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Effect of laptop computer games on vision

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Abstract
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EFFECT OF LAPTOP COMPUTER GAMES ON VISION

By

KRISTEN KOSIR
JOANNA PLAVIN

A thesis submitted to the faculty of the
College of Optometry
Pacific University
Forest Grove, Oregon
for the degree of
Doctor of Optometry
May 2005

Advisor:

Bradley Coffey, O.D.
EFFECT OF LAPTOP COMPUTER GAMES ON VISION

Signatures

Kristen Kosir

Joanna Plavin

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BIOGRAPHY

Kristen Kosir grew up in Jamestown, North Dakota. She received her Bachelor's degree from North Dakota State University in 2001 with a Zoology major and Chemistry minor. She looks forward to her Doctorate in Optometry from Pacific University in May 2005.

She intends to join a family practice in the Fargo, ND community, where she lives with her spouse, Michael. Her specialty interests include low vision and neurorehabilitation.

Joanna Plavin was raised in Gladstone, Oregon. She graduated with honors from Linfield College in 1999 with a major in Biology and a minor in Chemistry. Joanna will graduate from Pacific University College of Optometry with a Doctorate in Optometry in May of 2005. She aspires to specialize in vision therapy and neurorehabilitation at a private practice in Southern Oregon.
ABSTRACT

Prolonged near work has been proposed to cause nearwork-induced transient myopia (NITM), a form of temporary nearsightedness. Although NITM has been demonstrated in other nearpoint tasks, this effect has never been studied in laptop computers. This study looked at the effects on refractive condition and visual acuity after playing a computer game on a laptop computer for 90 minutes. This task simulates real-world conditions. A Grand Seiko WR-5100K was used to take pre- and post-task refractive state measurements. Visual acuity was also assessed pre- and post-task. Overall, an initial myopic shift of 0.12D was noticed, with a return to baseline by 30 seconds post-task. A loss of visual acuity with magnitude 0.1 LogMAR was noted immediately post-task with a return to baseline accompanying the refractive state return to baseline. These findings suggest prolonged laptop usage in a real-world environment causes transient blur and brief NITM.
ACKNOWLEDGMENTS

We wish to sincerely thank Bradley Coffey, O.D. for his guidance and support during this process. We would also like to thank our families for their patience and support.
INTRODUCTION

Prolonged near work has been proposed to cause nearwork-induced transient myopia (NITM). NITM is a form of temporary nearsightedness that has been associated with nearwork activities such as reading or computer use. This effect has been shown after 10 minutes of nearwork\(^1,2\) up to an 8 hour work day\(^3\), with a mean magnitude of about 0.40 D\(^2,4\). The accommodative response to a near task rather than the actual cognitive demand of the task determines the myopic shift\(^5\).

The concern that the large amount of video game playing by children may be causing NITM prompted research interest in this area\(^6\). However there is a lack of research into the effects of computer games in young adults. Computer work has been implicated in NITM in this population, with a mean shift of 0.6D after 1 hour of reading on the computer\(^7\). Decreased cost and greater availability have increased the number of young adults owning laptop computers. The myriad of games available, both from the internet and stores, has made computer game playing a popular attraction.

It is important to determine if playing computer games causes the same visual changes as other computer tasks. This study examines the visual effects of prolonged computer game playing in young adults.
METHODS

Thirty-one young adult optometry students, age 20-35 years were subjects in this study. Their refractive condition was between +1.50 and -5.00 equivalent sphere with habitual visual acuity of at least 20/20 at distance and near. All subjects wore their habitual distance prescription throughout the task. Subjects were allowed to wear contact lenses or spectacle lenses. They had normal binocular vision as indexed by demonstrated stereoacuity of at least 100 sec arc measured using the Titmus test in the Randot Stereo Test and at least 50 of accommodative amplitude measured by Donders push-up test.

Distance refraction was measured using a Grand Seiko WR-5100K autorefractor. The Grand Seiko is an open field autorefractor similar in design to the Canon R-1, an instrument used widely in previous myopia research. The published Grand Seiko reliability is within 0.04D of the subjective refraction when using the mean of multiple autorefraction values\(^8\). Spherical and cylindrical values were measured in 0.12D increments, with cylinder axes given in 1 degree steps. These values were then converted to spherical equivalents for statistical analysis. The Grand Seiko was set to automatically take 3 readings per individual measurement and average them to yield a spherical and cylindrical refractive value. Measurements were taken over habitual lens Rx, with both spectacle lenses and contact lenses allowed. The residual refractive condition is measured using the Grand Seiko when the subject is wearing the habitual prescription. All autorefractor measurements analyzed in the study were
therefore residual refractive condition over habitual lens Rx. Measurements took less than 15 seconds each. Subjects viewed a 20/30 Snellen letter at 6 m during and between measurements.

Monocular visual acuity was determined with a Bailey-Lovie logMAR chart at 6m and a reduced Snellen chart at 40 cm. Pre- and post-task visual acuity measurements were taken at both distance and near.

Subjects used their own personal laptop computers to participate. Only PCs were allowed. Resolution was standardized at 1024 x 768 pixels. Laptops have digital LCD screens, with each pixel having its own transistor. Therefore these screens have fewer interactions between adjacent pixels and less pixel nonlinearity. This allows the laptop screens to produce better image quality with a better foveal target. Color was set to 32 bits. All subjects downloaded the computer puzzle game called Snood onto their laptops prior to testing. This game has a series of colored characters (or “Snoods”) suspended from the top of the screen in 4 or more rows. The player aims a “cannon” at the bottom of the screen to shoot more colored Snoods upward. When three or more Snoods of the same color are touching each other, they fall off the screen. The goal of the game is to clear all of the Snoods from the screen. The game was set at a medium window size, and subjects were allowed to play any difficulty level. A standard working distance of 50 cm was maintained throughout the experiment with the use of a pre-measured string attached to the screen of the computer. Subjects placed the loop of the string to the bridge of their nose at 5, 15, 30, 45,
60, and 75 minutes. The subjects were instructed to keep their eyes fixed on the game for the entire 90 minute time period.

Surveys were administered pre- and post-task questioning family history of refractive conditions, ocular symptoms, history of computer use, stress level, and interest in the computer game (see Appendix I and II).

The study proceeded as follows: Three initial residual refractive condition measurements were taken, followed by visual acuity measurements at distance and near. Participants were then instructed to take the pre-task survey and set up their computers. They played the computer game for 90 minutes. Working distance was measured six times during this 90 minute period. Immediately after task completion, residual refractive condition and visual acuity at distance and near were measured. Post-task, one residual refractive condition measurement was taken every 30 seconds for a five minute period, then every minute for an additional 15 minutes. After this 20 minute time period, three measurements were taken to determine if the subjects reached their baseline (within 0.12D of their original residual refractive condition). If baseline was reached, the average of these three values was the final autorefraction value for the subject. If the residual refractive condition did not return to baseline, autorefractor measurements continued at 5 minute intervals until baseline was reached. Upon reaching baseline, three autorefraction measurements were taken and averaged to become the final autorefraction value for the subject. If baseline was not reached by the end of 60 minutes post-task, three autorefraction measurements were taken at 60 minutes. The average of these three values was the subject’s
final autorefraction value. The maximum autorefraction time post-task for any subject was 60 minutes. Based on previous research, the investigators decided that if baseline was not reached by 60 minutes post-task, continued measurements would not yield significant information. After baseline was achieved, visual acuity measurements at distance and near were repeated. The post-task survey was administered after all measurements were completed.
RESULTS

The data were submitted to analysis using ANOVA for independent groups. The subjects were classified into four different refractive condition groups: early onset myopia (EOM), late onset myopia (LOM), emmetropia (EMM), and hyperopia (HYP). Emmetropia was defined as +0.99 to -0.49D. Hyperopia was defined as more than +1.00D. Myopia was defined as -0.50D or greater. Early onset myopes received their first myopic lens Rx before age 13, based on subject-provided information. Late onset myopes received their first myopic lens Rx after age 13. There were 8 early onset myopes, 8 late onset myopes, 14 emmetropes, and 1 hyperope, with a total subject base of 31. Tables 1 and 2 show the mean data for each of the groups. Each autorefraction value reported is the mean change from the pre-task value. Refractive change through time and visual acuity data were analyzed. ANOVA between the refractive groups (the single hyperope excluded) did not reveal any differences in results based upon refractive condition.

Immediate post-task refractive change across all subjects was analyzed using a standard t-test. There is a statistically significant myopic shift of 0.12 D (p < 0.01) that occurs immediately post-task and returns to baseline by 30 seconds post-task. Table 1 depicts the refractive shift between pre-task and post-task for each refractive group with respect to time. Figure 1 graphically depicts these results.
Although the mean refractive change for all subjects returned to baseline early, individual subjects' autorefractor measurements continued to fluctuate for long periods of time. Seventeen out of 31 subjects were not back to baseline by the end of 20 minutes, and three subjects did not return to baseline by the end of the 60 minute testing period. In the early onset myope group, 6 out of 8 subjects were not back to baseline by 20 minutes, and one subject was not back to baseline by 60 minutes post-task. In the late onset myope group, 4 out of 8 were not back by 20 minutes, and one was not back to baseline by 60 minutes. In the emmetropic group, 6 out of 14 were not back to baseline by 20 minutes, and one was not back to baseline by 60 minutes. In the hyperopic group, 1 out of 1 was not back to baseline by 20 minutes, but reached baseline before 60 minutes post-task.

There was substantial inter-subject variability in response to the gaming task. We found that while some individuals had an overall myopic shift, others shifted in the hyperopic direction, while others fluctuated around emmetropia. After analyzing survey and autorefraction data, we found no predictive method to determine the magnitude of shift for a given subject or how quickly a subject would return to baseline.

The logMAR visual acuity data shown in Table 2 compare the OD distance VA shift post-task compared to pre-task. These data were analyzed using two t-tests (Pre vs. Post1 and Pre vs. Post 2). There were two measurements taken post-task. The Post 1 measurement was taken directly after task completion. The Post 2 measurement was taken at the completion of the study, after the
subject's refractive condition had returned to baseline. As was the case with the refractive condition measurements, ANOVA revealed no significant differences in VA change between refractive groups. A comparison across all subjects showed a significant loss of 0.10 logMAR at Post 1, with a remaining loss of 0.026 logMAR at Post 2 (p < 0.01). These results are graphically depicted in Figure 2.
DISCUSSION

Prolonged near work has been proposed to cause transient myopia and an accompanying transient distance blur. No studies have been conducted on the effects of prolonged laptop usage, although it could be supposed that this type of near task would also cause a transient myopic shift with resultant blur.

This study simulates a real-world task that many young people perform on a regular basis. The working distance of 50 cm is realistic for normal laptop use, and the 90 minute time period is not unrealistic for young people today to be engaged in laptop computer games. Study participants brought in their own laptops so they would be familiar with the set-up and operation of the computer in order to better simulate real-world activities.

The mean myopic shift of 0.12D observed after the prolonged near work is consistent with previous research. The mean post-task myopia returned to baseline by 30 seconds. The overall mean for the group returned to baseline quickly, but individual subjects' autorefractor measurements continued to fluctuate for long periods of time. Over half of the group was not back to baseline by the end of the 20 minute period, with 3 individuals not back to baseline at the end of the 60 minute maximum time period. We were unable to discern a predictive method to determine when subjects would return to baseline.

There are many factors that have been hypothesized to contribute to this transient myopic refractive shift, including accommodative hysteresis, ciliary muscle changes, crystalline lens changes, and neuropharmacological changes.

Accommodative hysteresis may account for the transient myopic shift. With a prolonged period of near work, individuals may start to adapt to the accommodation demand and show a transient myopic shift when distance tasks are resumed. During longer periods of accommodation, tonic accommodation maintains the accommodative system at a constant level. The tonic component
is presumed to be controlled in the brainstem and is not transient\textsuperscript{4}. However, a slow accommodative adaptive effect may also help maintain the accommodative system at the appropriate level, leading to the transient temporary myopic effect at the completion of the task\textsuperscript{4}.

Ciliary muscle changes aka “spasm” may be due to the prolonged task period. An inability to quickly relax the muscle would cause a temporary myopic response. Research has indicated that increased stimulation of the isolated ciliary muscle strips does not produce a prolonged decay of muscle contraction\textsuperscript{2}. Therefore, this mechanism does not appear to be involved for short term tasks. However, repetition of sustained near tasks over a period of months to years may still cause ciliary muscle changes\textsuperscript{2}.

Prolonged accommodation may lead to a change in the crystalline lens tonus itself\textsuperscript{4}. The lens may become temporarily less elastic during this prolonged stress leading to a temporary myopic shift until the lens rebounds to its original state. Research in this area has shown an elastic aftereffect following an induced accommodative state. However the forces used were on the magnitude of 0.7 to 2.2 g which is far greater than the maximum accommodative response, which is approximately 0.45g\textsuperscript{4}. Further study is needed in this area to determine if the crystalline lens is involved in NITM.

A sustained near task may induce a change in the parasympathetic or sympathetic systems. The accommodative system receives input from both branches of the autonomic system\textsuperscript{4}. The sympathetic system shows a slow response time of 10 to 40 seconds and may contribute to adaptation in a prolonged accommodative task\textsuperscript{4}. The slow decay of the sympathetic system following completion of a task may contribute to NITM\textsuperscript{4}. More research is needed to determine the level of involvement of the autonomic system in NITM.

A significant distance visual acuity reduction of 0.10 LogMAR occurred immediately post-task with a remaining significant loss of 0.26 LogMAR at the end of the measurement period. This amount corresponded to one line of loss
and the loss of one letter, respectively, on the LogMAR chart and is consistent with previous research \(^4\). \(^5\).

Since the myopic shift was minimal, the substantial blur the subjects experienced must be coming from a different portion of the visual system. The amount of blur shown would require a myopic refractive shift of approximately 0.50 D\(^\circ\), which is substantially more than the 0.12 D shift we found. One possible cause of this blur is dry eye.

Dry eye syndromes have been shown to cause blur when the blink response is suppressed during concentration on an object\(^\circ\). This blur response is of the magnitude of 20/60 compared to the best visual acuity of 20/20. Our patients were not initially assessed for dry eye, although the decreased blink rate found during computer use may induce temporary dry eye symptoms. Blinking was not measured during this study, but previous research has shown that blink rate decreases during computer use\(^\circ\). Tear film stability was not measured or quantified during this study, but poor tear films during post-task autorefraction were noted on multiple subjects.

The findings of this study open the door to further research on a topic that is of increasing importance to our computer-age society. As more people rely on laptops for everyday and work-related activities, the cause of this transient blur and the effects on eye health will need to be explored further.


<table>
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<tr>
<th>Refractive Condition</th>
<th>EOM</th>
<th>LOM</th>
<th>EMM</th>
<th>HYP</th>
<th>ALL</th>
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<td>Time (min)</td>
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<td></td>
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<td>-0.02</td>
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<td>-0.03</td>
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<td>0.07</td>
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Autorefraction means for each refractive condition. Each data point is the mean change, in Diopters, in autorefraction compared to pre-task baseline for each refractive group. Measurements were taken from immediately post-task (0 minutes) to 20 minutes post-task. The symbols refer to refractive groups. EOM = early onset myopes, LOM = late onset myopes, EMM = emmetropes, HYP = hyperopes, and ALL = mean for all data combined.
Table 2

<table>
<thead>
<tr>
<th>Refractive Condition</th>
<th>Time</th>
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<td>HYP</td>
<td>-0.12</td>
</tr>
<tr>
<td>ALL</td>
<td>-0.12</td>
</tr>
</tbody>
</table>

Visual acuity means for each refractive condition. Each data point is the mean logMAR visual acuity for each refractive group. Negative logMAR indicates better than 20/20 Snellen VA and positive indicates worse than 20/20. The symbols refer to refractive groups. EOM = early onset myopes, LOM = late onset myopes, EMM = emmetropes, HYP = hyperopes, and ALL = mean for all data combined. The time of measurement is as follows: PRE = before testing, POST1 = directly after 90 minutes of computer gaming, and POST2 = after the patients reached refractive baseline.
Figure 1

Autorefraction means 0-20 minutes

Autorefraction means 20-60 minutes

Autorefraction means for each refractive condition. Each data point is the mean change in the autorefraction spherical equivalent compared to pre-task baseline for each refractive group. The symbols refer to refractive groups. EOM = early onset myopes, LOM = late onset myopes, EMM = emmetropes, and ALL = mean for all data combined. Data for the sole hyperope are not included. Measurements were taken on all patients from immediately post-task (0 minutes) to 20 minutes post-task. Measurements continued up to 60 minutes post-task if baseline was not reached.
Figure 2

Figure 2: Visual acuity means for each refractive condition. Each data point is the mean logMAR visual acuity for each refractive group. Negative logMAR indicates better than 20/20 Snellen VA and positive indicates worse than 20/20. The symbols refer to refractive groups: EOM = early onset myopes, LOM = late onset myopes, EMM = emmetropes, and ALL = mean for all data combined. The data for the sole hyperope are not included. The time of measurement is as follows: PRE = before testing, POST1 = directly after 90 minutes of computer gaming, and POST2 = after the patients reached refractive baseline.
Appendix I

PRE-TASK SURVEY

Date: __________

1. ID Number: __________________

2. What is your age? __________

3. What is your gender?   M    F

4. We are trying to determine the amount of time you spend on your computer. Please estimate the following: In the last two weeks:

   How many days per week did you play computer games? __________
   During each session on the computer, approximately how long did you spend playing computer games? __________
   How many days per week did you do other computer tasks? __________
   During each session on the computer, approximately how long did you spend doing other computer tasks? __________

5. Please rate your past experience with EACH of the following symptoms ranging from 0 (never noticed) to 4 (often notice/interferes with work on the computer)

   ______ Eye strain
   ______ Dry Eyes
   ______ Tired eyes
   ______ Watery eyes
   ______ Red Eyes
   ______ Photophobia (sensitivity to light)
   ______ Double vision
   ______ Blur in the distance
   ______ Blurry vision at the computer
   ______ Blur when reading
   ______ Slow refocusing
   ______ Neck ache
   ______ Headache
   ______ Glare sensation
   ______ Observe “jumping” letters/text
6. Indicate your approximate time interval of prolonged work on the computer before taking a rest break (choose one):

- 1 – 20 minutes
- 21 – 40 minutes
- 41- 60 minutes
- 61-90 minutes
- > 90 minutes

7. What is your stress level today? (circle one)
   a. Much less stress than normal
   b. Less stress than normal
   c. Normal amount of stress
   d. More stress than normal
   e. Much more stress than normal

8. At what age did you get your first pair of glasses? ___________
Appendix II

POST-TASK SURVEY

ID Number

Date: 

1. How interesting was the game? (check one)
   
   _____ Very Interesting
   _____ Somewhat Interesting
   _____ Neutral
   _____ Not Interesting

2. Check any symptoms you experienced during or after playing the game
   
   _____ Eye strain
   _____ Dry Eyes
   _____ Blur up close
   _____ Tired eyes
   _____ Slow refocusing
   _____ Watery eyes
   _____ Neck ache
   _____ Double vision
   _____ Photophobia (sensitivity to light)
   _____ Headache
   _____ Blur in the distance
   _____ Blurry vision at the computer
   _____ Glare sensation
   _____ Observe "jumping" letters/text