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Investigating the relationship between negative relative accommodation recovery and high neutral retinoscopy

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Abstract

Negative Relative Accommodation (NRA) is a common subjective protocol used by many practitioners to assess a patient's ability to reduce accommodation relative to a nearpoint vergence demand of 40 centimeters. High Neutral retinoscopy (HN) is an objective test that utilizes a similar procedural protocol and vergence demand, also to assess a patient's ability to relax accommodation. During HN, excessive plus power is slowly decreased so that the patient must reduce accommodation in order to clear letters at a nearpoint distance of 50 centimeters. For reasons including examiner preference, difficulty of testing, confidence with endpoints or patient cooperation, HN is not a commonly utilized test. Although both NRA and HN assess how well a patient can "actively" release accommodation, HN requires the patient to clearly locate and identify letters alphabetically during the examination, adding a cognitive component. As a result, HN provides more of a "real life" (and arguably more practical) assessment of accommodative relaxation than NRA, and can provide valuable information in instances when a patient presents with problems that may be related to hyper-responsive accommodative. The purpose of this study is to determine if NRA recovery can confidently substitute for High Neutral retinoscopy when HN results are desired. Statistical analysis reveals an insignificant correlation between the net values of predicted versus actual HN net values (R=~ 0 .184) as determined by the equation -0.004076 1 (NRA recovery net) + 1.600883 15. From a clinical perspective, the errors of predicted HN to true HN results was within 0.37 diopters if specific clinical features were ruled out. The results of this study suggest that an examiner may elect to use a predicted HN net value based on the NRA recovery net value when only an approximation is desired, and only when latent hyperopia and a tendency for an accommodative lead under binocular conditions has been first ruled out.

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INVESTIGATING THE RELATIONSHIP BETWEEN NEGATIVE RELATIVE ACCOMMODATION RECOVERY AND HIGH NEUTRAL RETINOSCOPY

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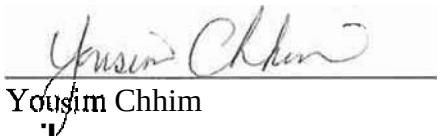
Authors: 
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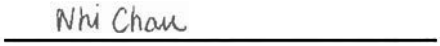
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BIOGRAPHY:

Yousim Chhim

Yousim was born in Thailand and came to America when she was only 4 years old with her mom and dad. She grew up in Seattle and attended the University of Washington where she earned a bachelors degree in Zoology prior to attending Pacific University College of Optometry. While at Pacific, Yousim was a member of the Professional Programs Committee, the Beta Sigma Kappa Optometric Honor Society and the American Student Optometric Association. Yousim plans on doing a residency after graduation and then returning to Seattle to start a practice of her own.

Nhi Chau

Nhi Chau attended the University of California, Davis, in 1996 and received a Bachelor of Science degree in Nutrition Science in 2001. Consequently, she began her optometric education at Pacific University College of Optometry in 2002, and is anticipating a Doctor of Optometry degree in 2006. Her future plans for optometric career is to work in a private practice or in a commercial establishment for approximately 3 years after graduation. Subsequently, she then plans to have her own private practice that focuses on primary care optometry.

ABSTRACT:

Negative Relative Accommodation (NRA) is a common subjective protocol used by many practitioners to assess a patient's ability to reduce accommodation relative to a nearpoint vergence demand of 40 centimeters. High Neutral retinoscopy (HN) is an objective test that utilizes a similar procedural protocol and vergence demand, also to assess a patient's ability to relax accommodation. During HN, excessive plus power is slowly decreased so that the patient must reduce accommodation in order to clear letters at a nearpoint distance of 50 centimeters. For reasons including examiner preference, difficulty of testing, confidence with endpoints or patient cooperation, HN is not a commonly utilized test. Although both NRA and HN assess how well a patient can "actively" release accommodation, HN requires the patient to clearly locate and identify letters alphabetically during the examination, adding a cognitive component. As a result, HN provides more of a "real life" (and arguably more practical) assessment of accommodative relaxation than NRA, and can provide valuable information in instances when a patient presents with problems that may be related to hyper-responsive accommodative. The purpose of this study is to determine if NRA recovery can confidently substitute for High Neutral retinoscopy when HN results are desired. Statistical analysis reveals an insignificant correlation between the net values of predicted versus actual HN net values ($R^2 = 0.184$) as determined by the equation -0.0040761(NRA recovery net) +1.60088315. From a clinical perspective, the errors of predicted HN to true HN results was within 0.37 diopters if specific clinical features were ruled out. The results of this study suggest that an examiner may elect to use a predicted HN net value based on the NRA recovery net value when only an approximation is desired, and only when latent hyperopia and a tendency for an accommodative lead under binocular conditions has been first ruled out.

KEY WORDS:

Negative relative accommodation, NRA, NRA recovery, High neutral retinoscopy, HN, Dynamic retinoscopy, Accommodation, Correlation

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INTRODUCTION:

The assessment of accommodative function is necessary to diagnose and treat many near point vision problems.[1] Complete assessment includes measurements of accommodative amplitude, relative range, accuracy and facility. An important component of accommodative assessment is the patient's ability to reduce accommodation relative to a near target plane. This ability can be determined by performing Negative Relative Accommodation (NRA) or High Neutral retinoscopy (HN). The visual requirement of HN is very similar to the visual task of the NRA recovery.

The NRA recovery is a subjective measurement of the most amount of plus lens power through which a subject can recover clarity for a 20120 target at 40 centimeters. NRA is performed by first placing a 20/20 target 40 cm away from the patient and then slowly adding plus power in 0.25 increments until the patient can no longer see any of the letters (NRA blur out). Once this point is determined, 0.25 diopters of plus are reduced until the patient first reports clarity of the letters again. This point is recorded as the patient's NRA recovery.

Unlike static retinoscopy where a patient is asked to fixate a distant target at optical infinity and encouraged to relax accommodation completely, in dynamic retinoscopy the patient fixates a near target and must accommodate to the near testing conditions. Thus the term "dynamic" is applied because the patient is engaging his accommodation actively while fixating the near target.[2]

HN is unique in design and interpretation from all other types of dynamic retinoscopy. It provides a more complete understanding of the maximal accommodative reduction in response to an extreme plus lens stimulus as opposed to accuracy with a given set of lenses and target. High Neutral retinoscopy is an objective measurement of the most amount of plus lens power through which a subject can clearly view 20180 letters at 50 centimeters. HN begins with slightly excessive plus for the target distance, forcing the conjugate focus into a lead for the target. Plus is reduced 0.25 diopters at a time while the patient attempts to read the letters or words on the 50 cm target. This cognitive engagement of the patient partially serves to encourage accommodative accuracy (reduction of accommodation in this case). When the patient's accommodative level and the plus add in the phoropter place the conjugate focus at the target plane (the first neutral retinoscopic reflex seen by the examiner), the endpoint is found.

Much literature can be found comparing different dynamic retinoscopy techniques, but no studies were found that specifically investigated the relationship between NRA recovery and High Neutral retinoscopy. In a study cited by Borish in the textbook Clinical Refraction, the correlation between HN and many tests are examined. Although a correlation between HN and NRA blur out is examined (coefficient of correlation = 0.50), no correlation is listed for HN and NRA recovery[3]. Additionally the study does not attempt to look for a mathematical relationship between any of the different tests, a logical inspection for a physiological function operating at the limit of its range of performance.

Although literature supports the use of dynamic retinoscopy techniques to help solve treatment dilemmas, such as when a young child presents with high hyperopia or when a patient presents with possible accommodative insufficiency, very few practitioners actually utilize these techniques.[4] Unlike subjective tests used to examine accommodation, HN relies heavily on examiner skill because the endpoint must be judged by the examiner as the first neutral without the chance to bracket the endpoint. This can make a novice examiner uncertain about the accuracy of his or her endpoint and therefore less likely to utilize the test. Unfortunately,

without performing the test, the examiner never gains the necessary skills or the confidence to use HN retinoscopy. All of these factors as well as a lack of education about its usefulness prevent this objective assessment of accommodative reaction from more frequent utilization.

HN endpoints have been promoted by many authors over the years and have played a key role in early case analysis methods. As its visual task is arguably similar to the NRA recovery, the more routinely tested and more easily obtained NRA recovery value might serve as a viable substitute (with or without extrapolation) for HN. This would make general clinical insights provided by HN more accessible to practitioners who are not inclined to perform HN testing.

The purpose of this study is to inspect the results of HN and NRA recovery to see if NRA recovery is an adequate predictor of High Neutral retinoscopy results or can be used to predict HN results, thus allowing a simple prediction of High Neutral retinoscopy for general analytical purposes where an estimated value may suffice.

SUBJECTS:

Subjects (N = 40) for this study were volunteers from the student population at Pacific University College of Optometry. All subjects were between the ages of 21 and 35 years old and were correctable to 20120 or better in each eye. Subjects with presbyopia, strabismus, amblyopia, significant anisometropia or any ocular disease were excluded from this study.

METHODS:

The study was conducted in a standard clinic examination room at Pacific University College of Optometry. The subjects were divided into two groups to allow randomization of testing order. The first 20 subjects had NRA recovery performed by Examiner 1 while Examiner 2 performed HN retinoscopy. The last 20 subjects had NRA recovery performed by Examiner 2 while Examiner 1 performed High Neutral Retinoscopy. Half of the subjects in the study had NRA recovery performed prior to HN while the other half had HN performed prior to NRA recovery. In both instances neither examiners were aware of the other examiner's data so as to avoid examiner bias. Each technique was performed as described below on all subjects in the study.

The subject's subjective refraction was first determined using standard, non-invasive, subjective methods so as to provide baseline values for the NRA recovery net. Because HN is evaluated relative to static retinoscopy results, once the subject's refraction was determined, distance retinoscopy was performed to ensure that the retinoscopic reflex appeared to be neutral to the examiner. If the reflex with retinoscopy was not perceived as neutral, lenses were adjusted until neutrality was perceived.

High Neutral was preset by adding +2.00 to the "neutral lenses", placing a 20180 acuity demand target (letters on a High-Neutral hole card) at 50 cm and providing standardized instructions to the subject. Each subject was told to find the letters of the alphabet in order on the High Neutral card and to call them out as each one is found. The examiner determined the subject's focusing accuracy throughout the test with a retinoscope held directly behind the test card. The subject continued to look for letters on the card as the initial excessive'plus was reduced in 0.25 diopter increments. The HN endpoint was determined by the first appearance of a neutral retinoscopic reflex as plus was reduced without bracketing the endpoint.

For the NRA recovery data point, a card with 20120 letters was placed in front of the subject at 40 centimeters. Subjects confirmed that they could clearly see the 20120 letters before 0.25 increments of plus were slowly introduced binocularly (stimulating the subject to "relax" their focus) until the subject reported that the letters were too blurry to identify (NRA blur out). An additional +0.50 diopters was applied to assure that the subject could not identify the letters to preset the NRA recovery procedure. Finally, plus was reduced in 0.25 diopter increments until the subject reported that he or she could first clearly identify all of the letters on the card again by accurately calling them out loud. This was the NRA recovery value.

RESULTS:

Statistical analysis of all 40 subjects together revealed a HN net of 1.54 ± 0.44 diopters and a NRA recovery net of 2.49 ± 0.44 diopters. With a T-test value of 0.645 and a R^2 value of 0.015, it is determined that there is no significant correlation between raw HN and NRA recovery data among the 40 subjects. Using a simple prediction by adding the mean difference to each raw NRA recovery value, only 19 out of the 40 predicted HN nets were within 0.25 diopters of the measured HN nets. When the tolerated difference between predicted HN net and measured HN net was expanded from 0.25 diopters to 0.37 diopters, the range of erroneous predictions also increased, and anywhere from 1.46 diopters of overestimation to 1.04 diopters of underestimation was noted.

In an effort to look for a relationship with "clean" data, some subjects' data was not utilized in the next step of analysis for one or more of the following reasons: 1) Subjects with "impossible" endpoints (greater than 2.00 diopters of plus on HN at 50 cm) were excluded because the patient was believed to be either overminused or had latent hyperopia making the data obtained unreliable (7 subjects removed). 2) Subjects who had more than 0.50 diopters of difference between the right eye HN net and the left eye HN net were also eliminated. In this instance, the patient's accommodative reliability and which eye's image dictated the nearpoint accommodative response during testing make the data questionable (4 subjects removed). 3) Subjects who demonstrated greater than 1.00 diopter of active accommodation (accommodative lead) during HN testing were also removed because of their strong tendency to lead resulting in a much smaller plus predicted HN endpoint (4 subjects removed). The remaining 25 subjects were considered to be a select and "ideal" sample from which to derive a meaningful mathematical relationship between actual HN net values and NRA net values.

Statistical analysis of this "ideal" sample resulted in a HN net of 1.59 ± 0.24 diopters and a NRA recovery net of 2.67 ± 0.28 diopters. However with a R^2 value of 0.0047, it is concluded once again that raw NRA recovery and HN retinoscopy date still do not correlate with one another. In order to further inspect the potential relationship between HN neutral and NRA recovery, linear regression analysis of this "clean" data was computed. This resulted in the tentative equation: Predicted HN net = [-0.0040761(x) +1.60088315] where x = NRA recovery net. Applying this equation to create predicted HN net values from NRA recovery net values and then comparing these to the actual HN net values, the correlation was again found to be 0.0047. This meant that 22 out of the 25 subjects would have predicted HN net values within 0.37 diopters of their true endpoints, while 17 out of the 25 subjects would have predicted HN net values within 0.25 diopters. The range of errors of this predicted value for this sample ranged anywhere from 0.41 diopters of underestimation to 0.34 diopters of overestimation.

In returning to the original sample with only the "impossible" endpoints removed and applying the equation above, a correlation of 0.145 was determined between actual NH net and predicted HN net. This meant that 17 out of the 33 subjects would have a predicted HN net within 0.25 diopters of their true endpoints while 27 out of the 33 had predicted HN net values within 0.37 diopters (see Table 1)

Table 1: Actual HN net and predicted HN net with "impossible" endpoinl subjects removed (Correlation = 0.1455)

Subject	NRA recovery net	Actual	Predicted	Difference
1	2.50		1.590693	-0.41
2	2.75		1.589674	
3	3.00	1.50	1.588655	0.09
4	2.50	1.50	1.590693	0.09
5	2.75	1.75	1.589674	-0.16
6	2.00	1.75	1.592731	-0.16
9	2.75	1.75	1.589674	-0.16
11	2.75	1.50	1.589674	0.09
13	2.25	1.75	1.591712	-0.16
15	2.75	1.75	1.589674	-0.16
16	3.00	2.00	1.588655	-0.41
17	1.75	2.00	1.59375	-0.41
18	2.25	2.00	1.591712	-0.41
19	2.25	1.50	1.591712	0.09
20	2.75	1.75	1.589674	-0.16
21	2.75	0.75	1.589674	0.84
22	3.00	1.75	1.588655	-0.16
24	2.25	1.75	1.591712	-0.16
25	2.75	1.50	1.589674	0.09
26	2.50	1.00	1.590693	0.59
27	2.75	1.50	1.589674	0.09
28	2.75	1.25	1.589674	0.34
29	2.50	1.25	1.590693	0.34
30	2.25	0.25	1.591712	1.34
31	3.00	2.00	1.588655	-0.41
32	2.50	0.75	1.590693	0.84
33	2.50	1.50	1.590693	0.09
34	2.75	1.00	1.589674	0.59
35	2.75	1.25	1.589674	0.34
36	2.75	1.50	1.589674	0.09
37	3.25	1.50	1.587636	0.09

38	0.75	1.00	1.597826	0.60
40	2.50	1.25	1.590693	0.34

Lastly, in eliminating the subjects from the above 33 who could easily be identified as having latent hyperopia and/or a notable tendency to lead, the correlation between actual HN and predicted HN increased from 0.145 to 0.184. This meant that 16 out of the 26 subjects would have a predicted HN net within 0.25 diopters of their true endpoints and 26 out of the 26 would have a predicted HN net value within 0.37 diopters.

In an attempt to determine if examiner skill played a role in how well HN retinoscopy and NRA recovery correlate, the first group of 20 subjects was compared separately from the second group of 20 subjects. The first group had a HN mean and standard deviation of 1.72 ± 0.22 and a NRA net mean and standard deviation of 2.47 ± 0.40. The second group had a HN mean and standard deviation of 1.32 ± 0.36 and a NRA net mean and standard deviation of 2.75 ± 0.22. In applying the proposed above equation (Predicted HN net = [-0.0040761(x) +1.60088315]) to the first and second group with "impossible" subject's data removed, predicted HN net and actual HN net values were calculated. Group 1 had a correlation factor of 0.307 with a range from 0.41 diopters underestimation to 0.34 diopters of overestimation. In comparison, Group 2 had a correlation factor of 0.362 with a range from 0.41 diopters underestimation to 1.34 diopters of overestimation.

DISCUSSION:

The purpose of this study was to determine if NRA recovery can confidently substitute or be mathematically modified to make a reasonable prediction for HN retinoscopy when HN results are desired. A simple conversion of NRA recovery net values into predicted HN net values based on the average difference yielded poor statistical and clinical relationships between the predicted HN net value and the actual HN net value.

Using linear regression of a "cleaned sample", the predicted HN net values were improved from a clinical perspective. After "eliminating" subjects whose results demonstrated latent hyperopia and/or a strong tendency for accommodative lead, all remaining subjects' predicted HN net values were within 0.37 diopters of actual HN results (rounding the errors to the nearest 1/8 diopter) and 16/26 were within 0.25 diopters. While statistics do not support a perfect relationship between HN net and NRA recovery net, the predicted HN net value errors approximate the variance that could easily occur in routine testing. Again, note that this is based on data after "impossible" subject's data and subjects with easily defined over-accommodation tendencies were eliminated. This implies that applying the equation above to predict an approximation of HN net values is not supported by this study in cases of latent hyperopia (and likely also pseudomyopia), gross accommodative instability, and/or a tendency toward an accommodative lead in binocular nearpoint viewing conditions. In the absence of these characteristics for a given patient, predicting the HN net based on NRA recovery net value as a means of "getting a feel" for the HN result is'a clinical judgment call not strongly supported based on traditional statistics, but according to the results presented here would likely be within a dioptrically-small range from the actual endpoint.

If diagnosis and/or patient management would be changed in the event that a predicted HN net result would be more than 0.50 diopters in error, this method should clearly be avoided. If this margin of error is acceptable to assist and speed analysis when consideration of HN net is

helpful, and a 0.25 to 0.50 diopter margin of error would not change the course of patient care, this estimate is probably acceptable in lieu of actual assessment of the HN net. Furthermore, this predicted HN net might prove to be useful for the inexperienced clinician as they gain confidence in interpreting the retinoscopic reflex for an accurate HN endpoint. More than approximately a 0.37 diopter difference should inspire retesting to assure that an accurate endpoint was found.

One of the most important and difficult variables to control during the study was examiner skill with performing high neutral retinoscopy. HN retinoscopy requires that the examiner make an objective endpoint of when the retinoscopic reflex is neutral. Thus HN retinoscopy is heavily dependent on how skilled the examiner is and what he or she perceives as being the "first" neutral. NRA recovery on the other hand, relies on the patient's perception and is less influenced by examiner bias. In an attempt to examine the influence that examiner skill has on the measured HN endpoint, half of the 40 subjects had high neutral performed by one examiner while the other half had HN performed by a different examiner. The difference in mean, the correlation for predicted versus actual HN nets and the wide variance range of errors indicates that the results for the first and second test groups are not well matched. The authors postulate that this variance can be accounted for by potential examiner inaccuracy in performing HN retinoscopy, and help to explain why some subject's data had to be eliminated. It should also be noted that although HN is considered to have provided the most variance during testing, NRA recovery could have also contributed since the exact criterion of "all of the 20/20" for the NRA recovery is guided by patient perception and thus somewhat at the mercy of the individual's depth of field and blur interpretation.

In conclusion, the results of this study suggest that an examiner may elect to use a predicted HN net value based on the NRA recovery net value when only an approximation is desired, and only when latent hyperopia and a tendency for an accommodative lead under binocular conditions has been ruled out. It is the authors' belief that further studies are needed to determine whether a predicted HN net value substitution is more accurate for myopes than for hyperopes or for those who tend to lead with accommodation. In addition to the differences between these three groups, it would be wise to better inspect other patient types such as those with NRA difficulties (convergence insufficiency, accommodative excess and pseudomyopes) versus those most likely to find NRA easy (convergence excess, accommodative insufficiency and early presbyopes) and/or to normal individuals.

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