Digital eyestrain (DES): a new problem or a conglomerate of old problems?

Prof Bruce Evans
BSc PhD FCOptom FAAO FBCLA DipCLP DipOrth
Director of Research
Institute of Optometry
Visiting Professor
City, University of London
Visiting Professor
London South Bank University
Private practice Cole Martin Tregaskis, Brentwood, Essex
© 1990-2017 Bruce Evans


PLAN

INTRODUCTION
CVS – NEW CONGLOMERATE OF OLD PROBLEMS
BINOCULAR & ACCOMMODATIVE CHALLENGES
VISUAL STRESS
SPECIFIC CHALLENGES WITH DISPLAYS
CONCLUSIONS

CAVEAT

Case study:
PX in early 20s: headaches with computer use
Saw 4 optoms, 7 physicians, 1 neurologist
Eventually, diagnosed with chronic intermittent angle-closure glaucoma, when it became acute, HM LE, field loss
Patient then sued all healthcare practitioners

Always greet symptoms with an open mind
DES is a diagnosis of exclusion

- Diagnosis by optom/ophthalmologist
- Neuro-optometric checks
  - Pupils, discs, fields, strabismus, comitancy, accommodation
- Check these things regularly

Full handout of slides from www.bruce-evans.co.uk
Definition of DES (CVS)
- "ocular complaints as a result of looking at a computer monitor"
  - Blehm et al (2005)
- "combination of eye & vision problems associated with the use of computers"
  - Rosenfield (2011) from AOA
- "collection of visual, ocular and musculoskeletal (neck and shoulder pain) symptoms that result from prolonged computer use"
  - Gowrisankaran & Sheedy (2015) from AOA

Classification of DES
- Blehm et al (2005)
- Rosenfield (2011):
  - Refractive error
  - Accommodation
  - vergence
  - dry eye
- Portillo et al (2012): Factor analysis falls into 2 groups: dry eye & accommodation
- Gowrisankaran & Sheedy (2015)
Sheedy et al. (2003) Not about DES

- Is all asthenopia the same?
- 20 young adults with good vision
- Rated symptoms after:
  - mixed astigmatism, close viewing distance, upward gaze, dry eyes, lens flipper, small font, glare, and flickering light (15Hz)
- “at least 2 different afferent pathways for the symptoms of asthenopia”
- ESF: burning, irritation, tearing, and dryness
  - From: holding the eyelid open, glare, up gaze, small font, and flickering
- ISF: ache, strain, and headache located behind the eyes
  - From: close viewing distance, lens flipper, and mixed astigmatism
  - “Accommodative/binocular stress”

Duke-Elder (1970) on causes of eye-strain

- Environmental factors:
  - Illumination (quantity, quality, distribution)
- Ocular factors:
  - ametropia, accommodation, heterophoria, convergence, fusion inadequacy, aniseikonia (perhaps)
  - Gross visual errors affect function, minor ones cause eye-strain through continuous error to correct the defect
- Constitutional factors:
  - Unfit, overwork, malnutrition, exhaustion, insufficient sleep, anxiety, emotional strain
- Symptoms:
  - Eyes tired, hot, uncomfortable, watery, prone to infections
  - Actual strain developing to pain
  - Referred symptoms: headaches, vertigo, digestive
  - “headache is the commonest symptom associated with eye-strain”, “occurs in almost every possible variety”

Duke-Elder (1970) on history of eye-strain

- Eyes have not “evolved sufficiently to fulfil the exorbitant demands of unremitting close work imposed upon them by a highly complex and artificial civilisation”.
- Asthenopia from Mackenzie (1843), treatment included abstinence from near work, “only very rarely in the aged convex lenses”, purgatives, tenotomy of medial recti, cauterization of urethra to stop spermatorrhea or diminish masturbation, and or emigrate to “follow the pastoral pursuits of an Australian colonist”.
- Donders (1864) said muscle strain, but Duke-Elder: “much of the symptom complex of eye-strain is probably due to tiring of higher perceptual processes”
**DES case study**

- 52 year old design engineer
- Clinical findings
  - V (LogMAR): R0.1 L0.0 B-0.06
  - Subjective: R-0.50 L-0.25 VA R=L-0.1
  - Add: @38cm +1.75 @57cm +1.00
  - Other findings normal except
    - NPC 11cm and N cover test & XP good recovery
- Visual requirements in different eras:
  - 1970s: SV NV spectacles & prism/VT
  - 1990s: IV/NV bifocals & CI exercises
  - 2017: no spectacles & no symptoms

---

**Are computers the latest thing to be blamed for asthenopia?**

---

**COMPUTERS CAUSE EYESTRAIN!**

**COMPUTERS CURE EYESTRAIN!**
Is the office a problem?
- Kim et al (2017) sought relationship between occupational noise/vibration exposure and headache/eyestrain
  - Survey of 25,000 Korean workers
  - N.B., not North Korea where tractors used differently
- 21% of those with severe noise had headache/eyestrain cf 17% of this with no noise (p<0.0001)
- 23% of office workers had headache/eyestrain cf 17% of manual workers (p<0.0001)

DSE reading cf hard copy
- More incomplete blinks with DSE
  - Portello et al (2013)
- More symptoms with DSE
  - Chu et al (2011)
  - Hue et al (2014)
- Slower with DSE
  - Hue et al (2014)
- Differences between different display
  - Hue et al (2014)
- For some, symptoms with DSE reduced by coloured filters

PLAN
- INTRODUCTION
- CVS – NEW CONGLOMERATE OF OLD PROBLEMS
- BINOCULAR & ACCOMMODATIVE CHALLENGES
- VISUAL STRESS
- SPECIFIC CHALLENGES WITH DISPLAYS
- CONCLUSIONS

Full handout of slides from www.bruce-evans.co.uk
Ocular motility problems
- Incomitancies are rare but A & V syndromes are common
- Workstation should avoid the px looking in problematic directions of gaze
  - Could potentially lead to decompensation
- Detect incomitancies
- Advice on workstation setup

Diagnosis of symptomatic heterophoria & binocular instability

Treatment of decompensated heterophoria & binocular instability
- Refractive correction/modification
  - Under-used
  - Simple to prescribe with naturalistic FD test
- Prisms
  - Probably under-used
  - Simple to prescribe with naturalistic FD test or EyeGenius
- Eye exercises
  - Can be successful for motivated patients
Debate over whether accommodation:
- Fatigues (Thiagarajan & Cuffreda, 2013)
- Does not fatigue (Vilupuru, Kasthurirangan, Glasser, 2005)
Clinical experience is that many users of digital devices are helped by accommodative support
Manufacturers are developing innovative solutions
- e.g., Hoya Sync III: available in 3 boost powers

**PLAN**

**INTRODUCTION**

CVS – NEW CONGLOMERATE OF OLD PROBLEMS
BINOCULAR & ACCOMMODATIVE CHALLENGES

**VISUAL STRESS**

SPECIFIC CHALLENGES WITH DISPLAYS
CONCLUSIONS

Optometric correlates of dyslexia: *Meares-Irlen Syndrome/Visual Stress (MISViS)*

**PREVALENCE:** ?20% of people with dyslexia
**AETIOLOGY:** cortical hyperexcitability causing *pattern glare* from text
**SYMPTOMS:** asthenopia, headaches, perceptual distortions (words *move*)
**SIGNS:** coloured overlays alleviate symptoms and improve rate of reading
**TREATMENT:** Precision Tinted lenses

(Evans & Allen, 2016)
PLAN

INTRODUCTION
CVS – NEW CONGLOMERATE OF OLD PROBLEMS
BINOCULAR & ACCOMMODATIVE CHALLENGES
VISUAL STRESS
SPECIFIC CHALLENGES WITH DISPLAYS
CONCLUSIONS

Children may be more at risk
- More prone to visual stress (Evans & Stevenson, 2008)
- Poor classroom design (Winterbottom & Wilkins, 2007)
  - 80% of schools have 100Hz flicker
  - Some desks at 1,000 lux
  - Interactive whiteboards often have uneven & excessive illumination
  - Pattern glare from window blinds
- Prone to addictive video-gaming
  - Adopting 3-D as more immersive
- PubMed search for video games & eyestrain:
  - 4 publications in 10y, 3 of 4 on 3-D

Additional considerations
- Neurological basis for visual discomfort
  - Wilkins (1984) seminal paper on visual discomfort
  - Wilkins (2016): for scenes from nature their gross aspects have a higher contrast than the fine detail
  - The Fourier amplitude spectrum decreases approximately as the reciprocal of the spatial frequency, 1/f (Field, 1987).
  - The neural computation involved in sight is well-designed to take advantage of the 1/f characteristic (Field, 1987, 1994; Geisler, 2008).
  - Explains much discomfort from inside (Wilkins, 2016) and outside (Le et al., 2017) of buildings
  - Discomfort can be predicted from the unnatural statistical properties of the image.
- The unnatural statistical properties are associated with inefficient neural processing and with a greater metabolic load in consequence.
Specific problems with displays

- Maybe in wrong position
- Can flicker
  - Possibility of stroboscopic interaction with fluorescent lights
- Can be too bright
- Can achieve very high contrast
- Can have unnatural colour contrast

3-D displays

- 3-D displays dissociate convergence & accomm.
  - Loss of spatial resolution (may help) OR
  - Loss of temporal resolution
  - Could this be helped by enhanced DoF lens?
  - Unusual degrees of stereopsis
  - Possible mismatch between depth cues
  - People with mild BV problems have more symptoms & worse performance with 3-D displays
  - 48% find 3-D TV uncomfortable & 64% would watch more if they found it comfortable

Background – Bad

- Avoid backgrounds that are distracting or difficult to read from
- Always be consistent with the background that you use

People with mild BV problems have more symptoms & worse performance with 3-D displays

Lambooij, Fortuin, Ijsselsteijn, Evans, Heynderickx (2010)

48% find 3-D TV uncomfortable & 64% would watch more if they found it comfortable

Atallah, Pelah, Wilkins (2012)
Initial effects of 3-D displays

- 39 normal adults (3 excluded as BV imperfect)
- BV, symptoms, WRRT assessed before/after 2-D or 3-D
- 3-D displays associated with:
  - Doubling of CISS symptom score
  - 25% slower reading
  - Improvement in convergent fusional reserves
  - Change in optometric measures generally insignificant
- 1 participant showed marked decrease in fusional reserves and 3x increased symptoms

PLAN

INTRODUCTION
CVS – NEW CONGLOMERATE OF OLD PROBLEMS
BINOCULAR & ACCOMMODATIVE CHALLENGES
VISUAL STRESS
SPECIFIC CHALLENGES WITH DISPLAYS

CONCLUSIONS

- Like any tool, computers can be used to good or to bad effect
- Asthenopia is the problem, not computers
- Detect & manage refractive error, BV/accommodative problems, & dry eye
- Abnormal eyes are likely to have problems
- Normal eyes may have problems in abnormal situations (e.g., 3-D displays)
- Flicker can be a problem even when not consciously perceived
- Visual stress from cortical hyperexcitability can cause symptoms sometimes blamed on BV/accommodative anomalies & vice-versa