Eyestrain and Accommodative Dysfunction
Collaborators

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Overview

- Symptoms and Near work
- Accommodation
- Autorefraction
Two symptom clusters

- 90% computer users (Salibello & Nilsen 1995)
- 50% children as young as 7.5 (Sterner et al 2006)
- 48% of work-related symptoms (Hayes et al 2007)

From Sheedy et al. 2003
Symptom prevalence is high among college students.

- Conlon unidimensional symptom scale
- 17% of student at Claremont Colleges
- 72% female
- Associated with accommodation

From Borsting et al 2007

N = 571. College students are unique: Above average readers; very few with CI in the sample. Conlon Survey: 23-items, 4-point rating scale. Unidimensional in two separate Rasch analyses.

Conlon mean = 15.4 (SD=10.2)

Conlon found 47% had moderate to severe symptoms in her University sample.

In a sample (N=89), 4.6% had abnormal function, most for refractive errors that are easily correctible.
Some symptoms are more common than others

From Borsting et al 2007

Rasch analysis of 23 Conlon et al survey items on 571 students randomly selected from Claremont Colleges.
### How long can you read before symptoms appear?

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>1 hr</th>
<th>½ hr</th>
<th>¼ hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Group</td>
<td>0%</td>
<td>40%</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>Low Group</td>
<td>22%</td>
<td>54%</td>
<td>19%</td>
<td>5%</td>
</tr>
</tbody>
</table>

### Do symptoms affect grades?

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Few times a year</th>
<th>Every few weeks</th>
<th>Almost always</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Group</td>
<td>19%</td>
<td>12%</td>
<td>46%</td>
<td>23%</td>
</tr>
<tr>
<td>Low Group</td>
<td>63%</td>
<td>22%</td>
<td>12%</td>
<td>3%</td>
</tr>
</tbody>
</table>
Symptom severity predicts academic problems

From Chase et al 2009

10-item self-report APS questions related to school work: reading, tests, homework, writing, computer use.
come see the play look up is cat not my and dog for you to
to the cat up dog and is play come you see for not to look my
you for the and not see my play come is look dog cat to up
dog to you and play cat up is my not come for the look see
play come see cat not look dog is my up the fort o and you
to not cat for look is my and up come play you see the dog
my play see to for you is the look up cat not dog come and
look to for my come play the dog see you not cat up and is
up come look for the not dog cat you to see is and my play
is you dog for not cat my look come and up to play see the
see the look dog and not is you come up to my for cat play
not up play my is dog you come look for see and to the cat
look up come and is my cat not dog you see for to play the
my you is look the dog play see not come and to cat for up
for the to and you cat is look up my not dog play see come
you look see and play to the is cat not come for my up dog
come not to play look the and dog see is cat up you for my
and is for dog come see the cat up look you play my not to
dog you cat to and play for not come up the see look my is
the come to up cat my see dog you not look is play and for
Slower readers are more symptomatic

Rate of Reading (Median Split)

Faster  Slower

Visual Discomfort

$t(63) = 3.16, p = 0.003$
1. These results imply that reading speed is the primary reading measure impacted in this college sample.
2. Methods of measuring reading fluency is lacking.
Accommodative dysfunction is common among adults with eyestrain.

Bill Reindel poster at AAO, SF 2010

N=253 asthenopic subjects between 30-40 years-old.
Lucien Howe – Buffalo, NY, Graduate of Bowdoin College, MD in 1871 at age of 22, Ophthalmologist at what was then the U of Buffalo, Built the first ergograph device for amplitude of accommodation (1912)

Review literature:
1. Early studies stressed accommodative system to induce symptoms – not very successful. Berens & Stark (1932) found 31% decrease in amplitude, 29% increase, and 40% no change. More recent study (Gur et al. 1994) found 0.7D decrease after a week of computer office work.
2. Later studies measured frequency of accommodative dysfunction in clinical and general populations – low incidence. In adult optometry clinical sample – 3% (Lara 2001) and 6% of college sample (Porcar  1997).

In summary, the research literature presents a confusing picture of the relationship between accommodative amplitude and visual discomfort. Near work accommodative demand appears to be associated with visual discomfort for some individuals, but studies also suggests that accommodation insufficiency or fatigue are infrequent conditions and so unlikely to be responsible for the relatively high incidence of visual discomfort found among college students.
Accommodative amplitude is a poor predictor of symptoms.

From Chase et al. 2009
Ages 21–30.

Positive but weak correlation ($R^2 = 0.28$) between two measures of the same function.

Pushup (subjective) overestimates autorefractor (objective) by average of 2D but as high as 5D. 95% overestimated amplitude by the push up method.

Subjective judgment about the onset of blur.

Blur detection is influenced by depth–of–field effects that are enhanced by accommodative pupil restriction; as the target is moved closer to the eye, the relative size of the target increases.

An individual may still be able to identify the target even in the presence of a large defocus error.

Sustained viewing better than short measure lasting a few seconds. Can’t even measure fatigue by current clinical procedures.
Only accommodative lag predicts symptom severity

From Chase et al 2009
Autorefracti on

- Open field
- Image-size Design
  - Analyzes IR ring projected onto retina
  - Myopic change increases diameter
  - Astigmatic change distorts shape elliptically
- Continuous recording
Accommodation insufficiency is found at 4 diopters or more.

From Chase et al 2009

High group = 1 SD above mean, or Conlon >=25

N = 23 college students. PS Conlon = 34; AT Conlon = 11

Using depth of focus cut-off of 0.9D at 20 cm viewing distance, 10 students (43.5%) had insufficiency. Not the typical definition of insufficiency because recordings were based on average accommodative performance over 90 secs. They also had significantly more symptom complaints than those with lag < 0.9D.
Accommodation fatigue is found after 20-30 seconds

From Tosha et al 2009

N = 31 college students (24 female). SC: Conlon = 27

Note the pattern of fatigue in the recording: stable for the first 10–15 sec, sudden drop, and then recovery from 15–20, trouble maintaining and instability, followed by short period of stabilization from 25–30 just at the edge of the field of focus. Then around 30 sec, another loss, greater instability from 30–50, and then more rapid deterioration.

Accommodation drift of about 0.4D per minute during this recording period. Don’t know if they level off, over time.
Conclusions

- Weak accommodation is associated with slower reading and symptoms.
- Autorefraction is needed to measure lag accurately.
- Autorefraction can observe changes in accommodative lag over time.
Implications for 3D

- Many adults have weak accommodation.
- 3D displays affect accommodative demand.
- With sustained viewing, accommodative dysfunction leads to eyestrain.