PLAN

INTRODUCTION

DES - THE RISE OF THE MACHINES?

VISUAL STRESS

CHILDREN

3-D DISPLAYS

CONCLUSIONS

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)

- Rosenfeld (2011):
  - Refractive error
  - Accommodation
  - Vergence
  - Dry eye

- 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
- "dry eye"

ISF: ache, strain, and headache located behind the eyes
- From: close viewing distance, lens flipper, and mixed astigmatism
- "Accommodative/binocular stress"

The good old days (Duke-Elder, 1970)

- Duke-Elder (1970) on causes of eye-strain
  - Environmental factors:
    - Irritation (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: headache, vertigo, digestive
    - "Headache is the commonest symptom associated with eye-strain"..."occurs in almost every possible variety"

DES case study

- 52 year old design engineer
- Clinical findings
  - V (LogMAR): R 0.1 L 0.0 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 8∆ 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

The good old days (Duke-Elder, 1970)

- 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 civilization"
  - Asthenopia from Mackenzie (1843), treatment included abstention from near work; "only very rarely in the aged convex lenses", purgatives, cauterization of medial recti, authorization of urethra to stop spermatorrhea or diminish masturbation, and 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"

Are computers the latest thing to be blamed for asthenopia?
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**Optometric correlates of dyslexia:**

*Meares-Irlen Syndrome/Visual Stress (MISVIS)*

**PREVALENCE:** 72% 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

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**Differential diagnosis:**

*Binocular vision anomaly or MISVIS*

<table>
<thead>
<tr>
<th>Sign</th>
<th>Binocular vision anomaly</th>
<th>Meares-Irlen Syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant praxis</td>
<td>May be present and if binocular instability</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Low fusional reserves</td>
<td>Present</td>
<td>May be present</td>
</tr>
<tr>
<td>Symptoms alleviated by occlusion</td>
<td>Yes</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Pattern glare</td>
<td>Unlikely</td>
<td>Present</td>
</tr>
<tr>
<td>Photophobia</td>
<td>Yes, but not colour specific</td>
<td>Yes, colour specific</td>
</tr>
<tr>
<td>Symptoms alleviated by coloured filters</td>
<td>Unlikely</td>
<td>Yes</td>
</tr>
</tbody>
</table>

In the CITT RCT for CI (2008) only 56% of those receiving optimal VT were asymptomatic at the end of 12 weeks of treatment (CITT, 2008).

Allen, Evans, Wilkins (2010) Vision & Reading Difficulties

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**Representation of colour in macaque area V2**

- Used optical recording & confirmed with electrode recording
- Identified "colour-prefering" modules
- Did not overlap with "orientation-prefering modules"
- Each contour illustrates the cortical region giving the maximal response to each tested colour
- But different colours produce different response magnitudes

Xiao et al., 2003, Nature

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**Pattern glare**

- High prevalence in:
  - Visual stress
  - Migraine
  - Photosensitive epilepsy
  - Autism

DO NOT VIEW THIS IF YOU HAVE EPILEPSY OR MIGRAINE
**Evans & Stevenson (2008)**

- Gender matched 38 oldest with 38 youngest participants
- Similar prevalence of migraine in both groups
- Groups differ up to 3cpd and 12cpd, but not at 3-12

**Children may be more at risk**

- More prone to visual stress (Evans & Stevenson, 2008)
- Poor classroom design (Winterbottom & Wilkins, 2007)
  - 84% of schools have 1000Hz flicker
  - Uneven & excessive illumination
- Prone to addictive video-gaming
- Adoption of 3-D is more imminent
- PubMed search for video games & eyestrain:
  - 4 publications in 10y, 3 of 4 on 3-D

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**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 & accommodation
  - Loss of spatial resolution (may help)
  - Loss of temporal resolution
  - Could this be helped by enhanced DoF lenses
  - 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 (Atallah, Pelah, Wilkins, 2012)

**Background – Bad**

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

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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

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CONCLUSIONS
- Like any tool, computers can be used to good or to bad effect
- Asthenopia is the problem, not computers
- People with migraine, dyslexia, autism, epilepsy are prone to visual stress
- Visual stress from cortical hyperexcitability can cause symptoms mistakenly blamed on BV/accommodative anomalies & vice-versa
- 3-D displays are visually demanding
  - Need good BV & accommodation
  - Lens that enhances DoF might be helpful
  - Flicker can be a problem even when not consciously perceived

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