ASSESSING THE RELATIONSHIP BETWEEN ACCOMMODATIVE RESPONSE AND VARYING WORKING DISTANCE USING DYNAMIC METHODS

by

Kristin Marie Bratek
Leanna May Pender

This paper is submitted in partial fulfillment of the
requirements for the degree of

Doctor of Optometry

Ferris State University
Michigan College of Optometry
May, 2016

ASSESSING THE RELATIONSHIP BETWEEN ACCOMMODATIVE RESPONSE AND VARYING WORKING DISTANCE USING DYNAMIC METHODS

by

Kristin Marie Bratek
Leanna May Pender

Has been approved
____ May, 2016

APPROVED:

____
Faculty Advisor: Paula McDowell, OD

[redacted]

ACCEPTED:

____
Faculty Course Supervisor

Ferris State University
Doctor of Optometry Senior Paper
Library Approval and Release

ASSESSING THE RELATIONSHIP BETWEEN ACCOMMODATIVE RESPONSE AND VARYING WORKING DISTANCE USING DYNAMIC METHODS

We, Kristin Bratek & Leanna Pender, hereby release this Paper as described above to Ferris State University with the understanding that it will be accessible to the general public. This release is required under the provisions of the Federal Privacy Act.

____

Doctoral Candidate(s)

____

Date

ABSTRACT

Background: Two common dynamic clinical techniques used to quantify a patient's accommodative response/posture are Nott retinoscopy and Monocular Estimation Method (MEM) retinoscopy. A standard test distance of 40 centimeters (cm) is utilized in both of these methods. However, outside of clinic, it is not uncommon for patients to hold their near work at distances other than 40 cm. This project will explore how other working distances affect the accommodative response. *Methods:* The design of this research project utilized Nott retinoscopy, MEM retinoscopy and the WAM-5500 auto-refractor for estimating accommodative response. Each technique was performed on the subject's right eye at three different test distances: 25 cm, 40 cm, and 50 cm. *Results:* When evaluating the MEM method using a one-way analysis of variance (ANOVA), we determined that the accommodative lag differed between the three working distances ($p = 0.0377$). A one-way ANOVA was also performed on the Nott retinoscopy data with a corresponding p-value of 0.8700. The Nott method showed the working distance did not significantly change the accommodative lag measurement. Next, both methods were analyzed using two-way ANOVA. Together, the data did not show a statistically significant relationship between the change in working distance to accommodative posture with $p= 0.06416$. *Conclusion:* Based on the analysis of our data, we cannot conclude overall that the accommodative response changes with different working distances; however, our results did reveal that the answer may be dependent on which dynamic test is used. MEM retinoscopy showed that the working distance does in fact change how much a patient may under/over focus on a target. Conversely, Nott retinoscopy did not show a significant change in measurements with respect to the target

distance. Therefore, when evaluating accommodative response at working distances other than 40 cm, the two methods cannot be used interchangeably.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION OF ACCOMMODATION AND ITS EFFECT ON BINOCULAR VISUAL SYSTEMS

Accommodation is the process by which the crystalline lens changes its dioptric power in order to create clear vision for targets closer than optical infinity.[1,2] Accommodation is a blur driven phenomenon directed by numerous physiologic factors involved in seeing clearly. These physiologic components leading to proper accommodative responses include proximal (the physical near location of the target), tonic (the natural accommodative position of rest), reflex (the initial automatic response to blur), vergence change (binocular eye movements in response to near or far targets) and the balance between parasympathetic (pupillary constriction and the near triad) and sympathetic (pupillary dilation) neural pathways.[3]

The purpose of dynamic accommodation testing is to determine the accuracy of a patient's focusing system, and indirectly to test binocular function.[3] When a patient is fully corrected we can expect these accommodative values to fall within a specific range, otherwise, values outside of the normal values may raise suspicion of accommodative or binocular disorders.[1,2] For example, when a patient focuses on a target at an average working distance of 40 cm, we can expect them to actually be focusing +0.25 diopters (D) to +0.75 D behind the target, a value known as the accommodative lag. Values above +0.75 may suggest under-accommodation and cause the practitioner to consider disorders of accommodative insufficiency, high esophoria or reduced negative fusional vergence.[1] If the value is less than +0.25 D, we refer to this as an accommodative lead. Values less than +0.25D may suggest over-accommodation and clue the practitioner into disorders of accommodative excess, high exophoria or reduced positive fusional vergence.[1]

Common dynamic clinical techniques used to quantify a patient's accommodative response/posture are Nott retinoscopy and Monocular Estimation Method (MEM) retinoscopy. A standard test distance of 40 centimeters (cm) is utilized in both of these methods. Historically, multiple studies illustrate that MEM and Nott retinoscopy techniques have been agreeable and highly repeatable when evaluating the accommodative response at this standard working distance.[4,5] However, outside of clinic it is not uncommon for patients to hold their near work at distances other than 40 cm. This study will explore how other working distances affect the accommodative response. To our knowledge, there are limited studies discussing how the accommodative response varies with working distances other than the standard 40 cm distance.

CHAPTER 2

METHODS & PROCEDURE

Fifty-six adults, aged 20-30, with grossly normal accommodative and binocular systems were used for this study. To qualify, participants were required to wear their most recent visual correction (contacts or glasses), and were screened for 20/20-20/25 monocular acuities at distance. A cover test was performed at near to ensure there was no strabismus present. If a patient met all requirements, his/her accommodative response was then assessed using three tests: Nott retinoscopy, Monocular Estimation Method (MEM) retinoscopy and the WAM-5500 autorefractor. The accommodative response (lag or lead) was evaluated on each patient's right eye at three different working distances of 50 centimeters (cm), 40 cm and 25 cm, always starting at 50 cm and proceeding inward toward the patient. The 50 cm (2 D demand) test distance was chosen to simulate a patient with longer arms, or one that simply prefers to hold their materials further away. The 40 cm (2.5 D demand) test distance is typically used as the standard for this population and was therefore also utilized as the control distance. The 25 cm working distance (4D demand) was chosen to simulate patients that prefer to hold reading materials much closer than the standard, likely putting their accommodative systems under increased stress.

Nott retinoscopy required the use of a phoropter, near point measurement rod, and 20/40 target in order to stimulate accommodation. The target was placed at each working distance and a lag/lead was measured using a retinoscope and the dioptric markings on the near point rod. MEM retinoscopy utilized loose lenses from -1.00 to +1.50 D in 0.25 D steps. The WAM-5500 autorefractor also included the use of a near point rod attachment to obtain the three working distances. In all techniques the patient was asked to view the target binocularly.

Three stations were set-up to obtain data. The participants were asked to wait at least two minutes in between each station to allow their accommodative systems to relax to their natural positions. Station one collected dynamic accommodation information using the WAM-5500 autorefractor. Subjects were asked to fixate and maintain clarity on a 20/20 Snellen target at 50 cm, 40 cm and 25 cm. The accommodative response was obtained at each distance and recorded.

Station two collected dynamic accommodation data using MEM retinoscopy. A response target was mounted on the retinoscope and each patient was scoped with a vertical streak of light. Subjects held a near point rod marked in centimeters at the center of their forehead. The retinoscope target was held at each of the three test distances. Subjects read the words on the near target out loud and the accommodative response was assessed by briefly (2-4 seconds) dropping loose lenses in front of the patient to determine the point of neutrality to the closest 0.25 D.

Station three tested dynamic accommodation using the Nott retinoscopy method. The accommodative target was placed at each working distance. Retinoscopy was performed with a vertical streak and the examiner either moved in front of or behind the target to neutralize the accommodative response. If the motion was initially seen as "with," the examiner moved backwards from the target until neutrality was found. If the motion was initially seen as "against," the examiner moved forwards until neutrality was obtained. The lag/lead was recorded to the nearest 0.25 D. The same examiner remained at each station to attempt to reduce inter-examiner error. A one-way ANOVA was used to analyze each of the techniques, and a two-way ANOVA was performed to look at the differences in the mean accommodative lag measurements as a function of working distance across the different techniques. This study was approved by the Ferris State University Institutional Review Board (IRB) committee and meets the requirements of the declaration of Helsinki.

CHAPTER 3

RESULTS

Accommodative lag measurements were successfully performed on fifty six adults using the MEM method, Nott method, and autorefraction. Autorefraction revealed a large variation of refractive cylinder on the majority of patients. For this reason, data from the autorefraction method was not further analyzed. For both MEM and Nott, data from all 56 subjects were included in the analysis for the 50 cm and 40 cm target distances. The data was limited to 54 subjects when analyzing the 25 cm test distances to exclude two outliers.

When first looking at the results, a histogram was created to find the distribution of the measurements. The expected normative value for accommodative lag lies within +0.25D and +0.75D.[2] When looking at the distributions, the majority of patients fell into this range for both MEM and Nott findings. The next largest frequency landed between the -0.25D to plano range for both methods. *Figure 1* and *Figure 2* show the distributions for MEM and Nott. A one-way ANOVA was used to asses for difference in mean lag measurements as a function of working distance for the MEM and NOTT methods.

Figure 1: MEM Lag Distribution Ranges

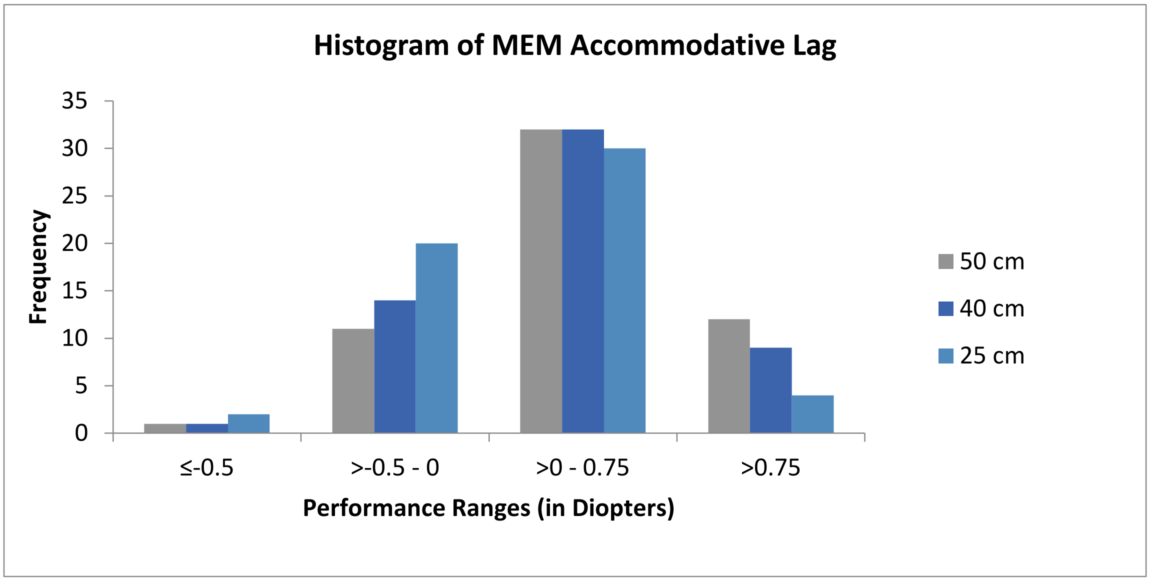
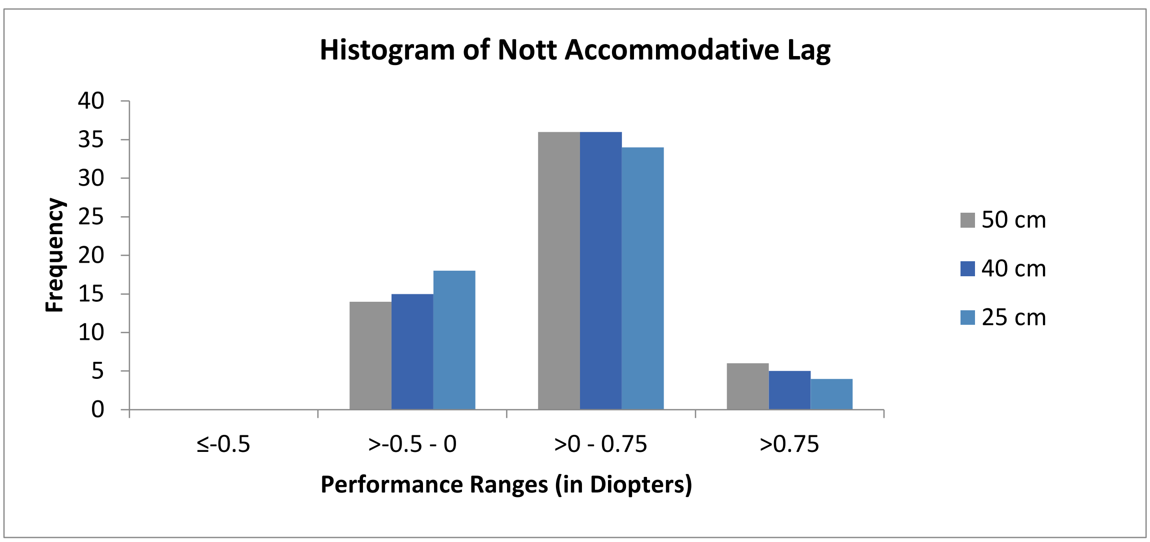


Figure 2: Nott Lag Distribution Ranges



The accommodative lag differed significantly between the three working distances when using the MEM method [$F(2, 163) = 3.34$, $p = 0.037$]. The average lag measurements for MEM at 50 cm, 40 cm and 25 cm respectively were as follows:

0.48±0.46 D, 0.43±0.49 D, and 0.26±0.47 D. More specifically, the accommodative response decreased, or became more negative, as working distance decreased when measuring with MEM retinoscopy.

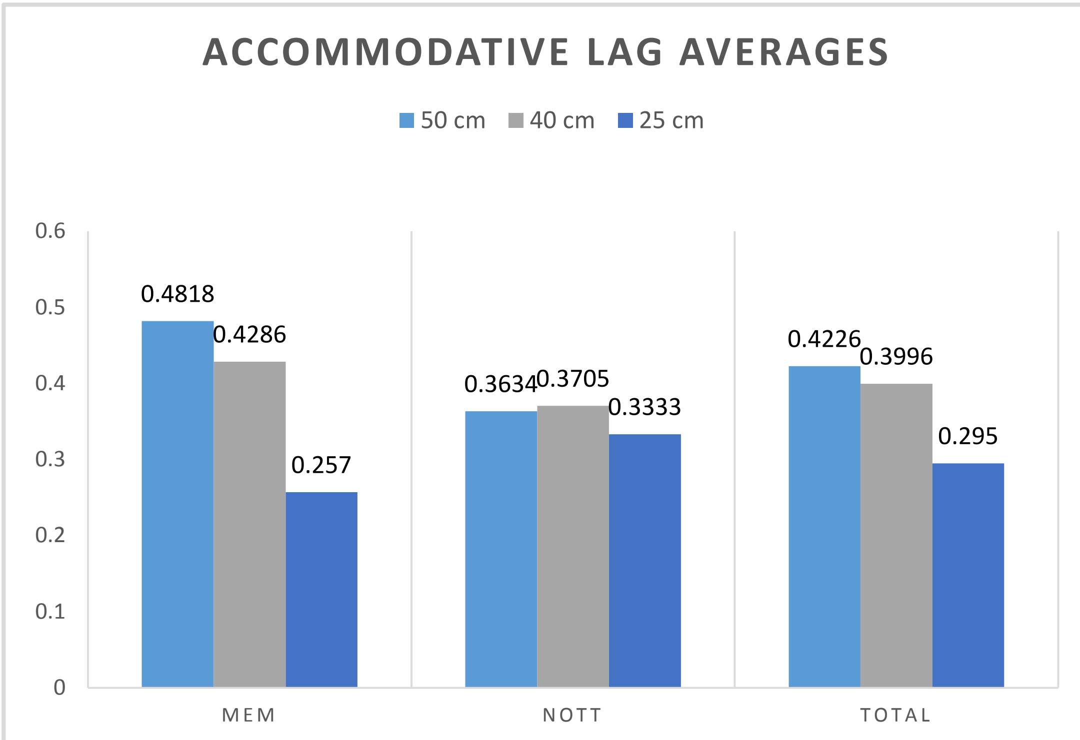
For the Nott method, the average lag measurements at 50 cm, 40 cm and 25 cm respectively were as follows: 0.36±0.44 D, 0.37±0.39 D, and 0.33±0.33D. It is not difficult to see that the accommodative lag did not vary considerably with target distance. For Nott retinoscopy, the mean accommodative lag with working distance was not statistically significant [$F(2, 163) = 0.14$, $p = 0.87$].

A two-way ANOVA was performed to look at the differences in the mean accommodative lag measurements as a function of working distance across the different techniques. The results were statistically non-significant [$F = (2, 2) = 2.77$, $p = 0.064$). This implies that under the conditions tested, any measured change in accommodative lag with working distance is not significantly different across the two techniques of MEM and Nott retinoscopy.

Table 1: Means, Standard Deviations, and p-values

	MEM	**Nott**
50 cm		
Mean (D)	0.4818	0.3634
SD (D)	0.4612	0.4405
40 cm		
Mean	0.4286	0.3705
SD	0.4941	0.3902
25 cm		
Mean	0.2570	0.3333
SD	0.4690	0.3329
p-value	0.0377	0.877

Figure 3: Accommodative Lag Averages



CHAPTER 4

DISCUSSION OF RESULTS

MEM and Nott retinoscopy are two clinical methods used to quickly test a patient's accommodative response. These tests typically use a single working distance to find the lag measurement. However, not all patients hold their reading material at this estimated average distance. This begged the question, do different reading distances change a patient's accommodative response? Our results revealed that the answer may be dependent on which dynamic test is used.

MEM retinoscopy showed that the working distance does change how much a patient may under/over focus on a target. Conversely, Nott retinoscopy did not show a significant change in measurements with respect to the target distance. We are unable to conclude whether working distance does in fact change a patient's accommodative response based on the differing data. It is, however, important to note that the two tests are similar at the standard working distance of 40 cm; but at the varied distances, the two dynamic methods cannot be used interchangeably. Therefore, the question now becomes, which method gives more accurate results, and how does this affect clinical testing?

The results showing that MEM and Nott retinoscopy give differing measurements is not something unique to this study. A study by Cacho et al. previously concluded that MEM showed greater values of accommodative lag.[6] It has been questioned whether inserting a lens in front of the patient is likely to influence results given that patients can quickly adapt to the lenses. For this reason, it was suggested that Nott was a superior test for finding accurate lag measurements. However, it can also be argued that estimating your scoping distance in Nott can be subjective, and less accurate than the MEM method. A study performed by the Pediatric Eye Disease Investigator Group (PEDIG) found results suggesting that both Nott and MEM retinoscopy actually underestimate lag of accommodation findings, specifically when testing myopes with lags greater than or equal to +1.00 D. They concluded that an open-field autorefractor is superior in these patients.[7] These differing inferences suggest that further studies must be assessed to find the validity of which method is superior.

There are several limitations to point out in our study. Our population only consisted of an age range of 20-30 year old students. The accommodative stresses on a graduate student are likely very different from that in children, and accommodative norms also differ across different aged populations. The time of day may also affect our clinical findings. A study repeating the measurements at different times of the day may help to reinforce the true measurements of each patient. In addition, patients were best corrected with either glasses or contact lenses. The type of correction was not taken into account while assessing the results in this study. The laws of optics dictate that contact lens corrected myopic patients accommodate more in their contacts compared to spectacles, while hyperopic patients accommodate more in their spectacles than in their contact lenses. These generalizations may also have an effect on the overall measurements collected. A more precise study would use the same type of correction in all patients, and include a larger sample size from which to draw from.

This research provides an informative starting point revealing that working distance may affect accommodative lag measurements. Further research assessing different age ranges and more objective techniques may help further conclude on this topic. Therefore, it is important for clinicians to know that different tests may reveal differing results. Furthermore, it may be important to get a better idea on where each patient typically holds their reading material, and then test at these distances to ensure the results are more applicable to each individual patient. This cuts out any generalizations we make when testing for accommodative and binocular vision disorders. On the other hand, if further research continues to show that distance does not have an effect on the accommodative response, then the clinical application means that optometrists do not have to be so exact in making sure that this test is performed precisely at 40 cm.

Special thanks to Dr. Vandana Rajaram for her assistance in the statistical analysis of the findings.

REFERENCES

1. Schieman, M. & Wick, B. Clinical Management of Binocular Vision. Philadelphia: Lippincott Williams & Wilkins; 2014:124-134
2. Optometric Clinical Practice Guideline Care of the Patient with Accommodative and Vergence Dysfunction. American Optometric Association. 2011. Available at: https://www.aoa.org/documents/CPG-18.pdf
3. Grosvenor, T. Primary Care Optometry. Philadelphia: Butterworth, Heinemann & Elsevier; 2007:81-85
4. Webb, Jon. (2014). *Comparison Of Various Clinical Techniques Used To Determine Accommodative Lag Of A Patient.*
5. Antona, B., Sanchez, I., Barrio, A., Barra, F., & Gonzalez, E. (2009). Intra-examiner repeatability and agreement in accommodative response measurements. *Ophthalmic and Physiological Optics, 29*(6), 606-614.
6. Del Pilar Cacho, García-Muñoz, García-Bernabeu, & López. (1999). Comparison between MEM and Nott dynamic retinoscopy. Optometry and Vision Science : Official Publication of the American Academy of Optometry,76(9), 650-5.
7. Manny, R., Chandler, D., Scheiman, M., et al. (2009). Accommodative lag by autorefraction and two dynamic retinoscopy methods. Optometry and Vision Science : Official Publication of the American Academy of Optometry, 86(3), 233-43.
8. Allen, P., O'Leary D. (2006). Accommodation functions: co-dependency and relationship to refractive error. Vision Research, 46(4), 491–505.

APPENDIX A

IRB FORM APPROVAL

FERRIS STATE UNIVERSITY

Institutional Review Board for Human Subjects in Research

Office of Academic Research, 220 Ferris Drive, PHR 308 · Big Rapids, MI 49307

Date: April 7, 2015

To: Dr. Paula McDowell, Kristen Bratek and Leanna Pender

From: Dr. Stephanie Thomson, IRB Chair

Re: IRB Application #150301 *(Assessing the Relationship Between Accommodative Response and Varying Working Distances*)

The Ferris State University Institutional Review Board (IRB) has reviewed your application for using human subjects in the study, *"Assessing the Relationship Between Accommodative Response and Varying Working Distances"* (#150301) and determined that it meets Federal Regulations *Expedited-category 2D.* This approval has an expiration date of one year from the date of this letter. **As such, you may collect data according to the procedures outlined in your application until April 7, 2016.** Should additional time be needed to conduct your approved study, a request for extension must be submitted to the IRB a month prior to its expiration.

Your protocol has been assigned project number (#150301), which you should refer to in future correspondence involving this same research procedure. Approval mandates that you follow all University policy and procedures, in addition to applicable governmental regulations. Approval applies only to the activities described in the protocol submission; should revisions need to be made, all materials must be approved by the IRB prior to initiation. In addition, the IRB must be made aware of any serious and unexpected and/or unanticipated adverse events as well as complaints and non-compliance issues.

Understand that informed consent is a process beginning with a description of the study and participant rights with assurance of participant understanding, followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document and investigators maintain consent records for a minimum of three years.

As mandated by Title 45 Code of Federal Regulations, Part 46 (45 CFR 46) the IRB requires submission of annual reviews during the life of the research project and a Final Report Form upon study completion. Thank you for your compliance with these guidelines and best wishes for a successful research endeavor. Please let us know if the IRB can be of any future assistance.

Regards,

S. Thomson

Ferris State University Institutional Review Board
Office of Academic Research, Academic Affairs

Version 1.2015