Adaptation to blur in myopic and emmetropic individuals

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1. Abstract

Background

The human eye is known to adapt adequately to a number of different changes in the environment to the point were the perceived blur can lessen noticeably. In this experiment we looked at the respective abilities individuals with myopia (nearsightedness) and emmetropia (normal visual acuity) to adjust to artificially-administered blur. We hypothesized that the myopic participants would be more adept at adapting quickly to changes than their emmetropic counterparts.

Methods

We used a computer program in which participants (a total of twelve altogether) evaluated the relative difference in shade between two differently sized dots. When the subject marked that the first circle was lighter it darkened and when he or she marked it as darker it lightened for the next trial.. Then, using prescription lenses added to special glasses, we blurred their vision and had them repeat the process.

Conclusions

Comparing the results between the group of nearsighted participants and normal-sighted participants we found that emmetrope seem to be more affected by external blurs than myopes as we hypothesized. We propose this could be due to reoccurring exposure to sudden blurs experienced by the latter group.

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2. Introduction

It has been said that eyes are the gateway to the soul. While this statement may not be provable in a scientific manner, it is certain that eyes are one of the major gateways for the mind to experience the outside world. To capture and process visual input the eye and visual system as a whole must meet the needs of the environment in all of their complexities. For the nearly 75 percent of Americans that make use of corrective lenses, however, part of this sensory system falls short of what is required (Ellisor, 2011). Despite certain deficits in function, studies show that there may be advantages to having difficulties in vision.

Humans are excellent at adapting to the world around them – that includes the blurriness of the world as it is perceived by those who have need of external correction for their vision. Studies have found that after an extended period of exposure to blurred stimuli images are perceived as sharper than is expected for the sensory information being administered (Webster, 2002). It is thought that neural aspect of the visual system adapts to the aberrations of the eye, thereafter removing much of the blur and abnormal effects from the image (Artal, 2004). Furthermore, Yehezkel et al. found that people have the capacity to use previously learned mental distortions of stimuli to correct different stimuli with moderate speed (2009). In fact according to that same study, participants needed only two four-hour periods of exposure to fully adapt to experimentally simulated astigmatism (2009).

We hypothesize that compared to emmetropic individuals, those with 20/20 vision, myopic participants will adjust to external blurriness more rapidly and be less impacted by the sudden change in vision just as astigmatic subjects have been recorded to do in prior studies (Vinas 2012).

2 Materials and Methods

2.1 Ethics Statement

All participants were familiarized with the processes of the experiment prior to their involvement. Each provided informed written consent according to the protocols enlisted by the International Review Board for Human Participants (IRB).

2.2 Participants

The sample attained consisted of 13 individuals who volunteered in response to posters placed throughout the University of Minnesota –Twin Cities Campus. Due to technical errors, however, only 12 participants recorded data. The age of these participants varied greatly, from 18 to 50, although the majority of participants fell within the range of 18 to 24 years old. Of these 7 self identified as male and 5 identified as female (58.33% and 42.66% respectively. 10 participants denoted their race as white, 1 as Black, and 1 as Indian (83.33%, 8.33%, and 8.33% respectively) From this sampling participants were separated into two groups based upon visual acuity. The first group consisted of 6 myopic (nearsighted) subjects that reported consistently wearing glasses or contacts to correct their vision. The second group contained 6 emmetropic (hereafter referred to as normally sighted) individuals.

Subject Number	Prescription (Left Eye)	Prescription (Right Eye)
1001	None	None
1002	n/a	n/a
1003	None	None
1004	-3.75	-3.25
1005	None	None
1006	None	None
1007	-1.25	-1.25
1008	-.5	-.5
1009	-4.5	-3.5
1010	None	None
1011	None	None
1012	-1.75	-1.75
1013	-2.0	-2.0

Table 1 Participant prescription as stated before admission to experiment.

2.3 Materials

Participants were given glasses frames that contained three slots for lenses at the beginning of the experiment. Lenses were added to directly mimic the prescriptions of individuals in the myopic group while, the normal-vision group was instructed to wear these frames without lenses in order to control for the frame itself. This state can be referred to as the clear condition. Later on +1.75 lenses were added to the frames regardless of group to create the blurred condition. MATLAB was chosen as the program on which to the run experiment.

2.4 Stimuli / Visual Task

The experiment consisted of two main sections: the practice and the test. Both sections occurred in a dimly lit room with the participant sitting exactly 1 meter from the 50 cm screen. On the screen, a black and white photo of San Francisco served as the background (Fig. 1). Then a red square appeared randomly on the screen briefly. Participants were asked to follow the square with their gaze; focusing on the center of the square later assured they would focus on random details of the picture and thus perceive how blurred the image became. After the square disappeared another identical red square flashed momentarily in the center of the screen in order to direct focus back to the middle of the screen and signal that the next trial was about to begin. At the same time as this square appeared the computer emitted an auditory beep to further alert the subject that they need to focus on the upcoming stimuli. Following this, a light gray circle appeared in the direct center of the screen. Immediately thereafter a large gray circle flashed in the center of that circle (Fig 2A), followed by a smaller circle (Fig. 2B). Participants were asked to denote which of these inner circles they perceived to be lighter by pressing a button on their keyboard; “n” corresponded to the first, larger square while “m” corresponded to the second, smaller circle. Each time the participant declared the first circle to be lighter the program darkened that circle for the next round and similarly when the subject declared the first dot to be darker it lightened. Despite its name the practice section functioned as more than a manner of familiarizing subjects with the controls. The practice section narrowed in on the average level at which the 2 internal circles appeared to be the same shade. The test section started the larger internal circle at this value.

The test section differs fundamentally from the practice section in that after 6 instances of interpreting the relative lightness of the internal circles each 10 seconds apart the participant was asked to close their eyes while the attending researcher would place +1.75 lenses in the subject’s frames in order to switch from the clear to blur condition. Then, the subject was instructed to open their eyes and press any key at the same time to activate the next set of stimuli without giving his or her vision time to adjust. After 6 more, the researcher removed the lenses to return to the clear vision, and so on until 14 rounds of each condition have been fulfilled.

Fig. 1. Black and white skyline of San Francisco used as background to the stimuli

Fig. 2A. Large internal circle surrounded by outer circle and background

Fig. 2B. Small internal circle surrounded by outer circle and background

2.5 Data Analysis

An independent samples two-tailed t-test at a .05 level of significance was used to determine the effect.

3.Results

Upon each completion of the experiment the values of the large internal circle at each point in time were recorded directly into the database. The process consisted of 11 instances of stimuli each 5.45 seconds apart so one trial lasted for slightly less than a minute (59.95 seconds). Each participant completed 14 trials in a clear state and 14 trials in a blurred state. These trials were averaged together. Then the individual averages were themselves averaged according to group – myopic or emmetropic. Subsequently these averages figures were graphed together for comparison. (fig. 3).

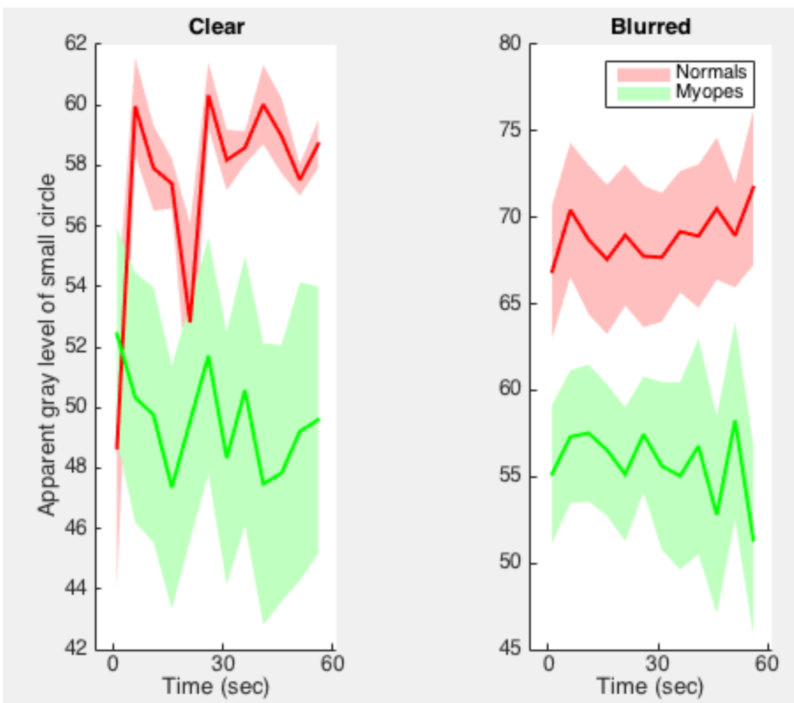

Fig. 3. Average values within each group at a given time

It is clear from the graph that in the majority of cases participants in the normal visual acuity group perceived both blurred and clear stimuli as lighter than the myopic participants. Two 2 independent samples 2 tailed t-tests show that in each case the average value, with all times having been combined, is significantly different in both conditions. (The critical value of t for both cases fell as 2.08. While in the clear and blurred situations the observed values of t proved to be 12.8 and 22.5 respectively). Similarly, the values both groups raised significantly when transferring from the clear to blurred conditions. (With t_{crit} still at 2.08 normal and myopic subjects recorded observed t values as 19.5 and 9.8 respectively).

More importantly, the difference between the changes of the normal and myopic groups also shows significance. The observed t value of this difference was 9.8 compared to the critical value that again fell at 2.08. The mean perceived gray value went up 5.8 points for the myopic group when switching from clear to blurred stimuli while the same change resulted in a 11.7 increase in value for normal participants. With standard deviations of 2.3 and 1.9 respectively the gap between these means is unlikely to have occurred by chance, therefore we reject the null hypothesis that blurring stimuli has the same effect on myopic and normally sighted individuals. This last test is especially important as it correlates directly to the hypothesis.

4. Discussion

It was found that the emmetropic group exhibited greater change when blurred lenses were added to their vision as a result of lacking the experience myopes encounter by removing their glasses and needing to adjust to some sort of blur daily. As a result of frequent adaptation to blur the myopes seem likely to be able to adjust to such a positive blur – one that shits in the same manner as when they remove their glasses outside of the lab – much more quickly and thoroughly than those who have no practice doing so. It has been proven that repeatedly practicing a specific visual task can lead to significant long-term improvement in regards to said task (Fahle, 2002). This would work to explain why the myopes' darkness values when blurred fell close to the values in the clear condition, but the emmetropes values were further apart. The myopes adjusted more fully.

4.1. Possible Sources of Error

The most likely source of error in this experiment comes from the limited number of participants. Expanding the number of participants would greatly benefit this study by accounting for individual differences. Additionally, on occasions the use of a shared lab resulted in some noise in the background that could have distracted certain subjects. A silent room in which all variables could be controlled between participants would also ensure more accurate results.

4.2. Future Research

Hopefully, now that it is known being subjected to blurs consistently over time helps to quickly and thoroughly adapt to new occasions of blur, future strides can be made in helping non-myopic individuals to better prepare themselves for times when vision is not as clear as typical whether as a result of smudges in sunglasses, rainwater on the windshield, teary eyes, or any other of a wide variety of circumstances in which a fuller adaption would be helpful. Furthermore, previous studies have found that the learned ability to adapt to extreme external blurs has been linked with an increase in visual acuity overall, even in times of clear vision (Pesudovs, 1993).

Perhaps further experiments in this field could help researches learn more about learning in general as well as more is learned about the long-term affects of continually adapting to a specific effect.

4.3. Researcher Contributions

Designed experiment: SE, PA. Coded MATLAB test: SE. Ran participants: DL. Analyzed the data: DL. Conducted research: DL. Wrote scientific article: DL. Supervised the experiment: SE.

6. Works Cited

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