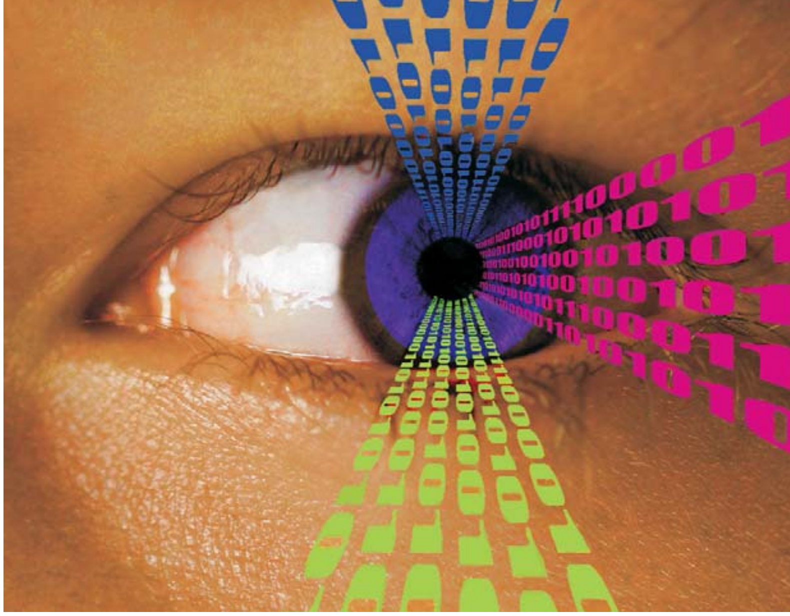
COMPUTER VISION SYNDROME: Accommodative & Vergence Facility



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Abstract

Computer vision syndrome (CVS) is a complex of symptoms experienced by up to 90% of computer users. Questions remain regarding its etiology. Changes in accommodation or vergence have been suggested as causative factors. This study sought to determine if subjects with CVS had abnormal accommodative or vergence facility findings and to identify if sustained computer use produces a change in these parameters. Twenty two subjects read text from a computer screen for a continuous 25 min period. Vergence facility and both monocular and binocular accommodative facility were measured. Following the computer task, subjects completed a questionnaire regarding their level of discomfort during the task. No significant change in monocular accommodative or vergence facility was observed following the computer task, although a small increase in post-task binocular accommodative facility was noted. The highest ocular symptoms reported were tired eyes, eyestrain and dry eye. These were not correlated significantly with the accommodative or vergence facility findings. The symptoms reported appeared to be related to dry eye, and not to either accommodative or vergence abnormalities.

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Key Words

accommodation, accommodative facility, computer vision syndrome, dry eye, vergence, vergence facility

INTRODUCTION

Computer Vision Syndrome (CVS) is defined by the American Optometric Association as the combination of eye and vision problems associated with the use of computers. These symptoms are thought to result from the individual having insufficient visual capabilities to perform the computer task comfortably.[1] In 2000, it was estimated that 75% of jobs involved computer use.[2] It seems likely that this number has now increased, and when combined with non-vocational computer use for e-mail, internet access and entertainment, computer usage is now almost universal.

Previous reports have suggested that between 64% and 90% of computer users experience visual symptoms including: eyestrain, headaches, ocular discomfort, dry eye, diplopia and blurred vision either at near or when looking into the distance after prolonged computer use.[2] These symptoms may be produced by the organization of the workstation environment, inadequate wetting of the corneal surface, near-vision abnormalities (such as accommodation-vergence difficulties) or inappropriate refractive correction. Rossignol et al[3] reported that the prevalence of visual symptoms increased significantly in individuals who spent more than four hours daily working on video display terminals (VDTs). Of these reported complaints, eyestrain or sore eyes were the most common condition. The occurrence was significantly greater for workers who used VDTs for at least seven hours per day, when compared with those who used the displays for shorter periods.

While both accommodation and convergence have been cited as contributing to CVS, there is relatively little objective data detailing how these oculomotor parameters are affected during computer work. Wick and Morse[4] reported that four subjects showed an increased lag of accommodation to the VDT (mean increase = 0.33D) when compared with a hard copy condition. Later, Penisten et al[5] found a larger mean lag of accommodation for a printed card when compared with VDT viewing, although the observed differences were relatively small (≈ 0.13D).

Mixed results have been found when measuring vergence parameters before and after periods of computer usage. For example, Watten et al[6] observed significant decreases in positive and negative relative vergence (vergence ranges) at near at the end of an 8-hour workday. In contrast, Nyman et al[7] found no significant change in these parameters. Neither did they find any significant changes in either distance and near heterophoria or the near point of convergence (NPC) following the work period. Similarly, Yeow and Taylor[8,9] observed no significant changes in NPC, near horizontal heterophoria and associated phoria with VDT use. However, Jaschinski[10] observed that near vision fatigue was associated with greater exo (or less eso) fixation disparity as the target was brought closer to the observer.

Accommodative and vergence facility are clinical tests that stimulate rapid changes in the accommodative and/or vergence stimulus.[11,12] These tests may be more predictive of CVS than the measurements of accommodation or vergence described above, since they require dynamic changes in the oculomotor response, rather than measuring the output to a fixed stimulus. This requirement to alter one's accommodative response rapidly may reflect more accurately the visual requirements of many work environments. Individuals often need to change fixation from the computer monitor to a distant object and vice versa. Indeed, in a retrospective review of clinical records of CVS patients. Sheedy and Parsons[13] reported that the most common diagnosis was accommodative infacility. This was defined as an inability to complete 20 cycles in 90 sec using a ±1.50D flipper. A cycle is completed when the subject is able to clear a near target through both the plus and minus lenses over the refractive correction.

The vergence facility test is similar to its accommodative counterpart, but uses base-out (BO) and base-in (BI) prisms to stimulate a change in the vergence response. Based on the work of Gall et al[12] standard prism values of 3Δ BI and 12Δ BO have now been widely adopted for this test.

One might predict that computer use would produce a decline in the ability to make dynamic oculomotor changes, possibly due to fatigue. A reduced facility finding could then be predictive of subjects with CVS. Accordingly, the aims of the present study were to determine if subjects with CVS had abnormal accommodative or vergence facility and to identify if computer use produced a significant change in either of these parameters.

Table 1. Mean Pre-and Post-task Values of Accommodative and Vergence Facility (cycles per minute)

	Accommodative facility (OD)	Accommodative facility (OS)	Accommodative facility (OU)	Vergence facility
Pre-task	11.00 (0.81)	10.54 (0.90)	8.25 (0.86)	11.39 (0.97)
Post-task	11.54 (0.73)	10.50 (0.80)	9.47 (0.90)	12.76 (0.86)
Change	0.54 (0.79)	-0.04 (0.67)	1.22 (0.54)	1.37 (0.82)
p=	0.51	0.95	0.03	0.12

Figures in parentheses indicate 1SEM.

Table 2. Mean Symptom Score Following the Computer Task

Symptom	Mean	SEM
Blurred vision while viewing the computer screen	2.36	0.48
Blurred vision when looking into the distance	2.96	0.53
Difficulty or slowness in refocusing your eyes from one distance to another	3.00	0.49
Irritated or burning eyes	3.40	0.59
Dry eyes	4.04	0.72
Eye strain	4.32	0.60
Headache	1.80	0.52
Tired eyes	4.44	0.67
Sensitivity to bright lights	2.20	0.53
Discomfort in your eyes	3.48	0.62
Mean symptom score	3.29	0.90

Symptoms were reported on a scale from 0 (none) to 10 (very severe), with a score of 5 representing a moderate response.

METHODS

Twenty two young, visually-normal subjects read text aloud from a desktop computer screen (Compaq Evo 5500 with a 15-inch monitor) at a viewing distance of 50 cm for a continuous 25 min period. A chin rest was used throughout the task to maintain a constant viewing angle and working distance. The study followed the tenets of the Declaration of Helsinki, and informed consent was obtained from all subjects after an explanation of the nature and possible consequences of the study was completed. The protocol was approved by the Institutional Review Board at the SUNY State College of Optometry.

Both before and immediately after the computer task, monocular and binocular accommodative facility and vergence facility were measured. Subjects wore their habitual refractive correction (either spectacles or contact lenses) throughout, and the same correction was worn for all sessions. The order of the three performed tests (i.e., monocular and binocular accommodative facility and vergence facility) was randomized across trials.

Accommodative facility was assessed while subjects viewed a near acuity card at a distance of 40 cm. Subjects were instructed to fixate a line of letters, one line larger than the acuity of the poorer eye, and ±2.00D lenses were introduced alternately. Subjects reported when they could see the near target clearly through these additional lenses. The number of cycles, comprising both the plus and minus lens, completed in a 60 second period was then determined. Each eye was so tested during the monocular phase.

For the binocular accommodative facility test, a pen was placed approximately halfway between the subject and the acuity card. The number of cycles comprising the ±2.00D lenses were recorded. Subjects were instructed to report if this pen ever appeared single during the binocular accommodative facility measurement test.

Vergence facility was tested while subjects viewed a vertical line of letters (approximately 20/30) at a distance of 40 cm. A 12Δ BO and a 3Δ BI prism were alternately introduced before the right eye over the habitual distance refractive correction. The subject indicated when the target appeared both clear and single. Again, the number of cycles (BI and BO) in a 60 second period was determined.

Finally, all subjects completed a written questionnaire (taken from Hayes et al[2]) regarding the level of ocular discomfort experienced during the task. Post-task symptoms were reported on a scale from 0 (none) to 10 (very severe), with a score of 5 representing a moderate response.

RESULTS

Mean pre- and post-task values of monocular and binocular accommodative facility and vergence facility are shown in Table 1. No significant change in the monocular accommodative facility or vergence facility findings was observed. A significant increase in binocular accommodative facility was noted immediately following the computer task (paired t-test; $t=2.27$; $df=24$; $p=0.033$).

The mean post-task ocular symptom scores are shown in Table 2. No significant correlation was observed between the mean symptom score and any of the pre- or post-task accommodative facility

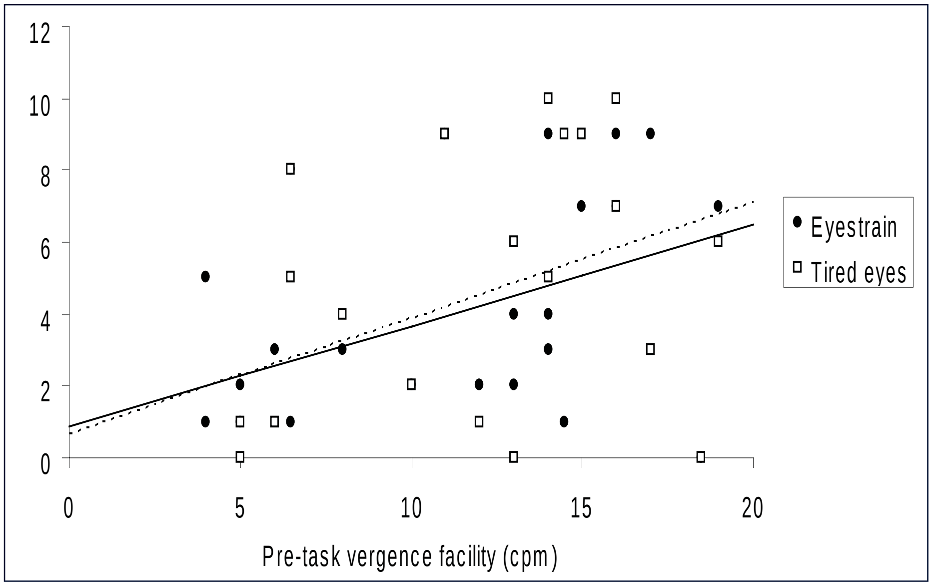

Figure 1. A non-significant positive association was observed between pre-task vergence facility measured in cycles per minute (cpm) and the symptoms of eyestrain (p=0.09) and tired eyes (p=0.07). The solid and dashed lines represent the regression lines for eyestrain and tired eyes, respectively.

findings. However, when considering the highest ocular symptoms reported (tired eyes and eyestrain) there was a non-significant association between pre-task vergence facility and to tired eyes (r=0.378; p=0.07) and eyestrain (r=0.358; p=0.09). In each case, subjects having higher pre-task vergence facility reported the most severe ocular CVS symptoms. This is illustrated in Figure 1. In addition, a significant positive correlation was observed between dry eye symptoms and mean vergence facility (r=0.417; p=0.05). Again, symptoms were greater in subjects having higher vergence facility findings.

DISCUSSION

The results of the present study suggest that CVS is not associated with accommodative abnormalities since no significant relationship was observed between symptoms and either monocular or binocular accommodative facility. This is consistent with our previous results that found no significant difference in the accommodative response measured during the course of computer work in both symptomatic and asymptomatic individuals.[14] Furthermore, since computer work produced no significant change in monocular accommodative facility and a small, significant increase in binocular accommodative facility, one cannot explain the symptoms on the basis of oculomotor fatigue.

The observation that subjects with higher vergence facility had greater symptoms of CVS (Figure 1) is both surprising and difficult to explain. Previous studies have reported that symptoms of "binocular distress" are associated with lower rates of vergence facility.[15] Additionally, Christenson and Winkelstein[16] found significantly higher levels of vergence facility in athletes when compared with non-athletes. Accordingly, one would expect improved visual performance and a lower symptom score in subjects with higher levels of vergence facility.

One possible explanation is that the highest symptoms reported, namely tired eyes and eye strain (Table 2), were actually related to dry eye, rather than being caused by an oculomotor abnormality. Support for this proposal comes from finding a significant positive correlation between vergence facility and dry eye symptoms. It is difficult to apply a direct link between these two parameters as they appear to be unconnected. However, dry eye has previously been cited as a major contributor to CVS. For example, Uchino et al[17] observed symptoms of dry eye in 10.1% of male and 21.5% of female Japanese office workers using VDTs. Furthermore, longer periods of computer work were also associated with a higher prevalence of dry eye. Blehm et al[18] suggested that dry eye could either be caused by a reduced blink rate during the computer task or by increased corneal exposure produced by the primary gaze position of the monitor. It has also been observed that blink rate decreases as font size and contrast are reduced,[19] or the cognitive demand of the task increases.[20] Additionally, Sheedy et al[21] noted that voluntary eyelid squinting reduced the blink rate significantly. Symptoms of dry eye may include ocular discomfort and dryness, grittiness, or scratchy, burning, stinging, tired and other visual changes.[22] Thus, the symptoms of "tired eyes" and "eyestrain" are consistent with dry eye syndrome.

CONCLUSION

We conclude that in the sample examined in this study, symptoms associated with CVS were produced by dry eye rather than accommodation or vergence abnormalities. Current work in our laboratory is evaluating therapies designed to reduce dry eye symptoms, and to determine if these ameliorate the symptoms associated with CVS.

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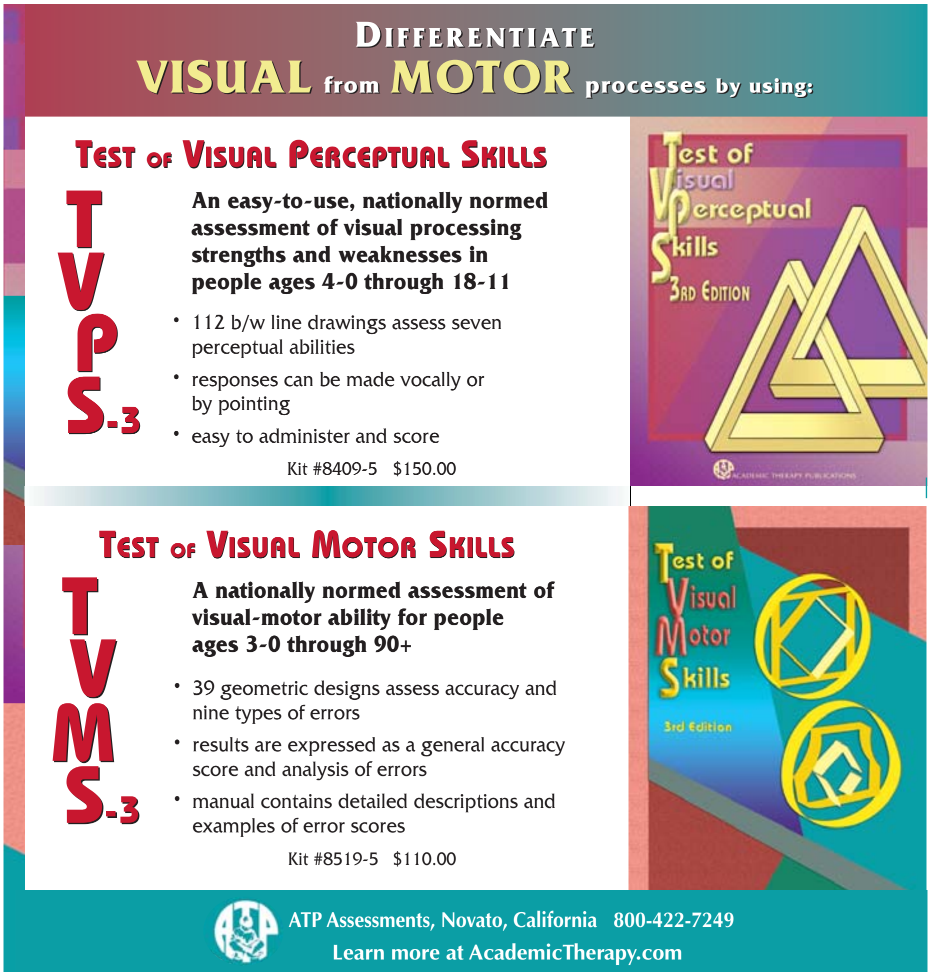

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