Digital eyestrain (DES)/Computer vision syndrome (CVS): a new problem or a conglomerate of old problems?

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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

For regular tweets on optometric research:

CAVEAT

Case study:
Px in early 20s: headaches with computer use
Saw 4 optoms, 7 physicians, 1 neurologist
5y later acute angle-closure glaucoma, blind LE; cl aimed 5y
chronic intermittent sub-acute angle-closure glaucoma
Patient sued all healthcare practitioners

DES is a diagnosis of exclusion
diagnosis by optom/ophthalmologist
Neuro-optometric checks
Pupils, discs, fields, strabismus, comitancy, accommodation
Check these things regularly


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)
Portello et al (2012)

Ref: Portello et al (2012): Dry eye & Accommodation
Refractive error
Accommodation
Convergence
Dry eye
Perimeter
Visual stress
Specific challenges
Environmental
Other factors
Is all asthenopia the same?

- 20 young adults with good vision
- Rated symptoms after:
  - Mixed astigmatism, close viewing distance, lens flipper, dry eyes, lens flaring light (15Hz)
  - "at least 2 different afferent pathways for the symptoms of asthenopia"
- ESF: burning, irritation, tearing, and dryness
- 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:
    - illumination (quantity, quality, distribution)
  - Ocular factors:
    - presbyopia, astigmatism, heterophoria, convergence, accomodation, vitreous humor, lens (film)
  - Stress environment affect faculties, lower rate cause eye-strain through damage (p<0.0001 vs 1970s)
- Constitutional factors:
  - optic, neurotic, emotional strain
  - Other factors: constitutional factors
  - Symptoms:
    - eyes tired, hot, uncomfortable, watery, prone to infections
    - Actual strain developing to pain
    - Ref: accommodative headache, vertigo, digestive
    - "Headache is the commonest symptom associated with eye-strain"… "Causes itself 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 Add: @38cm +1.75 @57cm +1.00
  - Other findings normal except
    - MC: 1.5 cm and N cover test 8 A V 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?

Is the office a problem?

- Kim et al (2017) sought relationship between occupational noise/vibration exposure and headache/eye-strain
  - Survey of 25,000 Korean workers
  - N.B., not North Korea where tractors used differently
  - 24% of those with severe noise had headache/eye-strain of 17% of those with no noise (p<0.0001)
  - 23% of office workers had headache/eye-strain of 17% of manual workers (p<0.0001)
DSE reading of hard copy

- More incomplete blinks with DSE
  - Bruni et al. (2013)
  - Chu et al. (2015)
  - Arfam et al. (2015)
- More symptoms with DSE
  - Chu et al. (2015)
- Slower with DSE
  - Hue et al. (2014)
- Differences between different displays
  - Hue et al. (2014)
- For some, symptoms with DSE reduced by coloured filters
  - Rosenfeld et al. (2015)

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

Conclusions

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Treatment of decompensated heterophoria & binocular instability

- Refractive correction/modification
  - Under-used & easy to prescribe with naturalistic PD test
  - Esophoria can be corrected by vocational lens (e.g., SYNC III)
- Prisms
  - Probably under-used
  - Simple to prescribe with naturalistic PD test or EyeGenius
- Eye exercises
  - Can be successful for motivated patients

Accommodative fatigue in computer users

- Debate over whether accommodation:
  - Fatigue (Tingay & Chung, 2011)
  - Does not fatigue (Windsor, 1993; Evans, 1997)
- 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
**Meares-Irlen Syndrome/Sensory Visual Stress**

**PREVALENCE:** 720% of people with dyslexia favor of the general population

**ETIOLOGY:** cortical hyperexcitability causing pattern glare from text/flicker

**SYMPTOMS:** asthenopia, headache, perceptual distortions (visual m/n)

**SIGNS:** coloured filters alleviate symptoms and improve rate of reading

**TREATMENT:** coloured background or lenses

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**Children may be more at risk**

- More prone to visual stress
- Poor classroom design
- Video gaming
- Pattern glare from window blinds
- Flicker
- Dry eye symptoms & signs improve when cease smartphones

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**Additional considerations**

- Neurological basis for visual discomfort
- Pattern glare
- Fluorescent lights
- Can achieve very high contrast
- Pattern glare from window blinds
- Might be wrong position
- Can be too bright
- Can achieve very high contrast
- Can have unnatural colour contrast

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**Specific problems with displays**

- Maybe in wrong position
- Can flicker
- Possibility of stereoscopic interaction with fluorescent lights
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3-D displays
- 3-D displays dissociate convergence & accommodation.
- Loss of spatial resolution may help OR
- Loss of temporal resolution.
- Could this be helped by enhanced depth vision?
- Increased depth of accommodation.
- People with mild BV problems have more symptoms & worse performance with 3-D displays.
- More if they found it uncomfortable.
- 48% find 3-D TV uncomfortable & 64% would watch more if they found it comfortable, (Van, Milan, 2011)

Initial effects of 3-D displays
- 39 normal adults (excluding BV exacerberated)
  - eye symptoms, WMF assessed before/after 2-D or 3-D
- 3-D displays associated with:
  - increased blink rate
  - slower reading
  - decreased vergence/fusion reserves
  - decreased accommodative reserve
  - 3 participants 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
- Find out about your patient's workstation
- 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 noticed
- Sensory visual stress from cortical hyperexcitability can cause symptoms sometimes blamed on BV/accommodative anomalies & vice-versa

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Adapting your eye exam routine to the digital age

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Vocation, history, symptoms

- Workplace factors:
  - Needs to be more detailed than most clinical record systems suggest!
  - The only general rule about working distance is that there is no general rule
  - What do they do & where do they do it?
  - You measure, or if engineer, they measure!
  - How feasible is it to adjust workstation?
Vocation, history, symptoms

- **History:**
  - Extrinsic muscle palsies

- **Symptoms:**
  - New or old?
  - Does symptom onset relate to any changes at work?
  - E.g., new desk, office, lighting, PC?
  - Related to task?
  - Internal or external?
  - But, symptom specificity a year

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Non-tolerances: conclusions

- Over 80% of non-tols are presbyopes
- [Don't over plus or under-minus]
- Partially prescribe
- Demonstrate the change
- Warn about adaptation
- Consider non-tols as an opportunity by excelling at dealing with these challenging patients

Visual acuity reserve (VAR)

- Conventional view is that acuity reserve (VAR) needs to be 2-3x for fluent to maximum reading (Lovie-Kitchin & Whittaker, 1999)
- Ko et.al. (2014) argued 2x reserve is appropriate for computer users
- Data with digital devices indicates VAR 6x for optimal reading
- Warns: more closer to monitor when glare present
- When individuals can freely adjust their posture & chair, they also select a viewing distance that maximizes the visual angle of font used (20-23 arcmin) (Lovie-Kitchin & Whittaker, 1999)
- Larger font improves productivity
- Applied to younger participants as much as older

Refraction

- Obtain refraction for all the relevant distances
- Prompt use Rx, but with very sensitive patients Rx trial & trial
- Rosenfield (2010) noted 0.50-1.00DC can increase symptoms in computer use
- Is a compromise Rx (same Rx for more than 1 distance) feasible?
- Depends on:
  - Age/accommodation
  - What is the difference between distances required?
  - Pupil size
  - Patient tolerance
  - Time at task
  - Use of screen
  - Prescription
  - Cannot apply simple rules for determining Add
  - Need to calibrate

Case study (13035)

- 73 year old male, average pupils (not small)
- Symptoms: "Cannot see engineering workbench & food preparation with current N glasses too strong"
- Distances estimated:
  - Reading breaks: 45cm
  - VDU: 50cm
  - Workbench & food: 90cm
  - Rx: R=+1.00/-1.00x107.5 6/7.5 L=+1.25/-0.75x80 6/6
  - Reading breaks: 45cm Add+2.5
  - VDU: 50cm Add+1.5
  - Workbench: 90cm Add+0.75
  - Current glasses: Add
  - Distance (no change)
  - VDU (add 10° top, NI at bottom): no change
  - Reading (add+2.5)
  - Solution: new glasses Add+0.75; discuss safety requirements

Over 80% of non-tols are presbyopes

Don't over-plus or under-minus

Demonstrate the change

Warn about adaptation

Consider non-tols as an opportunity by excelling at dealing with these challenging patients

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Users move closer to monitor when glare present

Larger font improves productivity

Applied to younger participants as much as older

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Prompt use Rx, but with very sensitive patients Rx trial & trial

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**Accommodative anomalies**

- Accommodative paralysis
- Accommodative insufficiency
- Accommodative fatigue
- Accommodative infacility (inertia)
- Accommodative spasm (excess)

**Accommodative fatigue**

- Accommodative fatigue: accommodation cannot be sustained for long periods of near vision
- A reduction in the amplitude of accommodation with repeat testing
- May be a milder form of accommodative insufficiency

**Amplitude accommodative testing**

- Best practice is to test accommodation amplitude in pre-presbyopes... **BUT**
- Measurement of AoA with ruler is prone to 15+ sources of errors
- Rule: Evans, A. (Diploena in Practice, 2014)
- E.g., amplitude of accommodation can vary significantly with gaze angle
  (Rosenfield, 2017)
- Still best to determine the add subjectively at the relevant distance

**Accommodation in reserve (Millodot & Millodot, 1989)**

- Determined Add subjectively & related to accommodation available
- % of accommodation used for a comfortable reading varies with distance:
  - At 20cm one third of accommodation in reserve
  - At 20cm half of accommodation in reserve
  - Risk very large inter-subject variation
- Conclusions:
  - The total half of accommodation in reserve (1/2) and the accommodative amplitude at distance of 1000 cm are relevant.
  - The accommodative amplitude at distance of 1000 cm is relevant
  - Relevance to DES: determine the Add subjectively at the relevant distance.

**Accommodative inertia (infacility)**

- Accommodation responds slowly
- Can test with flippers
  - Count cycles per minute
  - A flip from plus to minus is ½ a cycle
- Dynamic assessment of accommodative system
- Norms – age dependent
- Ideally, with suppression check
- Several confounding variables, ideally, use a control condition

More natural to test with Hart chart or similar.
Motility test

- Use reliable pen torch
- Check nose not occluding
- Really, three tests, so do three times:
  1. Observe corneal reflexes
  2. Cover test in peripheral gaze
  3. Ask about diplopia
- Beware of reports of diplopia
  - May break down (in view of target, distance, fus. res.)
  - May be variable
  - May be confused
- Know the muscle actions (RADSIN)

Actions of Superior Muscles

<table>
<thead>
<tr>
<th>Superior Muscles</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectus Medialis</td>
<td>Right</td>
</tr>
<tr>
<td>Rectus Lateralis</td>
<td>Left</td>
</tr>
<tr>
<td>Superior Oblique</td>
<td>Both</td>
</tr>
</tbody>
</table>

Lindblom’s Method

- 70cm rod at 1m, or double Maddox rods (+10° one SO)
- Where there is maximum diplopia, are the two images parallel or
torsional? parallel: RSR, RIR, LSR, LIR torsional: RSO, RIO, LSO, LIO

1. Where is the vertical diplopia greatest?
   - upgaze: RSR, LSR
downgaze: RIR, LIR

2. Does the separation increase on R or L gaze?
   - R: RSR, RIR
   - L: LSR, LIR

Conclusion: Paretic Muscle(s):

Lindblom, Westheimer, Hoyt (1997)
LINDBLOM’S METHOD

If crossed: (+) does the tilt angle increase in upward gaze or downward?
- If torsional:
  1. Does the illusion of tilt increase in upgaze or downgaze?
     - Upgaze: RSO, LSO
     - Downgaze: RIO, LIO
  2. Does the intersection of the rods point to the R (or L) or is it crossed?
     - R: RSO, RIO
     - L: LSO, LIO
  3. If crossed, (+) does the tilt angle increase in upward gaze or downward?
     - Upgaze: bilateral SO patients (very unlikely)
     - Downgaze: bilateral SO patients

Common incomitancies seen in optometric practice

- Superior oblique palsy
- Duane’s syndrome
- Lateral rectus palsy
- Brown’s syndrome

- Become familiar with what these look like:
  - CD in Pickwell’s Binocular Vision Anomalies, 5th edition
  - NB: all these are rare compared with “pattern strabismus” (e.g., A-syndrome, V-syndrome, etc)

SO palsy

- Usually:
  - Hyper-deviation of affected eye, worse in down-gaze
  - Underaction of affected eye when looking down and in
  - More likely to have symptoms with reading than with distance

- But, may have secondary sequelae
- Avoid fitting multifocal spectacles or monovision

Incomitancies: conclusions

- Some incomitancies are difficult to detect
  - If symptoms are suspicious, do cover testing in peripheral gaze
  - Testing for cyclo-deviations detects SO palsies
  - Refer new or changing incomitancies
  - In some long-standing cases, prescribing the prism indicated by the Mallld unit may help
  - Consider effect of incomitancy on workstation
  - Test binocular alignment and compensation under conditions replicating the habitual working conditions (Rosenfield, 2016)

Pattern strabismus/phoria

- V-syndrome: converge more than 15Δ from upgaze to downgaze
- A-syndrome: diverge more than 15Δ from upgaze to downgaze
- About 1 in 5 patients with strabismus may have an A- or V-pattern (Biglan, 1999)
- Also common in people with heterophoria
- Other patterns exist
  - https://www.avidtesting.net/ernt_fishman/vy- syndromes-diagramimage-1552773

- Important to detect “patterns” and advise on placement of monitor, tablet device, etc
- NB also relevant for other conditions that are gaze dependent (e.g., nystagmus)

KEY SIGNS OF DECOMP. PHORIA

- Symptoms
  - Poor cover test recovery
  - Aligning prism (FD test)
  - Low fusional reserve opposing phoria
  - Sheard’s criterion
  - Particularly useful for exophorias
  - For esophorias, size and imbalanced fusional reserves are relevant
  - For hyperphorias, size matters
ALIGNING PRISM: Mallett Unit

• Aligning prisms/spheres to eliminate FD
• Good foveal and peripheral fusion lock

Question set is important
• Ask if a line ever moves
  - Jenkins & Evans (2006)
• For symptomatic phoria:
  • Sensitivity 75%
  • Specificity 78%
  - Jenkins, Pickwell, & Yekta (1989)

Alignment of prisms
- Test in habitual gaze
- Prism dioptre steps: 0.5, 1.0, 2.0, 4.0
- Re-normalise BV between prisms
- Minimum prism for alignment
- Use hand held loose prisms
- Increase lighting, full field of view

Patient management
• Maintain normal binocular vision

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Keeping your patient for life
- Customised care is the secret to patient retention
- The handover from optometrist to optician is crucial for the patient & the practice
  - Good approaches to handover:
    • Optometrist does eye exam & dispensing
    • Optometrist calls optician into consulting room, ideally before final management discussion
    • Optometrist takes patient to optician and reviews management discussion
  - Bad approaches to handover:
    • “Go and see the optician”
    • Leave notes for optician to pick up
    • Worst outcome is patient has dispensing elsewhere
- Not in the interest of the patient or the practice
- Best avoided by integrated pathways from eyecare to eyewear

Patient management
• Discuss the options, including pros & cons
• Presbyopes:
  • PAL
  • Vodocal
  • Single vision
  • CL
• Pre-presbyopes:
  • Single vision
  • Accommodative support (e.g., Sync III)
  • CL
• Phoropter is good for initial determination of add, but
  - In the consulting room, simulate patient’s working conditions and let the patient check your proposed fit with actual frames

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**Additional points**

- Dry eye workup also important
- Computers don’t affect blink rate, but increase proportion of incomplete blinks (Chu et al., 2014)
- UK perspective sceptical about blue light blocking for computer users
  - Sunlight exceeds typical levels of artificial lighting by a factor of 10 times or more (Chu et al., 2015)
  - The amount of short-wavelength radiation emitted from digital screens far smaller than from most artificial light sources (Rosenfield, 2016)
  - Blue filtering lenses “have very little effect on incident light/energy” (Dickinson, 2017)
- Lack of high quality evidence (Lawrenson & Hull, 2017)
- “Attenuation of short wavelength blue-violet for everyday wear clear lenses seems a sensible development” (Marshall, 2017)

**Conclusions**

- Every patient is unique, and this has never been truer than in the digital age
- The best way to help your patient is to customise your eye exam to their needs
- Dispensing also needs to be customised to each patient’s needs
- Handover from optometrist to optician is essential
- A patient with complex visual demands who is well-managed will be a patient for life