Differences in adaptability to nearpoint visual stress and psychological stress between late-onset myopes and early-onset myopes

Timothy Daniel Nelson
Pacific University
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Abstract
For many years the exact mechanisms of environmentally induced myopia have been sought. Many have investigated the roles played by the accommodative and vergence systems in this type of myopia. The present study sought to expand the knowledge base regarding the role of the vergence system by comparing the vergence adaptability of late-onset and early-onset myopes. Fixation disparities were measured on forty first year optometry students, before and after a nearpoint task comprised of reading while wearing base out prism. Information comparing the levels of psychological stress and anxiety between the two groups was also gathered, using the State-Trait Anxiety Inventory and the Stress-Arousal Check List. No significant differences were found in the fixation disparity data. In the psychological stress/anxiety data one significant difference was found between groups regarding trait anxiety. Conclusions and suggestions for future work are discussed.

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DIFFERENCES IN ADAPTABILITY TO NEARPOINT VISUAL STRESS AND PSYCHOLOGICAL STRESS BETWEEN LATE-ONSET MYOPES AND EARLY-ONSET MYOPES.

By

TIMOTHY DANIEL NELSON

A thesis submitted to the faculty of the College of Optometry Pacific University Forest Grove, Oregon for the degree of Doctor of Optometry May, 1990

Adviser:
Dr. Bradley Coffey
DIFFERENCES IN ADAPTABILITY TO NEARPOINT VISUAL STRESS AND PSYCHOLOGICAL STRESS BETWEEN LATE-ONSET MYOPES AND EARLY-ONSET MYOPES.

TIMOTHY NELSON

Accepted for the faculty of the College of Optometry, Pacific University in partial fulfillment of the requirements of Doctor of Optometry.
May 20, 1990

Advisor's Signature: [Signature]
Date: 5/20/90
BIOGRAPHY

Timothy Nelson was raised in the small town of Sublimity, Oregon. He attended four years of undergraduate studies at Western Oregon State College, and has a BS degree in Visual Science. Graduate studies were performed at the Pacific University College of Optometry, where he will receive his Doctorate in Optometry in May, 1990. Mr. Nelson has accepted the commission of Captain, United States Air Force, and has been assigned to Norton AFB, San Bernardino, California.
ACKNOWLEDGEMENTS

Thanks to Mr. Steve Agnes and Mr. Brad Parsons for their help in collecting data for the experiment. Thanks to Dr. Niles Roth for answers and suggestions. A very big thank you is owed to Dr. James Lane, of the Oregon Graduate School of Professional Psychology, for much help in understanding concepts and mechanisms involved in anxiety and psychological stress. Also for Dr. Lane's valuable assistance in finding the STAI and SACL tests used in this study. A huge debt of gratitude is also owed to my adviser, Dr. Bradley Coffey, whose input and ideas kept me on track, who offered much patience and encouragement, and who invested a great deal of his own time and effort.
ABSTRACT

For many years the exact mechanisms of environmentally induced myopia have been sought. Many have investigated the roles played by the accommodative and vergence systems in this type of myopia. The present study sought to expand the knowledge base regarding the role of the vergence system by comparing the vergence adaptability of late-onset and early-onset myopes. Fixation disparities were measured on forty first year optometry students, before and after a nearpoint task comprised of reading while wearing base out prism. Information comparing the levels of psychological stress and anxiety between the two groups was also gathered, using the State-Trait Anxiety Inventory and the Stress-Arousal Check List. No significant differences were found in the fixation disparity data. In the psychological stress/anxiety data one significant difference was found between groups regarding trait anxiety. Conclusions and suggestions for future work are discussed.
INTRODUCTION

Over the years many researchers have investigated and reported their speculations and conclusions as to the etiology of myopia. There have been nearly as many different causes of myopia theorized as the number of people writing on the subject. Several have attributed it simply to heredity (Stieger, cited in Goldschmidt, 1968; Duke-Elder, 1949; Sorsby, et al., 1957; Ren-yuan, et al. 1983; Hu, cited in Press, 1987), or physiology (Emsley, 1953). Donders, in 1864, postulated excessive use of the eyes as a cause. Numerous writers since then have recognized the genetic etiology for some myopias, but have also investigated the part that prolonged near visual activity plays in the cause of myopia (Cohn, cited in Goldschmidt, 1968; Young, 1958; Goldschmidt, 1968; Curtin, 1985; Birnbaum, 1984; Ebenholtz, 1983; Gilmartin and Bullimore, 1987). Although there is now a great deal of evidence in the literature in support of the "environmental" model linking near work and myopia, it is still unclear as to just which aspect of near work is the culprit, accommodation, vergence, or both, or some other factor altogether.

To better differentiate the genetic and environmental etiologies of the myopic condition, work has been done in recent years with subjects in two categories: Early-onset myopes (EOM's), for whom genetic factors are considered primary, and late-onset myopes (LOM's), for whom environmental factors are thought to be the primary etiological factor. The age of myopia onset which differentiates EOM's and LOM's has been set at 15 years by many investigators (McBrien & Millodot, 1988; Gilmartin & Rosenfield, 1987a; Goss & Winkler, 1983; Slataper, 1950), though Gilmartin and Bullimore (1987) have stated that this age cut-off is oversimplified. Most subjects will recall their age of onset as the age that they first received spectacles or contact lenses, even though their decrease in distance visual acuity due to myopia may have begun much earlier. It is also noted that the human eye has reached adult dimensions by the age of 13 years. (Sorsby, et al., 1957; Larsen, 1971)

The major environmentally-related factors thought to play a role in "induced myopia" (myopia as an adaptive change secondary to nearpoint visual stress [Birnbaum, 1985]), are accommodative hysteresis and convergence driven accommodation. Ebenholtz (1983) has suggested that hysteresis of tonic accommodation may be a precursor to myopia. Recent evidence confirms that LOM's demonstrate statistically significant myopic shifts in TA after near tasks, whereas EOM's and emmetropes do not (McBrien & Millodot, 1988, Gilmartin and Bullimore, 1987).

What role, then, is played by the vergence system? Birnbaum (1985) theorizes an esophoric shift in myopes after sustained near viewing, suggesting the
susceptibility of the vergence system to near point stress. Research has also shown significantly higher levels of accommodation induced by convergence during near tasks in LOM’s, compared to EOM’s or emmetropes during the period (Gimartin & Rosenfield, 1987a). Given that Birnbaum's theory is correct, it may be that nearpoint stress-induced esophoria causes an associated increase in convergence accommodation via the CAC/C cross-coupling. Adaptation within the vergence system would serve to lessen any such events. If this line of reasoning is true, it would appear to be somewhat at odds with the hypothesis of the present study.

Since the present study is interested in investigating the adaptability of the visual system after undergoing prolonged near work with a cognitive demand, or "visual stress", an accurate index of the induced stress was needed. Fixation desparity (FD) was chosen as this measure because it has previously been shown that FD will be present when binocular alignment, or fusion, is under stress (Mallett, 1964). Pickwell, et al (1989) have recently found that a reading task alone, under normal lighting and working distance (40cm) conditions does not increase FD, but when an additional stressor is introduced, such as prism, low illumination (Pickwell, et al, 1987a), or "abnormally" close working distance (20cm) (Pickwell, et al, 1987b), the FD shows a greater increase. It is also found that most of the change in FD occurs in the first ten minutes of a task (Pickwell, et al, 1987a).

Evidence indicates that under identical conditions the forced vergence FD curves (in which FD values are plotted versus the amount of prism which induces said FD(Sheedy and Saladin, 1983)) are "basically unchanged from moment to moment or day to day." (Schor, 1980) This impressive stability of the FD curve was also supported by Jones & Saladin, (cited in Daum, 1983). BO prism generally induces an EXO shift in FD, and BI prism generally induces an ESO FD shift (Pickwell, et al, 1987a; Sheedy and Saladin, 1983) when measurements are taken with the prism in place. It should be kept in mind however, that when FD’s are taken immediately after the use of prism the effects are just the opposite (i.e. FD just after BO prism use is expected to yield an ESO change in FD.)

Many of the current theories on induced myopia are centered around the idea of over stressing the visual system, and more specifically, arousal of the autonomic nervous system (Birnbaum, 1984). Hence, this study seeks any possible correlations between reactions to general, psychological stress, and reactions to visual stress. As
previously mentioned, FD was selected as the measure of visual stress, while anxiety was chosen as the feature of psychological stress to be measured. Anxiety is most commonly described as an emotional state characterized by subjective feelings of tension, apprehension, worry and nervousness, and by activation or arousal of the autonomic nervous system. It is also used in psychology to describe the complex process that occurs as a reaction to stress. (Spielburger, 1977).

Korchin (1963) states that "Anxiety is the most important among emotional stress reactions." If one has made an adaptation to their stress, that person will generally exhibit less anxiety. There are two categories of anxiety. State anxiety is the transitory or state-dependent anxiety brought about by a specific stimulus or situation. Trait anxiety is not directly manifested in behavior, but is the person's underlying level of "anxiety-proneness" (Spielburger, Gorsuch, et al, 1970). Those with higher trait anxiety are "more vulnerable to stress and tend to experience state anxiety reactions more frequently and often with greater intensity" (Spielburger, 1977) than those with lower trait anxiety.

Previous authors have examined numerous hypothesized correlations between psychological factors and different visual refractive conditions. Among them have been the classic and widely applied stereotypes of the "myopic introvert" and the "hyperopic extrovert" (Rice, 1930). Myopes have been shown to have higher achievement needs; a "need to do one's best, and to be successful at whatever task is undertaken"; higher intraception, or analyzing one's own motives and feelings; a greater need to seek the "encouragement of others"; and an increased tendency to "accept blame when things do not go right" (Young, 1963). Myopes are also more demanding, defensive and more persevering (Randle, cited in Gawron, 1981), more overcontrolled, and more tolerant of anxiety. (Lanyon and Giddings, 1974). Young (1963) and Stevens and Wolff (1965) found that although myopes are not inherently more intelligent, they do as a group tend to be better students.

Since it is widely held that the late onset myope is a product of induced myopia - or rather has made an adaptation to the visual stress of his environment - it is expected that LOM's in this study will show greater adaptation to the visual stress task as evidenced by relatively greater immediate post-task ESO FD values, and that the LOM's will show greater adaptation to psychological stress by showing lower levels of both trait and state anxiety.
METHODS

Subjects

Forty-six students from the 1st year class at Pacific University College of Optometry were screened for participation in the research project. Of these, forty were utilized as subjects on a volunteer basis, and were compensated by being given extra credit points for one of their optometric courses. They were between the ages of 21 and 35, with the mean age being 24.5 years. Degree of myopia ranged from 0.62D to 8.00D, and no subject had greater than 2.00D of astigmatia. Refractive status was verified by checking each person’s most recent (within six months) visual examination record. No subject had existing or previous pathology that had permanently altered their vision. All subjects used in the project had monocular best corrected visual acuity of at least 20/20 (6/6), and normal stereopsis (40” for 36 subjects, 50” for 2, 60” for 1 and 80” for 1 subject), as tested with the Titmus circles on the Stereo Fly test.

Objective Testing

The visual stressor imposed on the subjects was a combined reading/BO prism task. Each individual was asked to read a selection of attentionally demanding reading material for 15-20 minutes while wearing the habitual distance lenses and viewing at 40cm through 6^BO prism (3^BO each eye) and polarizing filters. The polarizing filters were utilized in conjunction with polaroid “bar readers” that were moved by the subjects, such that they always covered areas of text being read. If the subject suppressed during the task one or more of the bars on the bar reader would appear black and reading would be interrupted. Should this occur subjects were instructed to blink several times and look to the far side of the room for about 10 seconds, then continue reading. To help insure attention to the task, participants were told that they would be given a quiz on the reading material.

Fixation disparity was used to measure the effects of visual stress associated with the reading task. Forced vergence fixation disparity curves were plotted just prior to, and just after the reading task using the protocol developed by Sheedy (1980). Disparity was measured at vergence demands of habitual, 3^BI, 3^BO, 6^BI and 6^BO using the Sheedy Disparometer with one trial being taken from the ESO direction and one from the EXO direction (alternately) at each vergence demand level. Copies of the data recording forms are included in Appendix 1.

Lighting was provided by a 75 watt photography lamp facing the Disparometer and at a distance of 81-89cm. Some illumination was also provided by the standard overhead floourescent lights of the testing room.

Subjective Testing
Each participant completed two self-evaluations determining pre-task and post-task states of stress/anxiety. The first, is the State-Trait Anxiety Inventory (STAI). This is a test of the subject's "trait anxiety", or the underlying anxiety level, as well as their "state-dependent" or situational anxiety (Spielburger and Gorsuch, 1970), and was administered just prior to the pre-task FD and the reading task itself.

The post-task measure used was the Stress Arousal Check List (SACL), a measure of the individual's situational levels of stress and arousal (King, et al, 1983). This test was administered just after the post-task FD.

**Data Analysis**

Data were statistically analyzed using a two-tailed t-test. Secondary to the previously presented arguments of Gilmarin and Bullimore (1987), Sorsby and Davey (1957), and Larsen (1971), analysis of the data was performed at two separate age cut-offs. The first run was with the cut-off age set at 15 years, the second at 13 years.
RESULTS

Analysis of the pre-task and post-task FDs, and the change in FD from pre- to post-task at both the 15 and 13 year cut-offs showed very little difference between groups in either magnitude or direction. Although there were no statistically significant differences between groups on FD values, it might be noted that the LOMs had consistently greater ESO (or less EXO) FDs with either BO or BI stimulus. Table 1 gives mean values, standard deviations (SD), and probabilities for each group.

Differences between groups on psychological stress, as measured by the SACL, showed little difference in direction or magnitude, and were not significant.

Values for the anxiety scores, measured by the STAI, for the 13 year old-cut off data showed no statistical difference between groups. Unexpectedly, data for the 15 year old cut-off group showed the trait anxiety scores of the LOM subjects to be significantly higher (p<.05). This is opposite the direction of trait anxiety values predicted by the hypothesis.

As one would predict, the EOM subjects had mean RX values of higher minus lens power than did the LOM subjects. Taken to the nearest 0.25D the LOM’s mean lens values were -2.25D (OD, OS; 15 and 13 year old groups). EOMs mean lens values were -3.75D (OD, OS) in the 15 year old groups, and -4.00D (OD,OS) in the 13 year old group.
DISCUSSION

The hypothesis addressed in this study was that LOM's are more adaptable to visual and general stress than EOMs. We therefore expect LOM's to show relatively greater post-task (after completing a stressful nearpoint visual task) ESO FD, and also to have lower anxiety scores. As can be seen in the analysis of the data, the results yield no statistical support for greater post-task ESO FD or lower anxiety scores among LOM's in this study. Since we cannot look to the statistical analysis for confirmation of the hypothesis, one needs to perhaps look elsewhere to explain the lack of evidence.

Let us first consider the portion of the hypothesis regarding visual stress. Although the author's prediction of LOM's having greater tendency toward ESO FD's was not statistically supported, this group did consistently display ESO FD's of greater magnitude than those for the EOM's. Why didn't these values reach statistical significance? Obviously, confounding factors might have played some role. A lack of difference between groups might have been due to some factor intrinsic to myopia in general, both early-onset and late-onset myopia. In this case a more appropriate design would have tested LOM's vs. emmetropes, or might have included all three groups.

The small between-groups differences neither prove nor disprove the question posed in this study. When this research was undertaken the available literature did appear to support the hypothesis. Evidence was given that during near tasks LOM's have significantly higher levels of accommodation induced by convergence than EOM's or emmetropes (Gilmartin and Rosenfield, 1987a). It follows, then, that nearpoint stress-induced esophoria may cause an associated increase in convergence accommodation through the CAV cross-link.

The present study attempted to analyze adaptability to near stress, but did not differentiate between accommodative and vergence adaptability. A very recently published study indicates that there may, indeed be an inverse relationship between the adaptability of the accommodation and vergence systems (Schor and Horner, 1989). Schor and Horner now believe that the higher the adaptation of tonic accommodation, the lower the AC/A will be, and that subjects with lower adaptation of tonic vergence will exhibit a higher CA/C. Although FD is a very good indicator of vergence adaptability, if the present study were to be undertaken again, in light of Schor and Horner's work, the author might predict lower vergence adaptability (associated with greater accommodative adaptation) in LOM's. Since the present study found no difference between the groups, and therefore does not support this prediction, then if Schor and Horner are correct the presence of some flaw in the experimental design (such as a too small group of
experimental subjects given the apparent lack of robustness of the adaptation phenomena) of the present study must be acknowledged. Likewise, if a difference between groups could not be expected, then one would presume a flaw in Schor and Horner's study. In this particular case, a more appropriate solution might be to appraise accommodative adaptability instead of vergence adaptability, with the previous literature predicting the higher values in the LOM group (Gilmartin and Rosenfield, 1987a).

The assessment of general stress between groups in this investigation also showed little between-groups difference in stress, arousal, or state-anxiety. A significant difference between groups opposite the predicted direction was found in the trait-anxiety scale, however the number of variables analyzed was large enough to account for this significant finding on the basis of chance alone.

Although the STAI and SACL have been shown to be reliable and valid tests (King, Burrows and Stanley 1983; Spielburger and Gorsuch 1970), the context in which these two tests are generally utilized compared with that of the present study may have accounted for some of the lack of variation between groups. In this investigation both tests were used to differentiate two groups. Most frequently these tests are used in comparing an individual's reactions to differing environmental or psychological situations (Burrows, Cox and Simpson 1977; Ray and Fitzgibbon, 1981; Auerbach 1973), or the same situations at different times (Watts, Cox and Robson 1983), not to compare groups to each other. These scales are also used extensively to note change or lack thereof in patients undergoing psychological therapy (Gotlib and Robinson 1982; Johnstone, et al 1980).

It should be noted here also that comparing LOM's with emmetropes rather than, or in addition to EOM's may have lent itself to less confounding of the variables.

In conclusion then, it is noted that the data of this study neither prove, nor disprove the original hypothesis. Possible flaws in the hypothesis have been considered, and it is suggested, in light of recent research, that a viable new hypothesis could be tested in the future. Namely, the new hypothesis would predict that LOM's have higher accommodative adaptability, but lower vergence adaptability (hence lower post-task ESO FD) relative to emmetropes instead of, or in addition to, EOM's.

At present it is unclear whether the STAI and SACL are appropriate scales in this particular study, and more appropriate tests have not been found to date.

Comparing the stress adaptability between these two groups would probably be
best suited for a separate, self-standing study, which compares stress reactions of the groups to a discrete stressful situation (e.g., final exams) rather than comparing habitual stress levels between groups.
BIBLIOGRAPHY


Watts C, Cox T, Robson J. Morningness-eveningness and diurnal variations in

TABLE 1

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FD's in prism diopters
Rx's in diopters
probability values are between means of LOM and EOM groups
PR is pre-task FD
PS is post-task FD
SUBJECT SCREENING

Name____________________
Date__________ Time________
Male / Female

1. Current age ____ DOB ______

2. Age of onset of myopia (or, when did you get your 1st pair of corrective lenses?) ______

3. Did you perform demanding near-point tasks with excessive frequency or duration as a child? Y N
   as an adult (≥ 14 yo)? Y N

4. Are either or both of your parents myopes? Mo Fa Both
   If yes, at what age did they become myopic? Mo ____ Fa ____

5. Did either parent perform nearpoint tasks with excessive frequency or duration as a child? Mo Y N Fa Y N

6. Have you had any pathology (ocular or systemic) which has permanently altered your vision? Y N

7. VA (corrected) near
   OD___ OS___ OU___
   far
   OD___ OS___ OU___

8. Titmus Stereo Test arc min ______

9. Rx OD_________ OS_________
**DATA COLLECTION: FIXATION DISPARITY**

- subjects wear habitual Rx

Prism worn by subject

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