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# The effects of video gaming on vision

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## Abstract

Prolonged periods of playing games on laptop computers have been shown to cause nearwork-induced transient myopia (NITM), a temporary form of nearsightedness, with associated transient blur. Ocular dryness has also been shown to contribute to subjective reports of blurred vision that fluctuates with blinking. It has been further established that attention and fatigue can affect the tonus of accommodation. This study was designed to evaluate what effect playing video games on a large projection screen at a distance of 6m for a prolonged period would have on refractive status, visual acuity and ocular comfort. Visual acuity, refractive status and ocular comfort were assessed pre- and post-task during the study. Static refractive measurements were taken using a Grand Seiko WR- 5100Ka autorefractor. Ocular comfort was assessed by use of a modified DEQ dry eye questionnaire. A statistically significant loss of binocular visual acuity of 0.02 logMAR units was noted immediately post-task. These findings suggest that prolonged periods of playing video games can cause a temporary slight decrease in visual acuity.



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Bradley Coffey

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computer games, vision, discomfort, scratchiness, dry eye

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# THE EFFECTS OF VIDEO GAMING ON VISION

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# THE EFFECTS OF VIDEO GAMING ON VISION

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## Biography

**Andrew Werner** received his high school diploma from North Summit High School in Coalville, Utah, where he was part of the National Honor Society. He graduated from Southern Utah University Magna cum Laude with a Bachelor of Science degree in Composite Physical Science in 2001. Andrew then taught middle school Science for two years. He is currently in his final year at Pacific University College of Optometry for his Doctorate of Optometry, where he is a member of Beta Sigma Kappa International Optometric Honor Society.

**Shawn Cottrell** received his high school diploma from Lyman High School in Wyoming. There he was part of the National Honor Society and graduated salutatorian of his class. He then received a Bachelor of Vision Science through the combined degree from Pacific University and Brigham Young University in 2003. He is currently working on his final year at Pacific University College of Optometry for his Doctorate of Optometry.

# Abstract

Prolonged periods of playing games on laptop computers have been shown to cause nearwork-induced transient myopia (NITM), a temporary form of nearsightedness, with associated transient blur. Ocular dryness has also been shown to contribute to subjective reports of blurred vision that fluctuates with blinking. It has been further established that attention and fatigue can affect the tonus of accommodation. This study was designed to evaluate what effect playing video games on a large projection screen at a distance of 6m for a prolonged period would have on refractive status, visual acuity and ocular comfort. Visual acuity, refractive status and ocular comfort were assessed pre- and post-task during the study. Static refractive measurements were taken using a Grand Seiko WR-5100K[a] autorefractor. Ocular comfort was assessed by use of a modified DEQ dry eye questionnaire. A statistically significant loss of binocular visual acuity of 0.02 logMAR units was noted immediately post-task. These findings suggest that prolonged periods of playing video games can cause a temporary slight decrease in visual acuity.



## Keywords

Computer games, vision, discomfort, scratchiness, dry eye,

# Introduction

Video games have become a more common entertainment activity in recent times, and never before have so many people been involved with playing video games. A visit to the local electronics store or large retail department store will reveal at least three separate video gaming systems, not to mention handheld video games and the hundreds of game titles available for use with the home computer. Halo 2, the video game used in this study, recently reported that more than a half-*billion* games have been played online.[1]

The concern that the large amount of video gaming that occurs in children and young adults could cause nearwork-induced transient myopia (NITM)[2] prompted the recent study Effect of Laptop Computer Games on Vision[3]. The study concluded that using laptop computers to play video games could cause transient blur and brief NITM. This correlates to the findings of Rosenfield and Ciuffreda that the cognitive demands of the task and the length of time on task can cause NITM[4,5].

The effects of ocular dryness and blinking have also been shown to be associated with a decrease in visual acuity, both with and without the use of visual display terminals[6,7]. In their study of blink rates associated with dry eye,[8] Goto et al. reported that dry eye patients blink with twice the frequency as normal controls, and that during acts such as gazing, reading or using a visual display terminal (VDT) the blink reflex was suppressed.

This study was designed as a follow-up to the Effect of Laptop Computer Games on Vision study, and to investigate what effect playing video games on a large projection screen at a distance of 6m for a prolonged period would have on refractive status, visual acuity and ocular comfort.

# Methods

Thirty-two young adult optometry students aged 21-33 years participated in this study. Subjects were volunteers from the Pacific University College of Optometry, with 87% of the participants in their first year of optometry school. Fifteen of the 32 subjects were female.

Subjects were provided informed consent documentation acknowledging potential risks and informing them that they would be playing Halo 2, a first-person shooter game for Microsoft XBOX. Efforts were taken to prevent participants from knowing the exact purpose of the study to prevent potential data contamination. Participants were also required to sign a photography release to assist in data collection.

A pre-task survey was used to gather information about refractive conditions, type of optical correction used, ocular comfort, presence of systemic conditions that might affect ocular comfort, and use of any medications. Twenty-eight different variables about ocular comfort, including items addressing dryness, itchiness, scratchiness and how bothersome these symptoms were to the subject were queried in the survey. Subjects were asked to rank the occurrence of their symptoms on a scale of 0-4 with 0 corresponding to "never" and 4 corresponding to "constantly." Subjects were also asked to rank the severity of their discomfort on a 0-5 scale with 0 "never have it" to 5 "very intense." The occurrence and severity of symptoms were drawn directly from the Dry Eye Questionnaire published and utilized by the Indiana College of Optometry[9]. See Appendix A.

Monocular visual acuity was checked, and all participants were required to have visual acuity of at least 20/25 in each eye (logMAR +0.10) and 20/20 OU, (logMAR

0.00) when tested at 6m on a Bailey-Lovie logMAR chart. Presence of stereopsis at six meters was determined with a Bernell Corporation BC909[b] Stereo Trainer. Subjects were required to correctly identify the direction of float of the center ring while maintaining awareness of the anti-suppression cues. Ocular alignment was assessed using a distance cover test to ensure that all subjects were non-strabismic.

To better correlate the results of this study to the Effect of Laptop Computer Games on Vision study, the method of measuring refractive status was kept the same. Distance refractive status was measured using a Grand Seiko WR-5100K[a] autorefractor. The published Grand Seiko reliability is within 0.04D of the subjective refraction when using the mean of multiple autorefraction values [10]. Spherical and cylindrical values were measured in 0.12D increments, with cylinder axes given in 1-degree steps. 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 the habitual lens Rx for subjects wearing contact lenses, but without Rx in subjects wearing spectacles to facilitate easier measurement and eliminate risk of measurement error. Measurements took less than 15 seconds each. Subjects viewed a 20/30 Snellen letter at 6m during and between measurements.

After subjects completed the pre-task survey and initial testing, they were given instructions on playing the video game Halo 2. Following instruction, subjects played Halo 2 for one hour, a typical short gaming period.

Halo 2 is a first-person shooter game for the Microsoft XBOX game console and carries a rating of Mature from the ESRB for language, violence, and blood and gore. In Halo 2 the goal of the game is to locate and shoot other characters. For the purpose of

this study, the game was configured in a multiplayer set-up, with four players able to participate at a time. When a character is killed, a groan is emitted and the character falls dead in a pool of blood. A new character will then spawn, or reappear, on the map after a slight delay. The delay ranges from 2 seconds if another player killed you, to 10 seconds if you inadvertently were the cause of your own demise. Each character would spawn with random weapons of differing lethality, and different weapons were available to be picked up on the map.

All subjects were seated 6m from the projected image of the video game. The projected image measured 239 cm across by 184 cm high, with each participant having one quadrant of the image space where their character was played. Participants began the gaming session with a fifteen minute staggered start to allow for data collection to be completed before the next subject was to begin.

Desiring to study the effects of blinking and blink rates on visual acuity and ocular comfort, 19 of the 32 subjects were videotaped for the first five minutes of the gaming session to establish a baseline blink rate. Those same subjects were then videotaped for the last five minutes to assess any change in their blink rates.

After the gaming session was finished, monocular and binocular visual acuities were immediately taken using the Bailey-Lovie logMAR chart. Once the VA's were taken, refractive status was assessed immediately using the Grand Seiko WR-5100K[a] autorefractor, using the same protocol as with the pre-task measurements. Refractive status was considered stable if both the average spherical and cylinder measurements were within 0.25D of the initial measurement. If refractive status was not back to baseline immediately post-task, measurements were re-taken at one minute post-task, and

if still not at baseline, a final measurement was taken at five minutes post-task. The five-minute post-task cutoff was established by the investigators after noting that the majority of subjects in the Effect of Laptop Computer Games on Vision study returned to baseline within this time period [3].

The subjects then completed a post-task survey after all other measurements were obtained. The post-task survey asked subjects to compare ocular comfort to their pre-task responses, using the same criteria previously mentioned. See Appendix B.

# Results

The measurements of spherical and cylindrical refractive status, as well as horizontal and vertical keratometric readings for each eye of the 32 subjects were analyzed using ANOVA to determine any pre-to-post-task change. ANOVA analysis was performed on the entire sample to include subjects who hadn't returned to baseline at the immediate post-task measurement, and therefore had more than 2 measurements to compare. Significant changes were seen in OD cylinder measurements and OD horizontal keratometric readings, with an increase in cylinder values of -0.211 D ($p = 0.015$) and an increase in keratometric values of 0.125 D ($p = 0.012$). See Appendix C for Visual Acuity and Refractive Status Results.

The pre-to-post-task changes in refractive status, keratometric values, and visual acuity of all subjects were analyzed using a standard paired t-test. The paired t-test analysis was to determine the change from the pre- and immediate post-task measurement for each subject. A significant decrease in visual acuity of the right eye of 0.06 logMAR units, the equivalent of 3 letters on the Bailey-Lovie logMAR chart, was noted immediately post task ($p = 0.0009$). Binocular visual acuity also decreased by .02 logMAR units, or 1 letter equivalent, immediately post task ($p = 0.0163$). OS visual acuity was unchanged. Cylinder measurement and horizontal keratometric values of the right eye also revealed significant changes, concurring with the ANOVA evaluation. Subjects were considered returned to baseline refractive status if the average post-task spherical and cylinder measurements were within +/- 0.25D of the baseline values. Nineteen of the 32 subjects had no change in their refractive status immediately post-task, with 7 additional subjects returning to baseline within the first minute post-task. Of the

remaining 6 subjects, 4 failed to return to within +/- 0.25D of their baseline refractive spherical and/or cylindrical values by the end of the 5-minute period established by the study.

Evaluation of the 19 subjects videotaped for blink rates revealed large inter-subject variability, as well as large intra-subject variability. The average number of blinks during the first 5 minutes of gaming was found to be 47.2 +/- 10.8 blinks, or an average of 13.2 blinks per minute, with values ranging from 2.4 to 33.6 blinks per minute. The average number of blinks for the last 5 minutes was 48.2 +/- 11.1 blinks, or an average of 14.4 blinks per minute, with values ranging from 4.0 to 36.0 blinks per minute. The subject who recorded the lowest number of blinks during the first 5 minutes increased blink rate during the last 5 minutes, while the subject with the highest frequency of blinks at the start reduced the blink rate during the trial.

Subjective rankings of ocular comfort were analyzed using the Wilcoxon Signed Rank Test. Analysis revealed significant decreases in frequency ($p = 0.0495$) and intensity ($p = 0.0386$) of ocular discomfort during the gaming period when comparing to an average day. Decreased scratchiness ($p= 0.0464$), tired eyes ($p= 0.0423$), watery eyes ($p = 0.0003$) and reports of being bothered by the watery eyes ($p = 0.0437$) during the gaming task were also found to be significantly lower. Twenty-two of the 28 ocular comfort variables showed no change. Though not statistically significant, 14 out of 32 subjects reported increased discomfort in the first 30 minutes of the gaming trial. Eleven subjects reported increased dryness in that same time period, and 18 reported an increase in tired eyes. See Appendix D for a summary of changes in ocular comfort. See Appendix E for a chart showing ocular comfort results.

# Discussion

Transient myopia with associated distance blur has been shown to be caused by prolonged nearwork[2,3,4]. It has recently been shown that prolonged laptop usage for computer gaming can also cause transient myopia[3]. Ocular dryness has also been implicated in subjective reports of distance blur[11]. To our knowledge, no studies have been conducted to investigate the effects of playing video games at 6m on refractive status and acuity, nor have any studies been conducted to investigate ocular comfort while playing video games. It can be proposed that a prolonged period of gaming might cause an increase in subjective reports of ocular discomfort, tired eyes and ocular dryness in the first 30 minutes, but is not expected to have a significant effect on visual acuity or refractive status.

This study simulates a real world task that many children and young adults perform on a daily basis. The one-hour gaming period is not unrealistic; some would even consider it short for an average gaming session. While the working distance of 6m and screen size are larger than those typically used by many gamers, it was important to the design of the study to try to eliminate prolonged accommodation as the cause of any change in refractive status and to better determine the cause of any decreased visual acuity found.

Similar to the Effect of Laptop Computer Games on Vision study, there was substantial inter-subject variability in response to the gaming task. Nine out of 32 subjects (six male) had a myopic shift when immediate post-task measurements were taken. Four subjects (all female) had a hyperopic shift at immediate post-task measurement. Nineteen subjects had no change in their refractive status when comparing

pre- to post-task auto-refraction values. The majority of those showing an initial myopic shift were male, and males are the typical video game target audience. It is interesting that more males than females showed the myopic shift after gaming, but it is impossible to predict exactly how each individual will respond to the task, or how quickly s/he will return to baseline status.

Surprisingly, significant increases in the cylinder values OD (-0.211D) and horizontal keratometric readings OD (0.125D) were found. All other refractive and keratometric measurements did not change. While statistically significant, these values were within the investigators' criteria for margin of error from average measurements, and so should be considered more suggestive rather than significant. These values are also less than mean magnitude of 0.4D found in previous NITM research[2,4,5].

Many factors have been proposed to contribute to NITM including accommodative hysteresis, changes in the ciliary muscle, crystalline lens changes and neuropharmacological changes[4,5]. This study was designed to limit the effects of accommodation and the ciliary muscle on refractive status by using a 6m working distance, but statistically significant changes in cylinder and keratometric values were still found immediately post-task. Previous research by Sheedy et al.[7] has shown that squinting can decrease the blink rate and subjective reports of ocular comfort. With the effect of the orbicularis oculi shown to be contributory to these findings, it is possible that the change in cylinder and keratometric values could be caused by the tonus of the orbicularis oculi muscle.

While it seems unlikely that accommodation would account for the decreased OD and OU visual acuity measured after working at a task distance of 6m, it is possible that it

could have contributed to the decreased visual acuity. The investigators would like to speculate that the effect on acuity was more likely due to tear film anomalies or possible effects from the orbicularis, but these factors were not measured in this study, and therefore it is uncertain what was the cause of the decreased visual acuity.

Blinking and the stability of the tear film have been shown to have a significant effect on visual acuity and subjective reports of blur[7,8,12]. Our data are inconclusive about what effect playing video games has on blink rates. There was a large inter-subject variability with blink rates, and when comparing blink rates during the first and last five minutes of gaming, there is a large intra-subject variability. The examiners had expected to find a significant decrease in the number of blinks for the subjects, but instead found that only 6 out of 19 subjects had decreased blink rates, 5 of whom were female. Twelve subjects increased their blink rate, 7 of whom were male. One subject experienced no change in blink rate.

Subjective responses to the ocular comfort surveys varied greatly, and the results returned were not what the examiners expected. Subjects reported that ocular discomfort, tiredness of the eyes and grittiness and scratchiness of the eyes all *decreased* during the gaming task. All three of these findings were found to be significant. Twenty-two of the 28 ocular comfort items did not change during the gaming task. Notwithstanding the variability of the results obtained from the surveys, 14 out of 32 subjects reported increased discomfort in the first 30 minutes of the gaming trial. Eleven subjects reported increased dryness in that same time period, and 18 reported an increase in tired eyes.

A possible explanation for the variability and overall unreliability of these findings is that the pre-task survey asked subjects to rank their ocular comfort on "an

average day in the past week." This wording is drawn directly from the original DEQ[9]. The post-task survey asked subjects to rank their symptoms during the gaming task. If the pre-task survey had asked the subjects to rank their symptoms for that exact moment in time, it might have allowed more reliable and relevant results to be obtained.

At this time, it is impossible to definitively state what effect playing video games at 6m will have on vision. In past research it has been shown that blink rates decrease with computer use[12] but we were unable to replicate those results with our study due to the large variability between subjects.

The results of this study show that there is a transient change in refractive status and a decrease in visual acuity. As video games continue to have increased popularity, it will be important for further research to explore the full effects of video gaming on vision.

## Acknowledgements

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# SOURCES

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b. Bernell BC909
http://www.bernell.com/

# Appendix A

## Halo Gaming Thesis
## Entry Questionnaire

Please fill in the blank or circle the answer that best describes you. Choose only one answer per question.

1. What is your age?

   _____

2. What is your gender?
   1 Male
   2 Female

3. Do you currently wear contacts or glasses?
   1 Yes
   2 No

4. If you answered yes to question 3, are you:

   1 Myopic (Nearsighted)
   2 Hyperopic (Farsighted)

5. What age were you when received your first prescription for glasses or contacts?

   0 0-5 years of age
   1 5-10 years of age
   2 10-15 years of age
   3 15-20 years of age
   4 after 20 years of age

6. Do you currently wear contact lenses? (If you don't wear contact lenses, please skip to question 11)

   1 Yes
   2 No

7. If you currently wear contact lenses, what type of contact lens do you wear?

| | | Yes | No | Not Applicable |
|---|---|---|---|---|
| a. | Rigid gas permeable | 1 | 2 | 0 |
| b. | Disposable (lenses replaced frequently) | 1 | 2 | 0 |
| c. | Soft daily wear (lenses replaced after 1 year or longer) | 1 | 2 | 0 |
| d. | Extended wear (lenses worn overnight) | 1 | 2 | 0 |

8. If you currently wear contact lenses, please name the lens that you wear:

_____

9. Please list the type of contact lens solution that you use:

_____

10. How many hours have you been wearing your contact lenses today? If you sleep in your lenses, how many days have you been in your current pair?

_____

11. Question about **EYE DISCOMFORT:**

a. During a typical day in the past week, **how often** did your eyes feel discomfort?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt discomfort, **how intense was this feeling of discomfort...**

b. Within the first two hours of getting up in the morning?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

c. At the end of the day, within two hours of going to bed?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

d. When your eyes felt discomfort, how much did the discomfort bother you?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

**12.** Questions about **EYE DRYNESS:**

a. During a typical day in the past week, **how often** did your eyes feel dry?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt dry, **how intense was this feeling of dryness...**

b. Within the first two hours of getting up in the morning?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

c. At the end of the day, within two hours of going to bed?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

d. When your eyes felt dry, how much did the dryness bother you?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

**13.** Questions about **EYE GRITTINESS AND SCRATCHINESS:**

a. During a typical day in the past week, **how often** did your eyes feel gritty and scratchy?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt grittiness and scratchiness, **how intense was this feeling of grittiness and scratchiness…**

b. Within the first two hours of getting up in the morning?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

c. At the end of the day, within two hours of going to bed?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

d. When your eyes felt gritty and scratchy, **how much did the grittiness and scratchiness bother you?**

| Never have it | | | Not at all bothered | | Extremely bothered |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

14. Questions about **EYE BURNING AND STINGING:**

a. During a typical day in the past week, **how often** did your eyes feel burning and stinging?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt burning and stinging, **how intense was this feeling of burning and stinging…**

b. Within the first two hours of getting up in the morning?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

c. At the end of the day, within two hours of going to bed?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

d. When your eyes felt burning and stinging, **how much did the burning and stinging bother you?**

| Never have it | | | Not at all bothered | | Extremely bothered |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

15. Questions about **TIRED EYES:**

a. During a typical day in the past week, **how often** did your eyes feel tired?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt tired, **how intense was this feeling of tired...**

b. Within the first two hours of getting up in the morning?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

c. At the end of the day, within two hours of going to bed?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

d. When your eyes felt tired, **how much did the feeling of tired bother you?**

| Never have it | | | Not at all bothered | | Extremely bothered |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

16. Questions about **CHANGEABLE, BLURRY VISION:**

a. During a typical day in the past week, **how often** did your vision change between clear and blurry or foggy?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt grittiness and scratchiness, **how noticeable was the changeable, blurry, or foggy...**

b. Within the first two hours of getting up in the morning?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

c. At the end of the day, within two hours of going to bed?

| Never have it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

d. When your eyes felt gritty and scratchy, **how much did the changeable, blurry or foggy vision bother you?**

| Never have it | | Not at all bothered | | Extremely bothered | |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

17. Questions about **EYELID REDNESS:**

During a typical day in the past week, **how often** did your eyelid margins look red?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

18. Question about **WATERY EYES:**

During a typical day in the past week, **how often** did your eyes look or feel excessively watery?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

19. Question about **EYE MUCUS AND CRUSTING:**

During a typical day in the past week, **how often** was mucus or crusty material in or around your eyes?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

20. Question about **CLOSING YOUR EYES:**

During a typical day in the past week, **how often** did your eyes bother you so much that you wanted to close them?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

21. Questions about how much different **TYPES OF AIR QUALITY BOTHER YOUR EYES:**

a. a room with **cigarette smoke or smog?**

| Never have it | | | Not at all | | Very much |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

b. a building with the **central air conditioning or heating** turned on?

| Never have it | | | Not at all | | Very much |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

c. **shopping at the mall** or **shopping in retail** or **fabric stores**?

| Never have it | | | Not at all | | Very much |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

22. Question about **ARTIFICIAL TEAR USE:**

During a typical day in the past week, **how often** did you use artificial tears?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

23. Question about **DRYNESS OF THE NOSE OR MOUTH:**

During a typical day in the past week, **how often** did you experience dryness of the nose, or mouth?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

24. During a typical day in the past week, how often did you use a computer?

0 Never
1 1 to 2 hours
2 3 to 6 hours
3 More than 6 hours

25. In a typical week, how often did you play video games?

0 Never
1 1 to 2 hours
2 3 to 6 hours
3 6 to 9 hours
4 More than 9 hours

26. Are you currently taking any of the following medications?

| | | Yes | No |
|---|---|---|---|
| a. | Thyroid medications | 1 | 2 |
| b. | Blood pressure medications | 1 | 2 |
| c. | Diabetes medications | 1 | 2 |
| d. | Diuretics | 1 | 2 |
| e. | Arthritis medications | 1 | 2 |
| f. | Heart condition medications | 1 | 2 |
| g. | Depression medications | 1 | 2 |
| h. | Ulcer medications | 1 | 2 |
| i. | Oral contraceptives | 1 | 2 |
| j. | Antibiotics for acne or other skin conditions | 1 | 2 |
| k. | Hormone replacement therapy | 1 | 2 |
| l. | Allergy medications | 1 | 2 |

27. Have you been told you have dry eye(s)?

1 Yes
2 No

28. If you use any of the following treatments for dry eye, how much help do they provide?

| | | No help At all | | | Complete Relief | | Do not Use |
|---|---|---|---|---|---|---|---|
| a. | Artificial tears | 1 | 2 | 3 | 4 | 5 | 0 |
| b. | Lubrication ointments or gels | 1 | 2 | 3 | 4 | 5 | 0 |
| c. | Warm compresses or eyelid scrubs | 1 | 2 | 3 | 4 | 5 | 0 |
| d. | Punctal plugs or cauterization | 1 | 2 | 3 | 4 | 5 | 0 |
| e. | Room humidifier | 1 | 2 | 3 | 4 | 5 | 0 |
| f. | Other (please specify below) | | | | | | |

_____

29. Do you think you have dry eye(s)?

1 Yes
2 No

# Appendix B

## Halo Gaming Thesis
## Post Gaming Questionnaire

Please fill in the blank or circle the answer that best describes you. Choose only one answer per question.

1. Question about **EYE DISCOMFORT:**

a. During the gaming trial, **how often** did your eyes feel discomfort?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt discomfort, **how intense was this feeling of discomfort…**

b. Within the first 30 minutes of gaming?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

c. At the end of the gaming session?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

d. When your eyes felt discomfort, how much did the discomfort bother you?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

2. Questions about **EYE DRYNESS:**

a. During a the gaming trial, **how often** did your eyes feel dry?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt dry, **how intense was this feeling of dryness…**

b. Within the first 30 minutes of gaming?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

c. At the end of the gaming session?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

d. When your eyes felt dry, how much did the dryness bother you?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

3.Questions about **EYE GRITTINESS AND SCRATCHINESS:**

a. During the gaming trial, **how often** did your eyes feel gritty and scratchy?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt grittiness and scratchiness, **how intense was this feeling of grittiness and scratchiness...**

b. Within the first 30 minutes of gaming?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

c. At the end of the gaming session?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

d. When your eyes felt gritty and scratchy, **how much did the grittiness and scratchiness bother you?**

| Never had it | | | Not at all bothered | | Extremely bothered |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

4. Questions about **EYE BURNING AND STINGING:**

a. During the gaming trial **how often** did your eyes feel burning and stinging?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt burning and stinging, **how intense was this feeling of burning and stinging...**

b. Within the first 30 minutes of gaming?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

c. At the end of the gaming session?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

d. When your eyes felt burning and stinging, **how much did the burning and stinging bother you?**

| Never had it | | | Not at all bothered | | Extremely bothered |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

5. Questions about **TIRED EYES:**

a. During the gaming trial, **how often** did your eyes feel tired?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt tired, **how intense was this feeling of tired…**

b. Within the first 30 minutes of gaming?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

c. At the end of the gaming session?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

d. When your eyes felt tired, **how much did the feeling of tired bother you?**

| Never had it | | | Not at all bothered | | Extremely bothered |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

6. Questions about **CHANGEABLE, BLURRY VISION:**

a. During the gaming trial, **how often** did your vision change between clear and blurry or foggy?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

When your eyes felt grittiness and scratchiness, **how noticeable was the changeable, blurry, or foggy…**

b. Within the first 30 minutes of gaming?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

c. At the end of the gaming session?

| Never had it | | | Not at all Intense | | Very Intense |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

d. When your eyes felt gritty and scratchy, **how much did the changeable, blurry or foggy vision bother you?**

| Never had it | | | Not at all bothered | | Extremely bothered |
|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 |

7. Question about **WATERY EYES:**

During the gaming trial, **how often** did your eyes look or feel excessively watery?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

8. Question about **EYE MUCUS AND CRUSTING:**

During the gaming trial, **how often** was mucus or crusty material in or around your eyes?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

9. Question about **CLOSING YOUR EYES:**

During the gaming trial, **how often** did your eyes bother you so much that you wanted to close them?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

10. Question about **DRYNESS OF THE NOSE OR MOUTH:**

During the gaming trial, **how often** did you experience dryness of the nose or mouth?

0 Never
1 Rarely
2 Sometimes
3 Frequently
4 Constantly

# Appendix C

## Visual Acuity and Refractive Error Data Table

| Category | Pre-Task Mean +/- Standard Deviation | Post-Task Mean +/- Standard Deviation |
|---|---|---|
| Visual Acuity OD | -0.028 +/- 0.69 | 0.033 +/- 0.109 |
| Visual Acuity OS | 0.001 +/- 0.204 | -0.011 +/- 0.088 |
| Visual Acuity OU | -0.093 +/- 0.050 | -0.069 +/- 0.065 |
| Sphere OD | 0.077 +/- 0.46 | 0.135 +/- 0.426 |
| Cylinder OD | -0.462 +/- 0.393 | -0.673 +/- 0.426 |
| Horizontal K OD | 41.208 +/- 2.626 | 41.104 +/- 2.696 |
| Vertical K OD | 41.938 +/- 2.629 | 41.917 +/- 2.706 |
| Sphere OS | 0.058 +/- 1.786 | 0.038 +/- 1.607 |
| Cylinder OS | -0.481 +/- 0.346 | -0.346 +/- 0.24 |
| Horizontal K OS | 41.229 +/- 2.691 | 41.354 +/- 2.655 |
| Vertical K OS | 41.896 +/- 2.586 | 42.00 +/- 2.456 |

**Appendix C: LogMAR visual acuity results for OD, OS and OU. Each data point shows the mean value, comparing pre-task to post-task measurements. Auto-refraction and auto-keratometry mean values comparing pre-task to post-task measurements in diopters. Post-task measurements were taken immediately post-task.**

# Appendix D

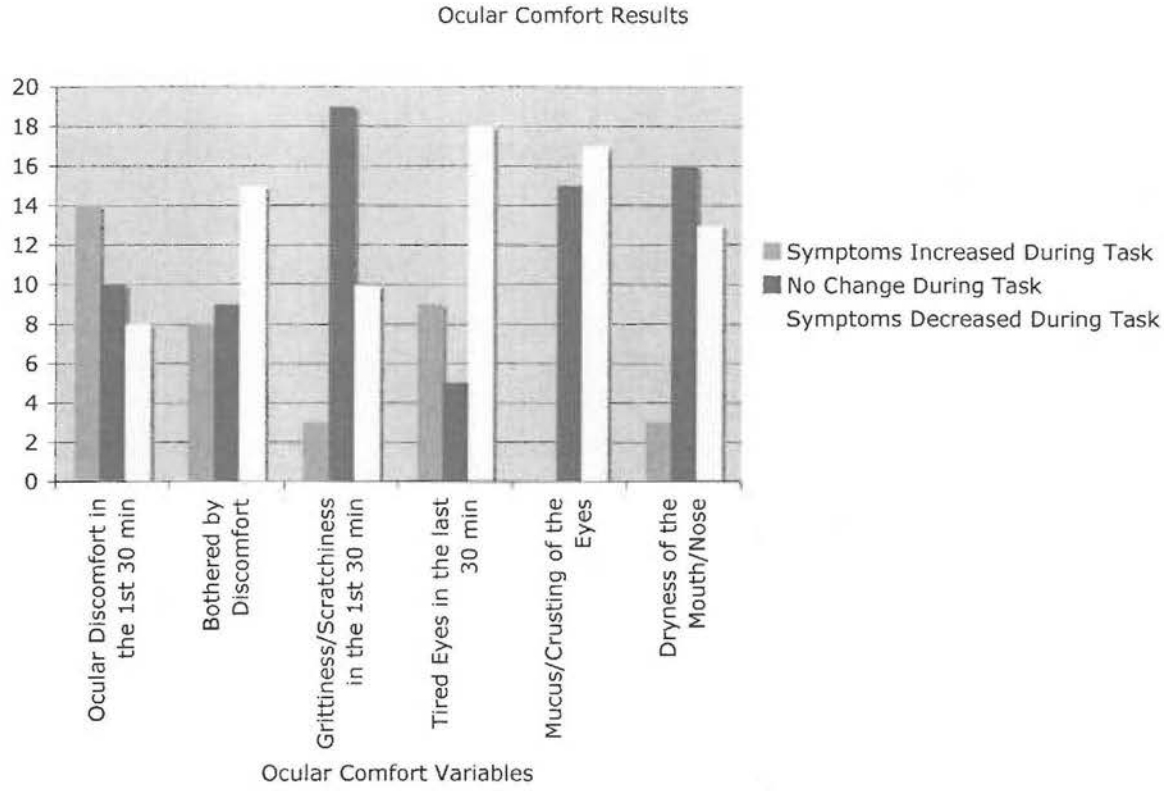
## Ocular Comfort Results

| Category | Symptoms Increased Post Task (Number of Subjects) | Symptoms Remained the Same (Number of Subjects) | Symptoms Decreased Post Task (Number of Subjects) |
|---|---|---|---|
| Ocular Discomfort | 10 | 10 | 12 |
| *Discomfort 1st 30 min | 14 | 10 | 8 |
| Discomfort Last 30 min | 8 | 7 | 17 |
| *Bothered by Discomfort | 8 | 9 | 15 |
| Eye Dryness | 7 | 12 | 13 |
| Eye Dryness 1st 30 min | 11 | 11 | 10 |
| Eye Dryness Last 30 min | 9 | 9 | 14 |
| Bothered by Eye Dryness | 9 | 9 | 14 |
| Grittiness and Scratchiness | 4 | 18 | 10 |
| *Grittiness and Scratchiness 1st 30 min | 3 | 19 | 10 |
| Grittiness and Scratchiness Last 30 min | 4 | 18 | 10 |
| Bothered by Grittiness and Scratchiness | 4 | 18 | 10 |
| Burning and Stinging | 5 | 23 | 4 |
| Burning and Stinging 1st 30 min | 9 | 20 | 3 |
| Burning and Stinging Last 30 min | 6 | 21 | 5 |
| Bothered by Burning and Stinging | 5 | 20 | 7 |
| Tired Eyes | 7 | 14 | 11 |
| Tired Eyes 1st 30 min | 18 | 6 | 8 |
| *Tired Eyes Last 30 min | 9 | 5 | 18 |
| Bothered by Tired Eyes | 9 | 6 | 17 |
| Blurry Vision | 9 | 13 | 10 |
| Blurry Vision 1st 30 min | 9 | 21 | 5 |
| Blurry Vision Last 30 min | 10 | 12 | 10 |
| Bothered by Blurry Vision | 9 | 14 | 9 |
| Watery Eyes | 6 | 23 | 3 |
| *Mucus or Crusting of the eyes | 0 | 15 | 17 |
| Wanted To close eyes 2' to overall discomfort | 8 | 12 | 12 |
| *Dryness of the mouth or nose | 3 | 16 | 13 |

* Denotes Significance

**Appendix D: Subjective responses comparing symptoms of ocular comfort. Results presented as number of subjects whose symptoms increased during the task, number of subjects whose symptoms remained the same during the task and number of subjects whose symptoms decreased during the task. Significant findings marked by an asterisk (*).**

# Appendix E




**Appendix E: Graph of significant ocular comfort results. Each data point shows the number of subjects whose symptoms increased, decreased or remained the same during the task.**