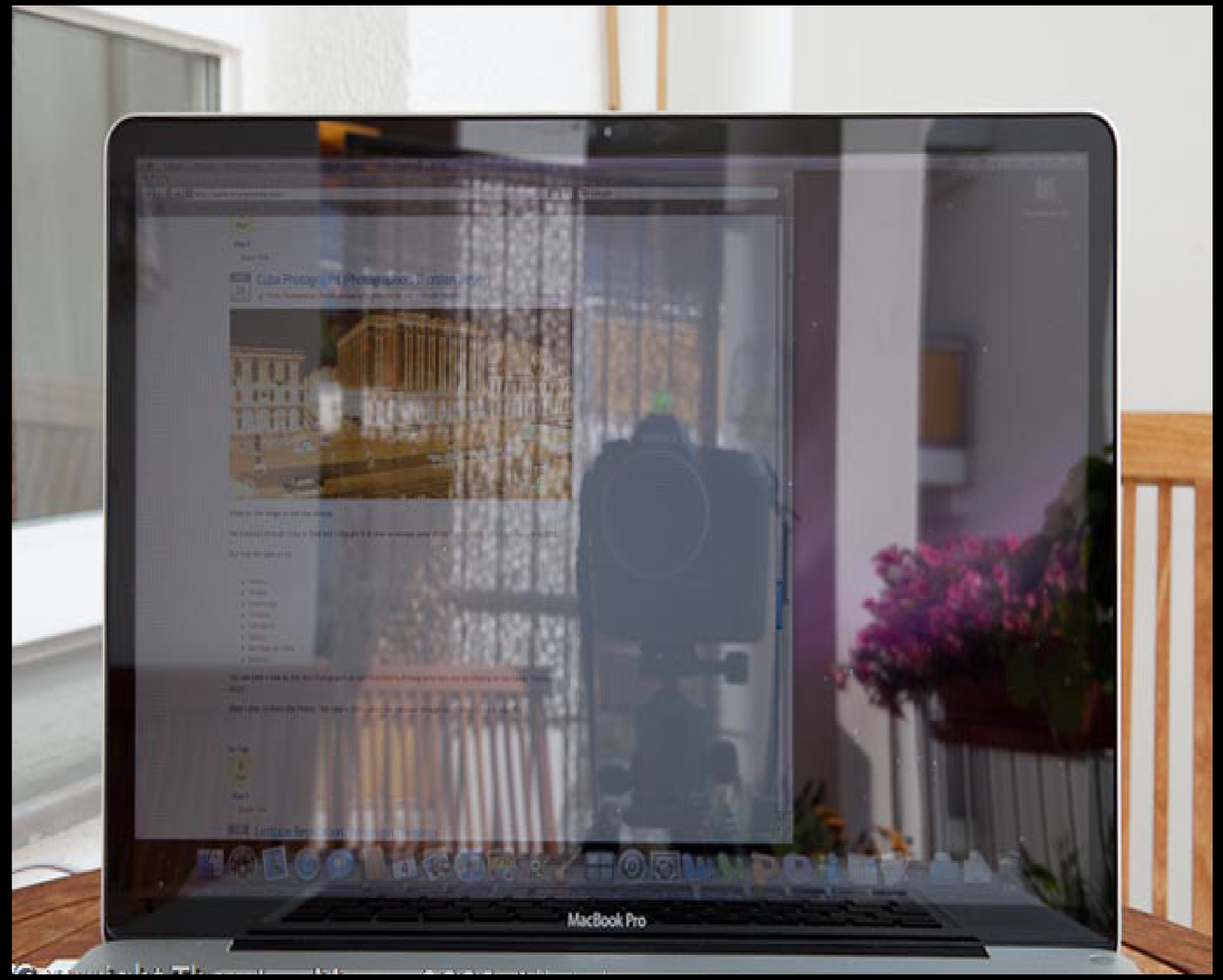
Glare:

Visual environment light causes glare on monitors causing veiling effect and reduces contrast. It leads to visual stress.

Causes of glare: Contrast discrimination

Overhead lights or lights from window when strike the illuminated objects on the computer monitor, creates light pollution in the viewing zone of the user. This conflicting displays on the screen reduces contrast.

Causes of glare: Colour discrimination



Excessive luminance level also creates a veiling effect on the computer display and thus creates a washed out effect making it difficult to discriminate different colours.

Causes of glare: Bright windows

Bright open windows, causes light sensitivity, rapid blinking, lack of concentration, narrowing of the *palpebral aperture* (opening between the eye lids), and *epiphora*. (excessive watering of eyes)

Visual task issues: Reading distance

Computer monitor is usually placed at 50-60 cm which is slightly more than reading distance and less than long viewing distance and it always keeps accommodative function active.

Visual task issues: Posture

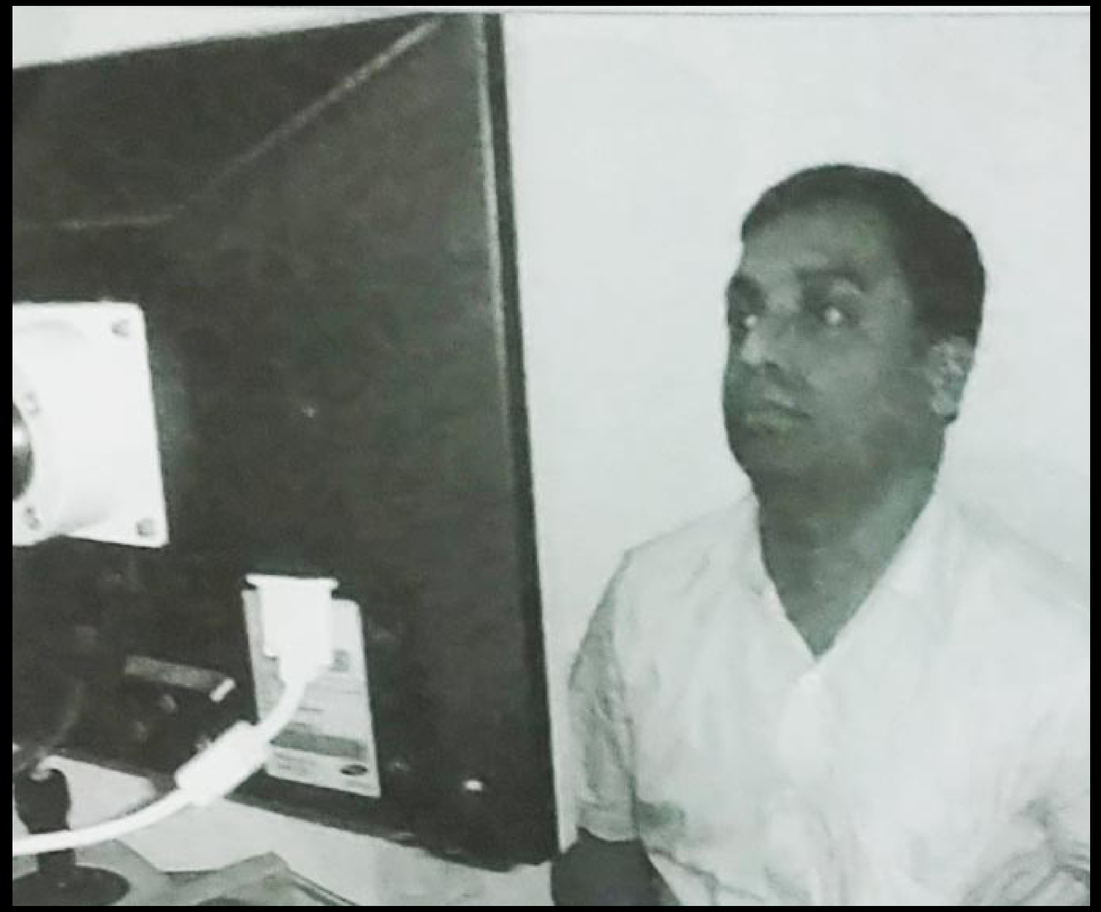
Computer workers often assumes an awkward posture that results in musculoskeletal problems such as carpal tunnel syndrome, back and neck pain.

Visual task issues: Blinking

Computer users while working on a computer hardly blinks more than 4-6 times per minute whereas normal blink rate is 15 per minute.

Causes of less blinks:

Concentration during computer task results in limited range of eye movement.



Higher gaze angle results in a greater percentage of incomplete blinks.

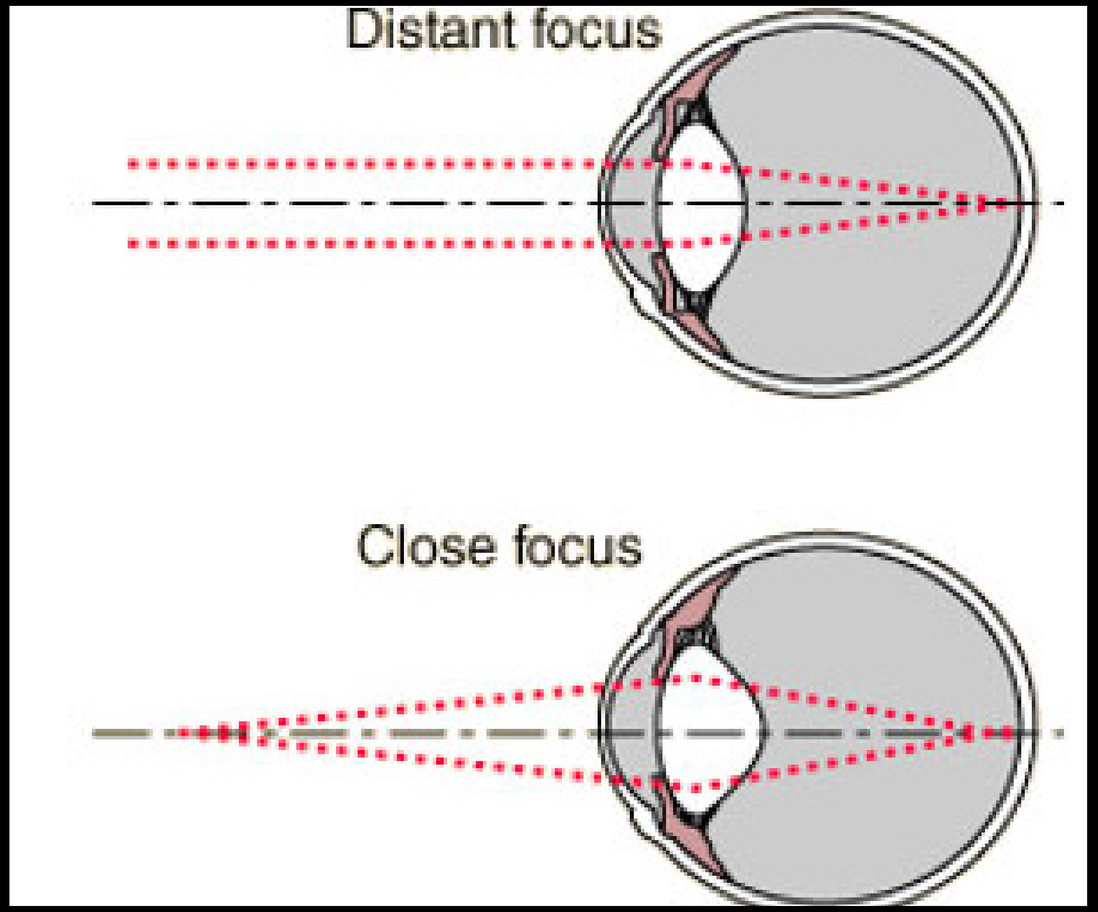
Causes of less blinks:

Computer tasks doubles palpebral aperture causing tear elimination through evaporation.

Lower workplace humidity may cause dryness of eye.

Stressed visual elements:

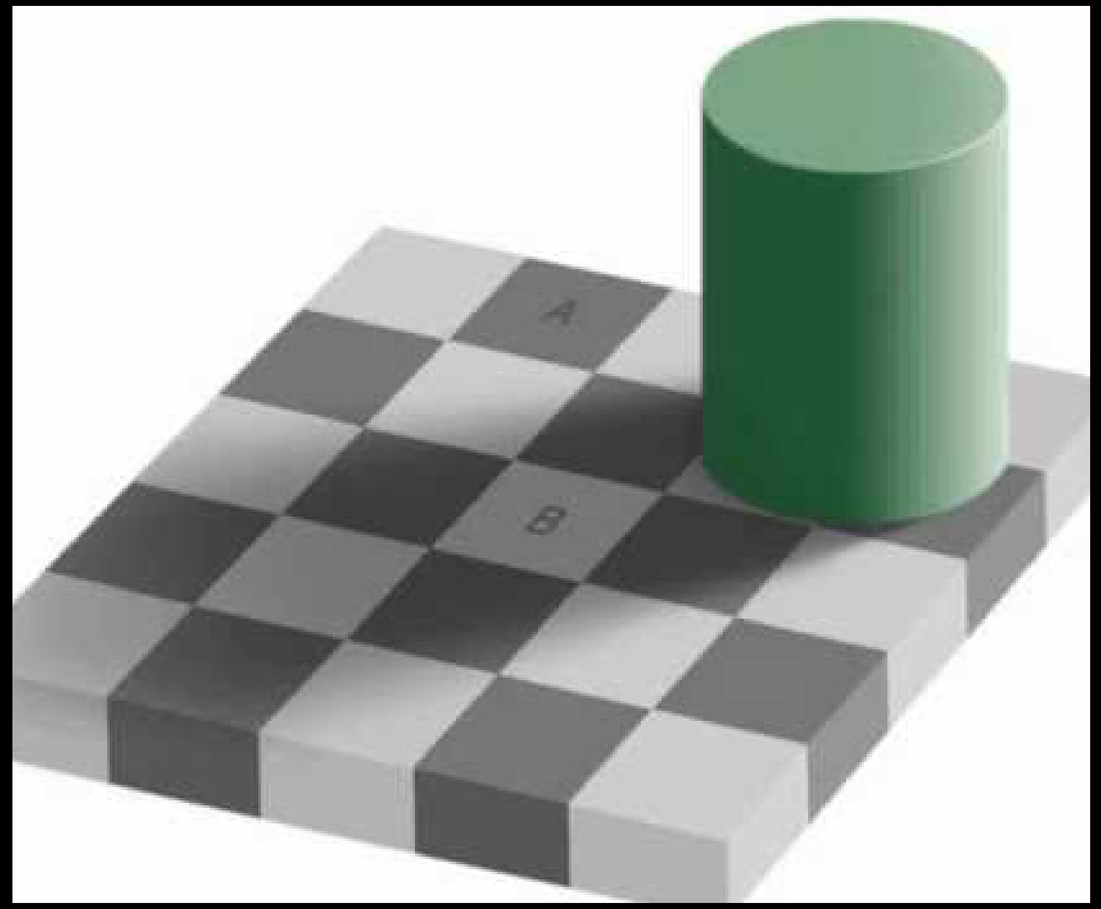
Visual acuity which is for aiming and focusing on computer monitor.



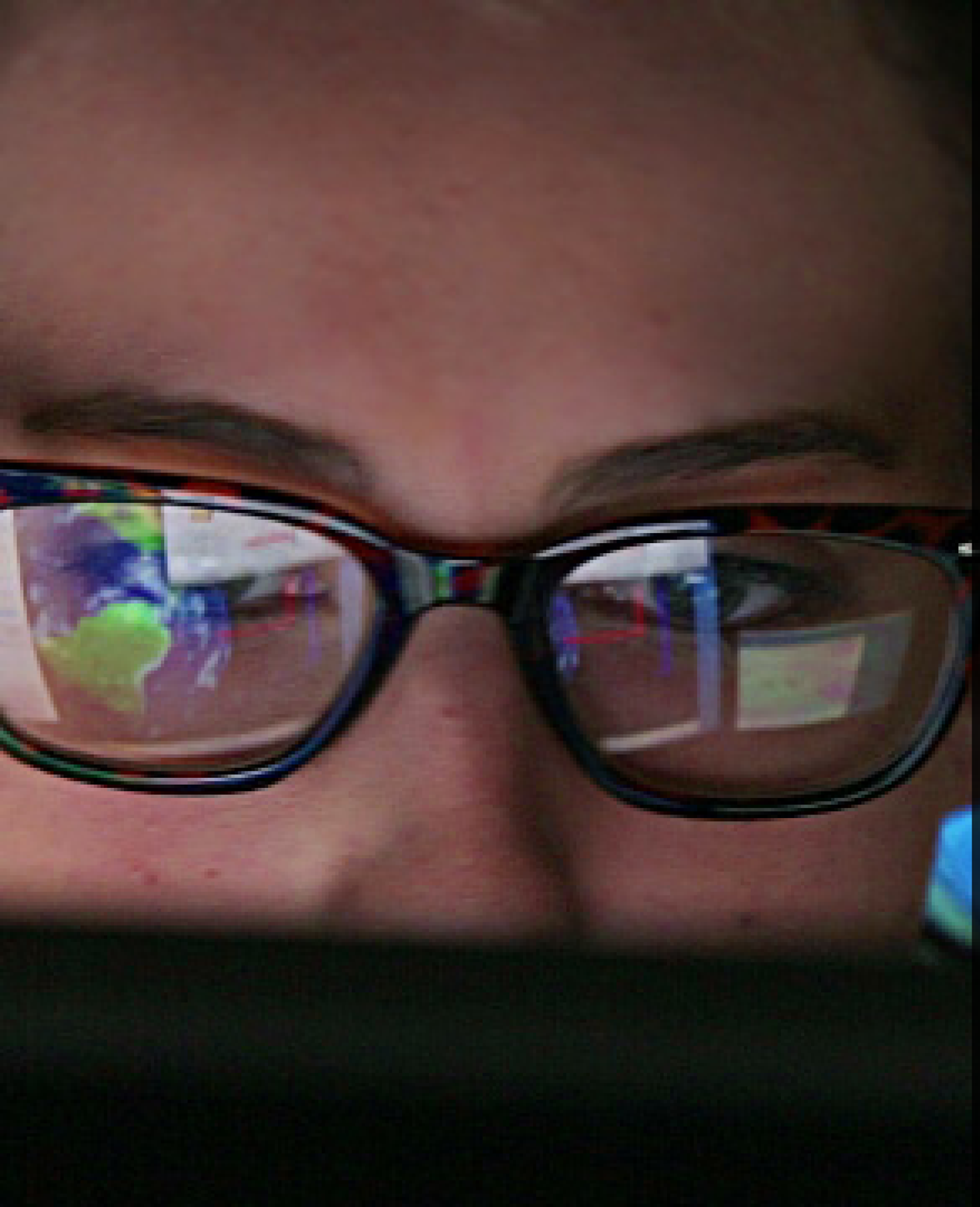
Accommodative system to look at the keyboard and screen.

Stressed visual elements:

Depth perception to perceive 3D world and gauge object's distance.



Colour perception for developing websites and other designing tasks.



Laws of Computer Vision:

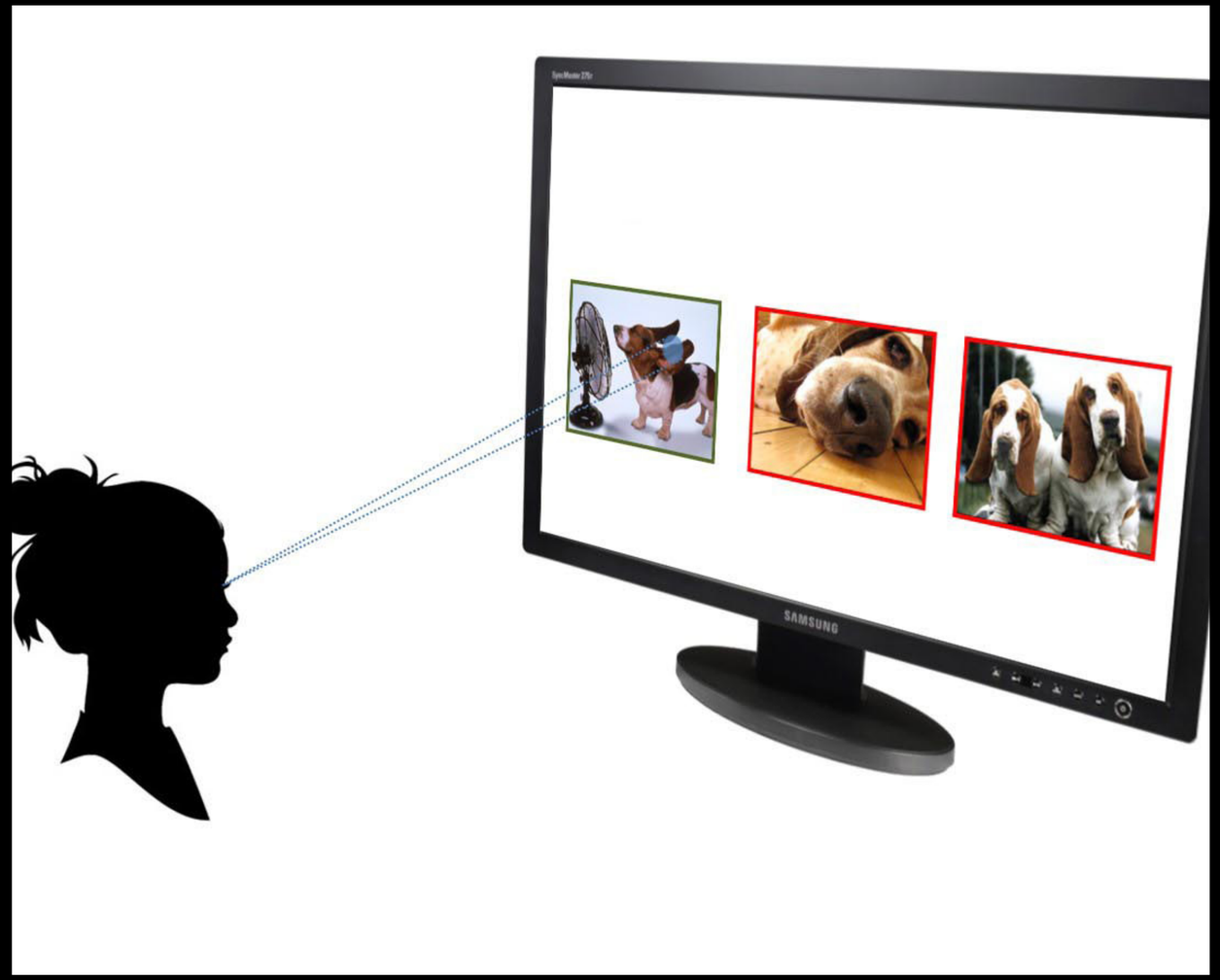
1. Computer worker fixates at the target and then follows the same. Fixation, Depth perception, Saccades and Regression are important visual skills needed for reading task.

2. The elements of visual system controls the performance of visual skills.

3. Visual abilities determine visual postures which is also influenced by visual environment.

4. A deficiency in any of the visual skills will lead to symptoms of Computer vision syndrome.(CVS)

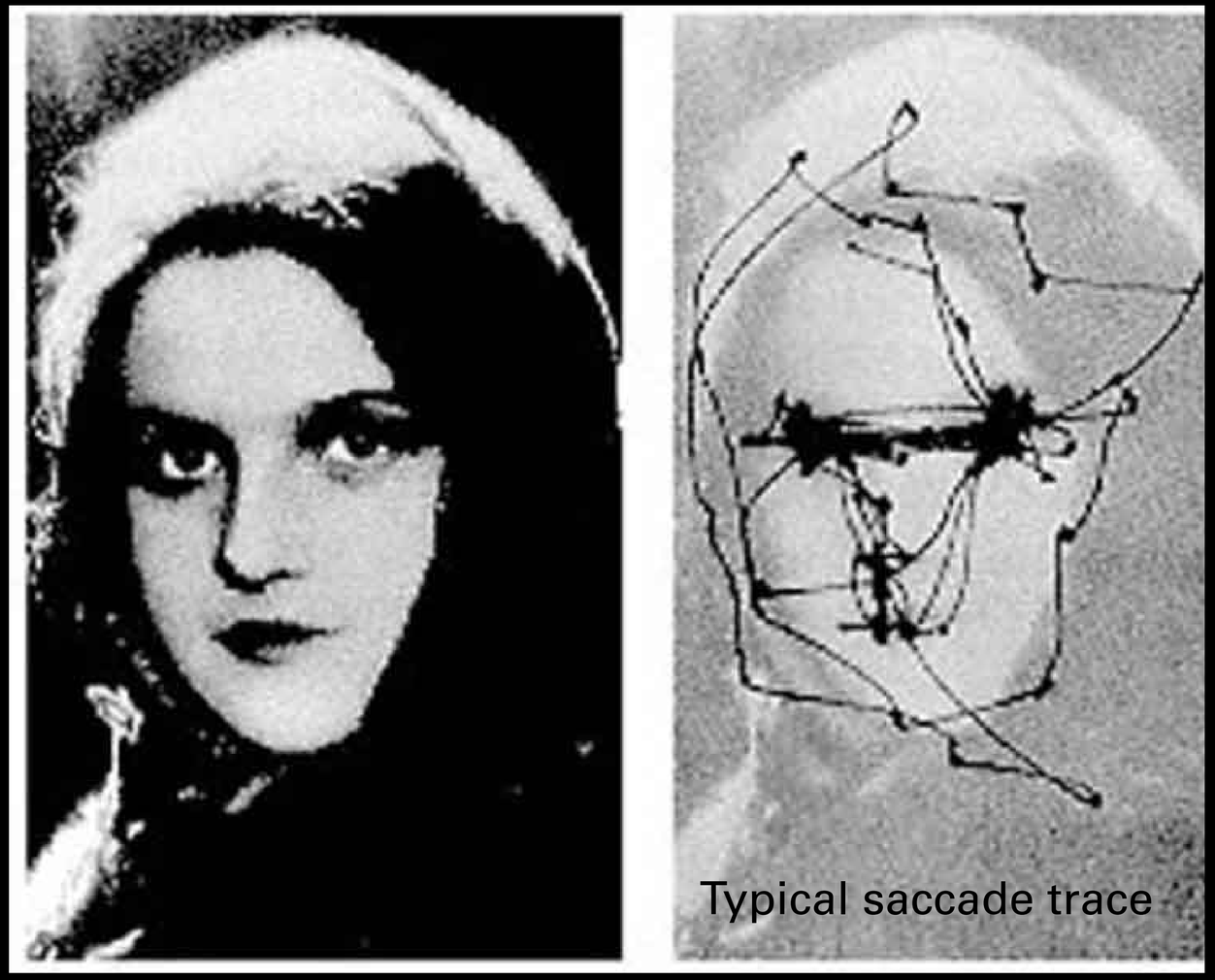
Visual skills: Fixation



Fixation is a steady maintenance of the image of the object of regard on the *fovea*. Reading difficulties and other symptoms may occur with poor fixation ability.

Fovea is a small depression in the retina of the eye where visual acuity is highest. The centre of the field of vision is focused in this region, where retinal cones are particularly concentrated.

Visual skills: Saccades



Saccades helps to rapidly redirect our line of sight so that the point of interest stimulates the fovea. The ideal saccade is a single eye movement that rapidly reaches and abruptly stops at the target of interest.

Visual skills: Regression

It is right to left eye movement and vice versa. It occurs 10-20% of time in skilled readers when they overshoots the target, misinterprets or face difficulties understanding texts.

Other causes of Visual fatigue:

- Prolonged computer viewing puts huge demand on the *accommodative mechanism* which often interacts with *refractive error.* Accommodative mechanism gets locked at the near viewing distance that delays the accommodation relaxing ability of the eye when they look at the distance after an extended work on the computer. This delay in focusing at distance aggravates as day passes.
- *Binocular vision* which is eyes ability to work together as a team to provides clear single vision gets effected. Excessive visual demand results in *phoria* where slight difference in the length, insertion or strength of the same muscles of eyes leads to a tendency for one eye to drift to a different position in its orbit from the other.

Visual fatigue symptoms: Refractive error

Uncorrected refractive error is important for computer users because tasks requires concentration which results in reduced blink rate and widening of the eyelids.

Types of refractive error: Hypermetropia

Patient may have blurred vision when looking at objects close to them, and clearer vision when looking at objects in the distance as image of a nearby object is formed behind the retina.

Myopia:

It is short-sightedness. Patient can see at near working distance without correction, but may experience difficulties while viewing at computer as it is located farther away from normal.

Astigmatism:

It is blur vision at all working distances. But when the visual demands increases with computer work, it affects visual performance. Sometimes, the individual may feel headache or eyestrain.

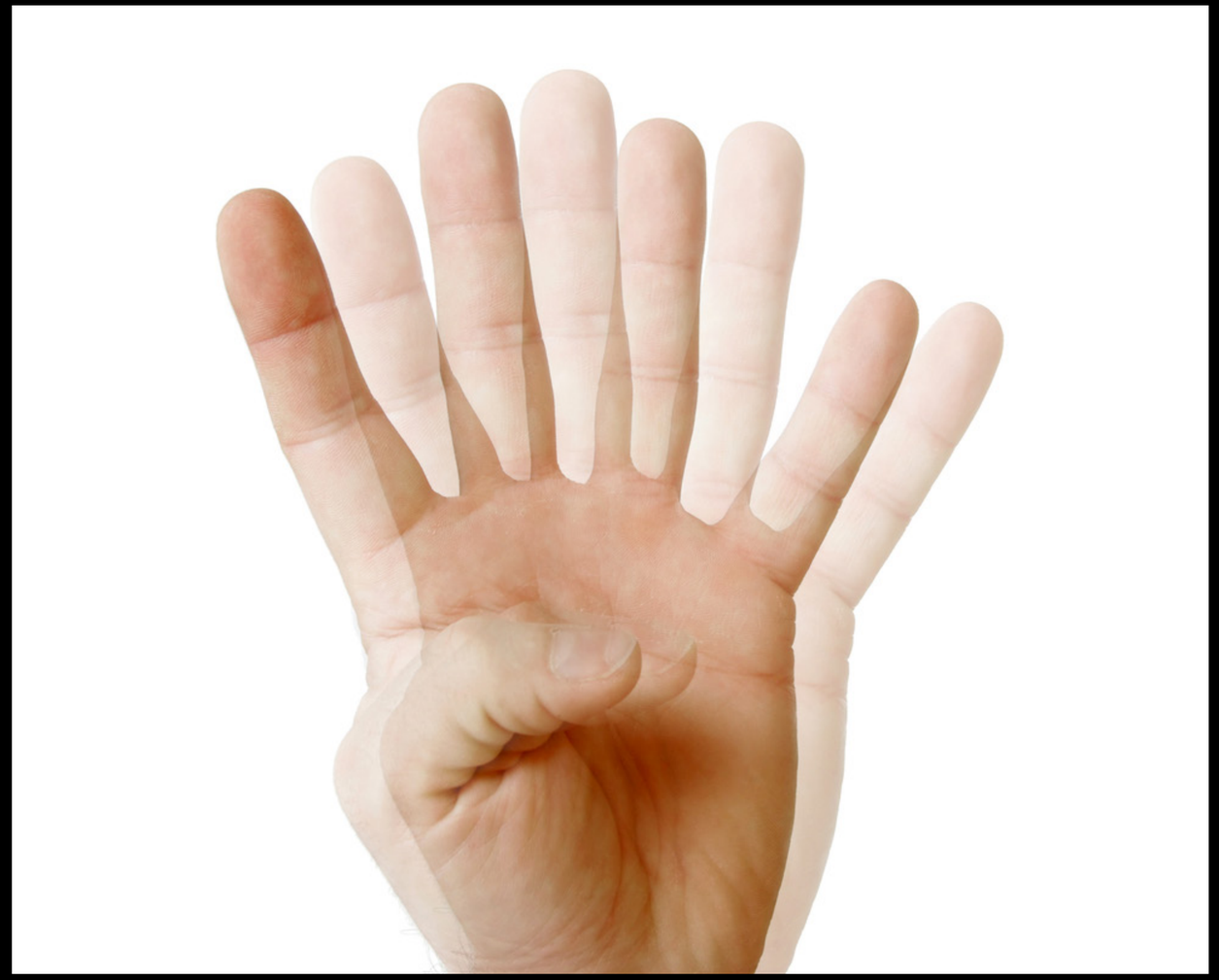
Presbyopia:

It is long-sightedness caused by loss of elasticity of the lens of eye, occurring typically in middle and old age.

Blurred vision:

Two main reasons for intermittent blurred vision and delay in focusing at a distance after long computer work are accommodation getting locked at near viewing distance and dry eyes.

Double vision:



In some extreme cases, symptoms related to double vision may be reported which straight away points towards binocular vision dysfunction.

Ocular symptoms:

The person often complains of itching eyes, burning eyes, foreign body sensation, sore eyes, excessive tears and blinks.

Asthenopic symptoms:

It commonly includes eyestrain, headache, eye fatigue, tired eyes. Victims of asthenopic symptoms often reports that they are more comfortable when the illumination level is reduced.

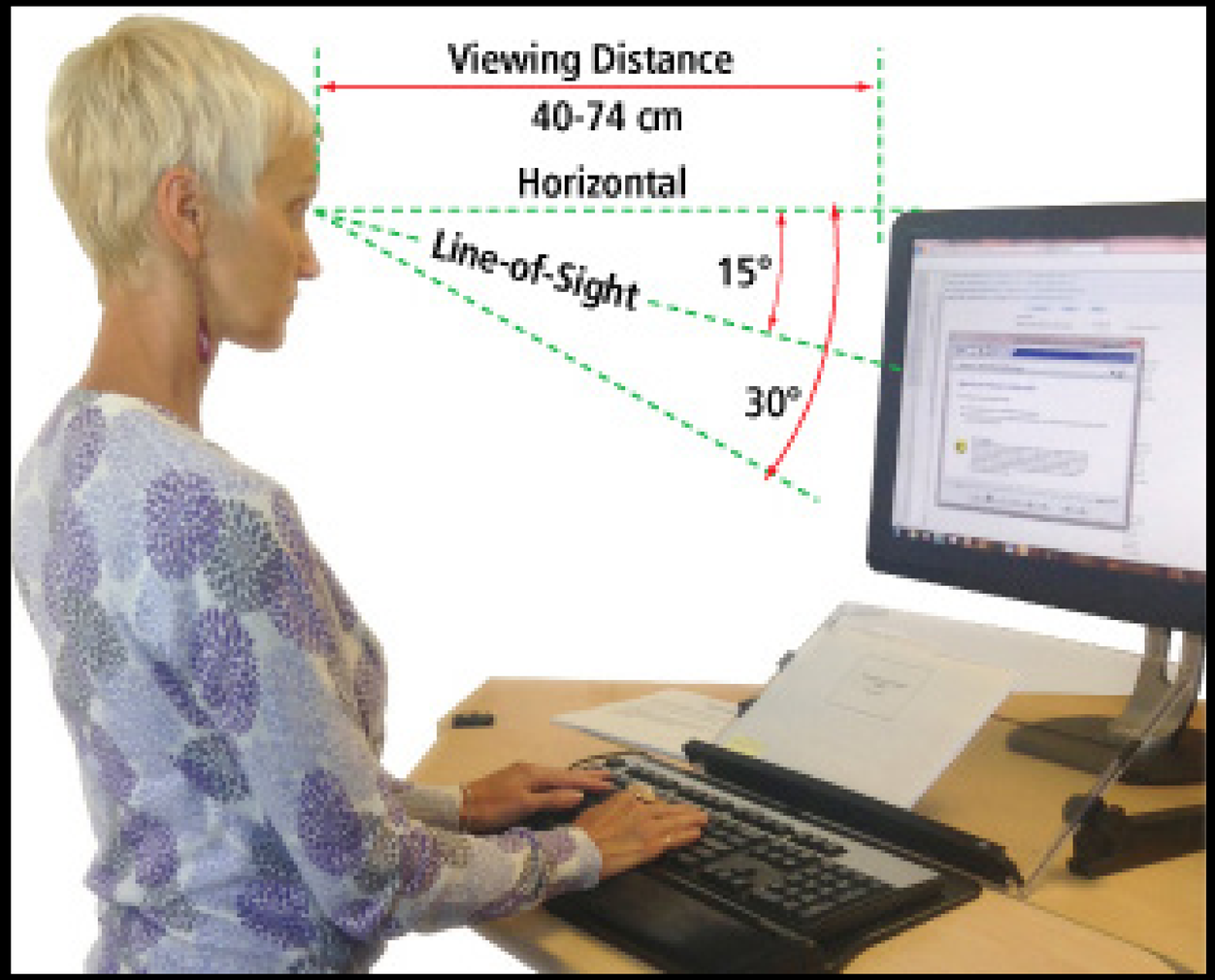
Musculoskeletal symptoms:

Maintaining similar postures for hours results into problems like pain in neck, shoulder, back, wrist and arms.

Minimizing visual fatigue:

Rest-time allowances in computer work are advised which help workers snatch a respite from long work by looking at a number of different things. It help minimize visual fatigue.

Proper gaze:

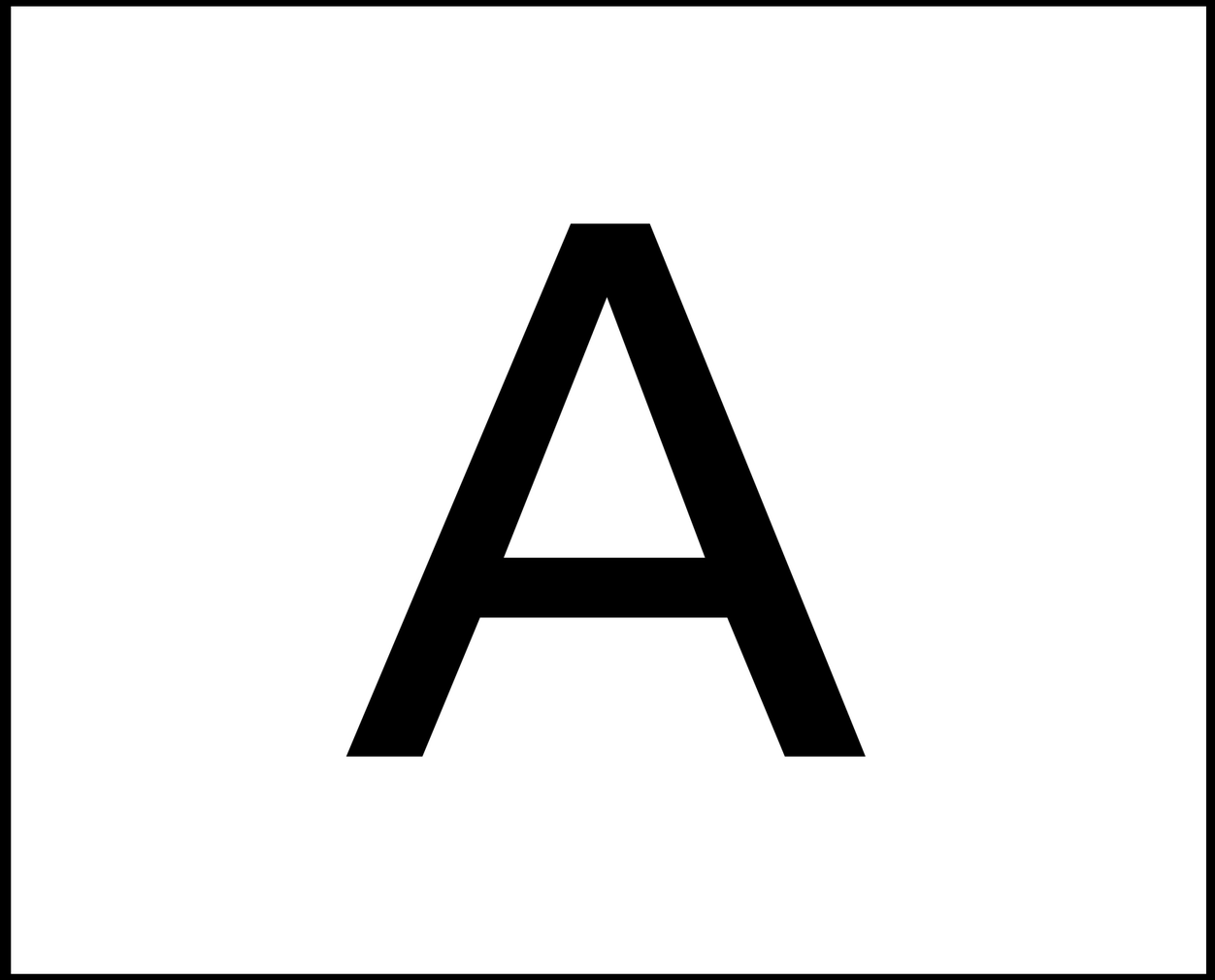


A down ocular gaze angle of 15-20° relative to straight ahead gaze is more ideal for computer task.

Uniform illumination:

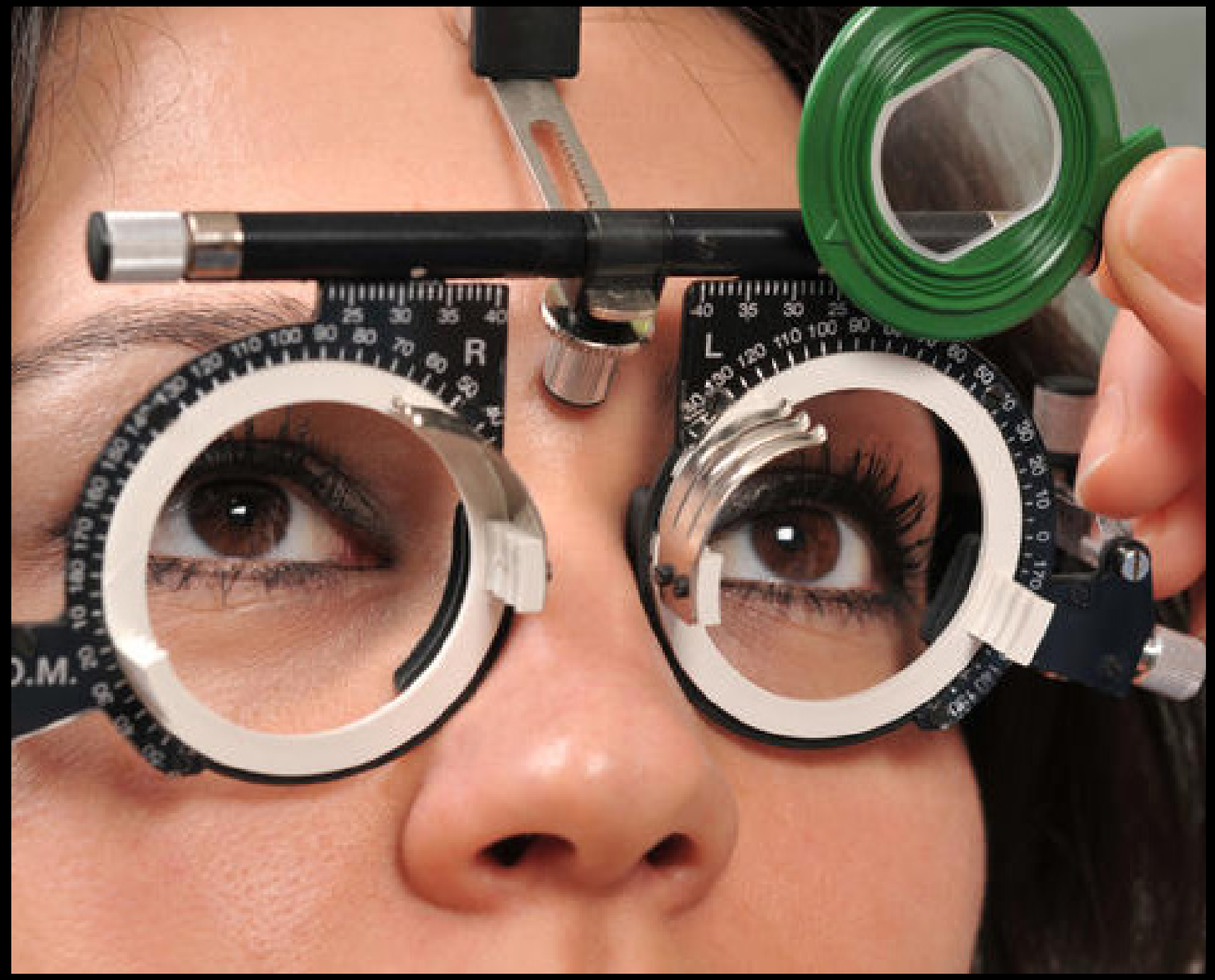
A good lighting is the situation when all the visual objects in the field of view are near uniformly illuminated to prevent discomfort from glare.

Letters:



Visual object letters on white background are better option than white letters on black background. Screen reflections are more noticeable when the person is using a dark background, creating discomfort glare.

Refractive error:



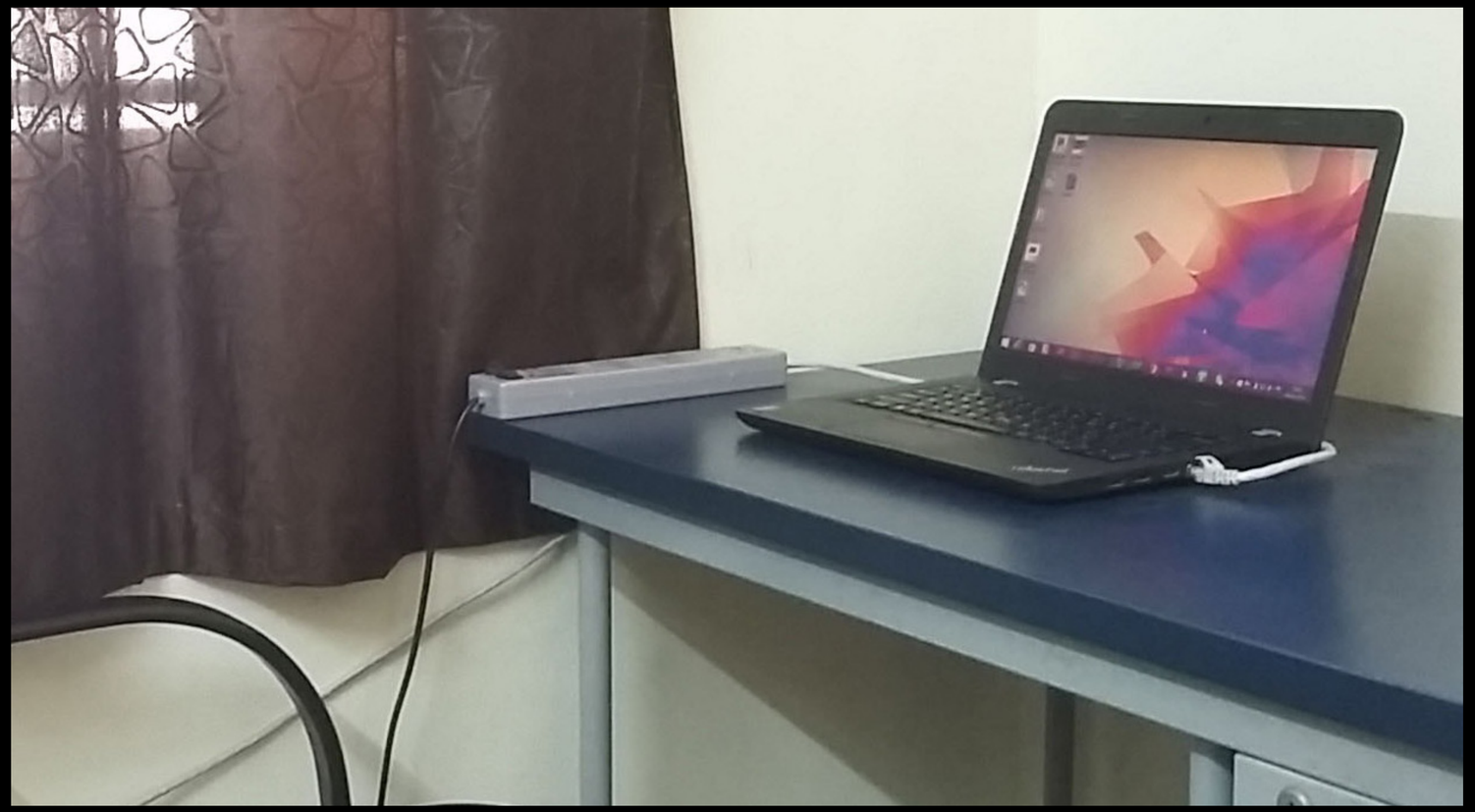
Eyeglass lenses correct refractive errors by focusing light directly on the retina. The type of lens depends on the type and severity of the refractive error.

Blinking:

Achieving complete corneal coverage during blinking may be more helpful in alleviating symptoms of visual fatigue during computer work.

My early workstation:

Adjustments made:



- Covered bright lights from window to reduce glare.
- Keeping lights on while working. It helps maintain uniform lighting environment.
- Started using f.lux which adjusts a display's colour temperature according to day time. It also reduces harmful blue lights from screen.

References:

- A.J. Dittner, S.C. Wessely, R.G. Brown - *The assessment of fatigue - a practical guide for clinicians and researchers.*
- Ajay kumar Bhootra, *Basics of Computer vision syndrome.*
- Agnieszka Wolska & Marcin Witula (2015) - *luminance of the surround and visual fatigue of vdt operators.*
- Atsuo murata , Atsushi Uetake, Miho Otsuka, Yosuke Takasawa - *Proposal of an index to evaluate visual*
- Atsushi Uetake, Atsuo Murata, Miho Otsuka and Yosuke Takasawa - *Evaluation of visual fatigue during vdt tasks.*
- Azmeh Shahid, Jianhua shen, Colin m. Shapiro (2010) - *Measurements of sleepiness and fatigue.*
- Chia-fen chiand fang-tsan lin, national taiwan university of science and technology, taipei, taiwan - *A comparison of seven visual fatigue assessment techniques in three dataacquisition vdt tasks.*
- Donghyun Kim, Sunghwan Choi, Sangil Park and Kwanghoon Sohn - *Stereoscopic visual fatigue measurement based on fusional response curve and eye-blinks.*
- E. M. A. Smets, B. Garssen, B. Bonke and J. C. J. M. De Haes - *The multidimensional fatigue inventory (mfi) psychometric qualities of an instrument to assess fatigue.*
- F mocci, A serra, G A Corrias - *Psychological factors and*

visual fatigue in working with video display terminals.

- J. Kuze, K. Ukai (2007) - *Subjective evaluation of visual fatigue caused by motion images.*

- Kazuhiko Ukai, Peter A. Howarth (2007)- *Visual fatigue caused by viewing stereoscopic motion images: background, theories, and observations.*

- Kimiko Kawashima, Jun Okamoto, Kazuo Ishikawa, Kazuno Negishi - *Parameter comparison of assessing visual fatigue induced by stereoscopic video services.*

- Lisa Whitehead, Phd, ma, Bsc (hons) - *The measurement of fatigue in chronic illness: a systematic review of unidimensional and multidimensional fatigue measures.*

- Masaru Miyao , Selim S. Hacisalihzade , John S. Allen & Lawrence W. Stark (2007) - *Effects of vdt resolution on visual fatigue and readability: an eye movement approach.*

- O. Ostberg Accommodation and visual fatigue in display work.

- Sumio Yano, Masaki Emoto, Tetsuo Mitsuhashi (2004) - *Two factors in visual fatigue caused by stereoscopic hdtv images.*

- Sumio Yano, Shinji ide, Tetsuo Mitsuhashi, Hal Thwaites (2001) - *A study of visual fatigue and visual comfort for 3d hdtv/hdtv images.*

- Susumu Saito (2007)- *Does fatigue exist in a quantitative*

measurement of eye movements?

- Tsuneto Iwasaki & Shinji Kurimoto (2007) - *Eye-strain and changes in accommodation of the eye and in visual evoked potential following quantified visual load.*

- Tsuneto Iwasaki , Shinji Kurimoto & Kageyu Noro (1989) - *The change in colour critical flicker fusion (cff) values and accommodation times during experimental repetitive tasks with crt display screens.*

- Merriam-Webster dictionary
- Wikipedia, Google

Thank You.

Rahul Kumar Dhanuk
M.Des, CD (2015-2017)
156250015