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The effect of varying target size on negative relative accommodation (NRA) and positive relative accommodation (PRA)

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Abstract

Clinical testing of negative relative accommodation (NRA) and positive relative accommodation (PRA) requires a nearpoint chart using small type. Most often, a 20/20 acuity demand is used and is considered to be the standard for these tests. Though it is understood that using different acuity demands affects the endpoints of these tests, differences have yet to be quantified for case analysis purposes. This study compares the endpoints of NRA and PRA with varying acuity demands and quantifies the differences. Fifty-six optometry students ranging in age from 22 to 38 years were tested using standard NRA and PRA test protocols on a specially constructed nearpoint card consisting of 20/20, 20/25, and 20/30 Snellen acuity lines of letters. Statistically significant differences were found in both blur-out and recovery values between each acuity demand on the NRA and PRA. Additionally, most mean values comparing monocular to binocular endpoints were statistically different. Results from this study demonstrate that different endpoints should be expected when using nonstandard targets or acuity demands for accommodative testing.

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THE EFFECT OF VARYING TARGET SIZE
ON NEGATIVE RELATIVE ACCOMMODATION (NRA)
AND POSITIVE RELATIVE ACCOMMODATION (PRA)

By

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AND
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Scott C. Cooper, O.D., M.Ed.

THE EFFECT OF VARYING TARGET SIZE
ON NEGATIVE RELATIVE ACCOMMODATION (NRA)
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Scott C. Cooper, O.D., M.Ed.

BIOGRAPHY

Grant W. Jones is a fourth year optometry student at Pacific University and will receive his Doctor of Optometry degree in May 1997. Grant comes from Torrington, Wyoming, where he graduated from high school in 1988. He is a 1993 graduate of the University of Wyoming in Laramie with a bachelor of science degree in Psychology. While in optometry school, he has been a member of Beta Sigma Kappa honor society, Phi Theta Upsilon social fraternity, and the American Optometric Student Association for which he chaired the entertainment committee for the 1996 AOSA Conference in Portland, Oregon. Awards received include a President's Honor Scholarship to the University of Wyoming and an Optometry Dean's Scholarship while at Pacific. His externship experience was at the Salt Lake City Veterans Administration and the University of Utah under the direction of Harald Olafsson, O.D. Optometric interests include primary care, contact lenses, ocular disease, and sports vision. His hobbies are snow and water skiing, swimming, golf, tennis, and travelling. Following graduation, Grant plans to return to his hometown and enter private practice with Larry C. Goddard, O.D., at Torrington Vision Clinic, P.C., a primary care optometric facility serving the southeast Wyoming and western Nebraska area.

Lee A. Kulas is also a fourth year optometry student at Pacific University and will receive her Doctor of Optometry degree in May 1997. Originally from Brooklyn Park, Minnesota, she graduated in 1993 from the College of St. Benedict in St. Joseph, Minnesota, with a Bachelor of Arts in Biology. Awards received in college included a College of St. Benedict Leadership Scholarship, College of St. Benedict Academic Scholarships, College of St. Benedict Dean's List, and a Mercy Medical Foundation Health Professions Scholarship. At Pacific, Lee has earned an Optometry Dean's Scholarship and a Pacific University Optometry Scholarship. She has been a member of the Optometric Extension Program as well as the National Optometric Student Association, for which she served as 1994-1995 Recording Secretary for Pacific. Like Grant, she is a member of both the Beta Sigma Kappa Optometric Honor Society and the American Optometric Student Association, and she, too, served as a Local Conference Committee member for the 1996 AOSA Conference in Portland, Oregon. Lee was also the 1995-1996 Equipment Representative for her class. Lee's externship took place with Kaiser Permanente HMO in Portland, Oregon, and her areas of optometric interest include contact lenses, pediatrics, and ocular disease. She looks forward to returning to the Twin Cities area to practice optometry.

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Grant Jones
Lee Kulas

ABSTRACT

Clinical testing of negative relative accommodation (NRA) and positive relative accommodation (PRA) requires a nearpoint chart using small type. Most often, a 20/20 acuity demand is used and is considered to be the standard for these tests. Though it is understood that using different acuity demands affects the endpoints of these tests, differences have yet to be quantified for case analysis purposes. This study compares the endpoints of NRA and PRA with varying acuity demands and quantifies the differences. Fifty-six optometry students ranging in age from 22 to 38 years were tested using standard NRA and PRA test protocols on a specially constructed nearpoint card consisting of 20/20, 20/25, and 20/30 Snellen acuity lines of letters. Statistically significant differences were found in both blur-out and recovery values between each acuity demand on the NRA and PRA. Additionally, most mean values comparing monocular to binocular endpoints were statistically different. Results from this study demonstrate that different endpoints should be expected when using nonstandard targets or acuity demands for accommodative testing.

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INTRODUCTION

The term *relative accommodation* refers to the changes in accommodation that can be elicited with vergence held constant. *Negative relative accommodation* (NRA) is the relaxation or reduction of accommodation relative to a given fixation distance. Clinically, it is indicated by the maximum amount of plus lens power which allows clear, single vision. *Positive relative accommodation* (PRA), the increase of accommodation relative to a fixed target, is clinically measured by the maximum amount of minus lens power permitting clear and single vision.[1]

Clinical testing protocol for NRA and PRA requires a nearpoint chart with a 20/20 line or utilizing the smallest visible type seen by the patient if the 20/20 line is unreadable.[2] A variety of acuity demands may therefore be used by practitioners. For example, a low vision patient may require a large acuity demand, or a practitioner may prefer to use the "diamond card," which has a 20/25 demand, for NRA and PRA testing. Though it is known that using different acuity demands affects the endpoints of these tests, differences have yet to be quantified for case analysis purposes. Also, statistics made available by most accepted studies base mean values on a 20/20 nearpoint demand. Mean PRA has ranged from -2.23 to -3.15 and NRA from +1.75 to +2.32, depending on the tested population.[3,4,5,6]

Various studies have examined target size effects on accommodation. In some studies, target size alone has been shown to affect accommodative response,[7,8] and response has been found to be more sensitive to higher temporal frequencies.[9] Perception of blur can also be a factor in accommodative control,[10] as it has been shown to be more sensitive when target size is small.[11] Other studies have refuted the notion of size affecting accommodation.[7,12] Dynamic rather than static targets have elicited a stronger accommodative response with size held constant, suggesting that changing size is not a particularly effective stimulus, but that it influences accommodation indirectly through changes in apparent distance.[10] Additionally, accommodative amplitude can be overestimated when alternative testing procedures are used.[13] Manufacturers' specifications have also been found to be inconsistent with regard to target size.[14]

The goal of this experiment was to compare the endpoints of NRA and PRA with varying acuity demand, and to quantify the differences. The results of this study will help clinicians make appropriate adjustments in patient analysis when a 20/20 target size is not used.

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METHODS

Fifty-eight optometry students ranging in age from 22 to 38 years volunteered for this experiment. Each subject was questioned for history of diplopia, strabismus, amblyopia, eye strain, vision therapy, and medications. Inclusion criteria consisted of absence from any history of diplopia, strabismus, amblyopia, and severe eye strain resulting in visual impairment. Presbyopes and subjects with prior vision therapy treatment for strabismus or amblyopia were excluded, as were any subjects taking antihistamines or medications containing muscle relaxants. The fifty-six subjects who met the inclusion criteria were then screened for 20/20 habitual acuities at both distance and near.

A nearpoint card consisting of 20/20, 20/25, and 20/30 Snellen acuity lines was constructed (see Figure 1). Letters were printed in Geneva font on cardstock paper using a Macintosh-based graphics system. The lines were separated by 1 cm, and each consisted of seven letters with three spaces between each letter. A mix of rounded and squared letters were chosen. The final card was verified by measuring actual letter size with a Peak scope. Point sizes of 3.00, 2.45, and 2.05 were used for the 20/30, 20/25, and 20/20 lines, respectively. These point sizes corresponded with Peak scope measurements of 0.87 mm (20/30), 0.73 mm (20/25), 0.58 mm (20/20) letter heights, based on the standard 8.73 mm height of a 20/20 Snellen letter at 6 meters.

Standard NRA and PRA tests (binocular and monocular) were performed at 40 cm on the nearpoint card by each subject while wearing their habitual near correction.[2] Subjects were asked to first report sustained blur-out on the 20/20 line, then the 20/25 line, and finally the 20/30 line. Following this, subjects were asked to report recovery (ability to identify half or more of the letters), this time in the opposite order (20/30, 20/25, then 20/20). The NRA tests were performed first, followed by the PRA tests, to minimize hysteresis. If at any time during binocular tests a subject reported diplopia before they reported blur-out, these particular results were not used in the data analysis. The subject's monocular results were included, however. Subjects reporting that the letters were unidentifiable due to minification during PRA testing were included in the data analysis, using "all letters unidentifiable" for blur-out values and "half or more of letters identifiable" for recovery values.

DATA ANALYSIS

Due to medications that may have affected their accommodation, two subjects were completely excluded from the study. Also, because the examiners felt that Subject #28 demonstrated highly variable subjective responses, this subject's PRA results were excluded from data analysis. However, because this subject's NRA responses were confident, these results were used.

The results of subjects who reported diplopia before blur-out during binocular PRA testing were excluded from binocular data analysis, but monocular PRA findings of these subjects were used. Consequently, 30 subjects were included in the binocular PRA data and 55 in the monocular PRA data. Though *n* therefore differs in mean and standard deviation calculations for these two groups, paired t-test calculations used only paired findings (results from subjects with *both* binocular and monocular values). Mean and standard deviation differences between binocular and monocular PRA findings were therefore not affected by mismatched subject pools. Although subjects initially started the tests with their habitual near correction, all PRA and NRA nets were calculated relative to each subject's distance refraction.

RESULTS

Tables 1 and 2 display individual subject data from PRA and NRA tests, respectively.

Table 3 compares the blur-out means to those of recovery from each acuity demand, both on the PRA and NRA test. PRA means varied from -4.14 D for 20/20 OU blur-out to -7.87 D for 20/30 OS blur-out. NRA means were less varied, ranging from +2.51 D for 20/20 OD recovery to +3.64 D for 20/30 OU blur-out. These means are graphically depicted in Figures 2, 3, and 4.

Table 4 first compares the mean difference between acuity demands, and secondly compares the difference in means between OD, OS, and OU for each PRA blur-out and recovery. Table 5 offers the same comparisons for NRA values. Standard deviations and p-value determinations are also presented for each comparison on both tests.

Statistically significant differences between each acuity demand were found in both PRA and NRA blur-out and recovery means. The spread of these differences ranged from as little as a 0.21 D difference between 20/20 and 20/25 OD NRA recoveries to as high as a 2.32 D difference between 20/20 and 20/30 OS PRA blur-outs. Consistently, there were greater dioptric differences between acuity demands in the PRA test than the NRA test.

Additionally, most mean values comparing binocular to monocular findings, as well as right eye to left eye findings, were statistically different. Most binocular means (PRA and NRA) were more plus than monocular means, and left eye values were more minus in PRA testing and more plus in NRA testing than right eye values. See Tables 4 and 5 for complete p-value results.
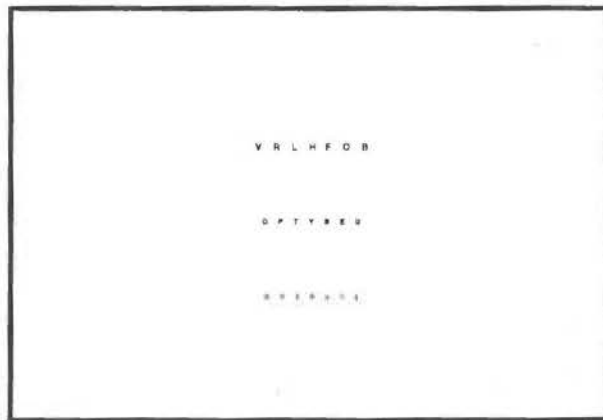
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Figure 1. Nearpoint card (actual letter size)

V R L H F O B

O P T Y B E U

B V E R U O E

Table 1. Individual PRA subject data

SUBJECT #	20 BLUR OU	25 BLUR OU	30 BLUR OU	30 REC OU	25 REC OU	20 REC OU	20 BLUR OD	25 BLUR OD	30 BLUR OD	30 REC OD	25 REC OD	20 REC OD	20 BLUR OS	25 BLUR OS	30 BLUR OS	30 REC OS	25 REC OS	20 REC OS
1	-4.75	-5.25	-6.00	-5.75	-5.50	-4.75	-5.00	-6.00	-7.00	-6.75	-5.75	-4.50	-6.50	-6.50	-7.50	-7.00	-6.00	-5.25
*2							-2.25	-3.50	-6.25	-6.00	-5.25	-3.50	-3.50	-4.50	-7.75	-7.50	-6.75	-3.75
3	-2.00	-2.75	-3.25	-3.00	-2.75	-2.50	-2.00	-3.00	-3.75	-3.50	-3.00	-2.25	-3.25	-3.75	-4.25	-4.00	-3.50	-2.75
4	-4.50	-5.00	-5.25	-4.75	-4.75	-3.75	-6.25	-7.25	-8.75	-8.00	-6.25	-5.75	-6.75	-7.50	-8.00	-7.50	-7.00	-5.75
5	-3.75	-5.00	-6.50	-5.50	-5.25	-3.50	-3.25	-5.25	-6.50	-5.75	-4.00	-3.50	-3.75	-4.75	-6.25	-5.25	-4.25	-1.00
6	-4.00	-4.75	-5.25	-4.75	-4.25	-4.25	-5.50	-6.25	-6.50	-6.00	-5.25	-5.00	-4.50	-5.25	-6.50	-6.25	-5.50	-5.00
7	-5.50	-6.50	-7.50	-7.75	-6.50	-5.00	-4.50	-5.50	-7.50	-6.50	-3.50	-2.50	-5.25	-6.75	-8.00	-7.50	-6.50	-4.50
*8							-6.75	-8.25	-9.00	-9.00	-8.50	-8.00	-8.00	-9.00	-9.50	-10.00	-9.75	-9.25
*9							-3.25	-3.50	-4.50	-4.50	-4.00	-3.50	-1.75	-2.25	-4.25	-4.00	-3.00	-1.50
10	-3.75	-4.25	-4.50	-4.50	-4.50	-3.50	-4.00	-5.25	-6.00	-5.75	-5.25	-4.50	-4.25	-5.75	-7.00	-6.50	-5.75	-4.25
11	-6.25	-6.75	-7.25	-7.25	-6.25	-5.25	-7.75	-9.00	-10.75	-10.75	-10.00	-8.00	-9.75	-11.00	-12.00	-11.25	-10.25	-9.50
12	-2.25	-3.00	-3.75	-3.25	-3.00	-2.50	-3.25	-3.50	-4.00	-3.50	-3.25	-3.00	-3.75	-4.00	-4.50	-4.00	-3.50	-2.75
13	-2.75	-3.50	-4.50	-4.25	-3.25	-2.50	-3.00	-3.50	-4.00	-3.75	-3.00	-2.75	-2.75	-4.00	-5.00	-4.25	-4.25	-3.75
14	-4.25	-4.50	-4.50	-4.25	-4.25	-4.25	-6.00	-6.75	-8.25	-7.75	-7.25	-6.00	-6.25	-7.75	-8.75	-8.25	-7.25	-5.75
*15							-7.25	-7.50	-8.00	-7.75	-7.00	-6.25	-8.00	-8.00	-9.25	-8.75	-8.25	-5.50
16	-2.50	-2.75	-3.25	-3.00	-3.00	-2.50	-3.50	-4.75	-5.75	-5.25	-4.75	-3.75	-2.25	-3.25	-4.50	-4.25	-3.50	-2.50
17	-4.75	-5.50	-6.25	-6.25	-5.50	-4.75	-3.25	-4.00	-4.50	-4.25	-3.25	-1.75	-4.25	-5.25	-6.00	-5.50	-4.75	-3.50
*18							-8.25	-9.75	-11.00	-10.25	-10.25	-9.00	-8.25	-9.00	-10.50	-8.75	-8.75	-7.25
19	-6.75	-7.50	-8.00	-8.00	-6.00	-6.00	-4.25	-6.00	-8.00	-8.00	-7.00	-6.25	-4.75	-8.25	-9.75	-9.25	-8.75	-8.25
*20							-4.25	-7.50	-8.50	-7.75	-7.25	-6.00	-6.75	-7.50	-8.50	-7.75	-6.00	-3.50
21	-4.75	-6.25	-7.00	-7.25	-5.75	-3.50	-7.00	-8.00	-10.00	-9.00	-7.50	-5.50	-7.25	-8.75	-9.75	-8.75	-7.50	-7.00
22	-1.75	-2.25	-2.50	-2.25	-1.75	-1.50	-0.75	-1.25	-2.00	-1.75	-1.50	-0.75	-3.00	-3.75	-3.75	-4.00	-3.25	-3.00
*23							-7.00	-7.75	-8.75	-8.00	-7.50	-7.25	-7.50	-8.50	-9.25	-8.50	-8.25	-8.00
*24							-5.50	-7.00	-8.75	-8.50	-8.25	-7.50	-8.00	-9.00	-10.75	-10.50	-10.25	-9.50
25	-5.25	-5.75	-6.50	-6.00	-5.50	-5.25	-5.00	-5.50	-6.50	-6.00	-5.25	-4.50	-5.00	-5.50	-6.25	-6.25	-5.00	-4.50
*26							-7.00	-7.50	-8.25	-8.00	-7.25	-6.50	-7.25	-7.25	-8.00	-7.50	-7.00	-6.50
*27							-4.50	-6.25	-6.75	-6.75	-6.75	-6.00	-3.75	-5.75	-7.75	-7.50	-7.50	-5.75
***28																		
29	-5.00	-5.25	-5.75	-5.25	-4.75	-3.75	-3.50	-4.50	-5.75	-6.00	-5.00	-3.75	-5.25	-6.00	-7.00	-6.75	-6.25	-4.75
*30							-1.50	-3.00	-6.50	-6.50	-5.25	-3.00	-2.25	-5.00	-6.50	-6.50	-5.50	-0.75
**31																		
*32							-3.75	-5.75	-7.00	-7.00	-6.50	-5.00	-4.50	-5.50	-6.00	-6.25	-6.25	-5.50
33	-6.00	-6.25	-6.75	-6.00	-6.00	-6.00	-8.00	-8.50	-9.25	-9.75	-9.75	-9.75	-11.00	-11.75	-13.75	-14.25	-13.25	-13.25
*34							-4.00	-5.00	-6.50	-6.25	-5.75	-5.00	-6.25	-7.00	-8.25	-7.75	-7.25	-6.25
35	-3.00	-3.75	-4.75	-4.25	-3.50	-3.00	-4.00	-4.25	-5.50	-5.75	-5.25	-4.25	-4.00	-4.25	-5.25	-4.50	-4.00	-3.50
*36							-2.00	-7.25	-8.50	-8.50	-7.50	-6.50	-8.00	-9.25	-9.75	-9.75	-9.00	-8.25
*37							-3.50	-4.50	-5.25	-5.25	-4.75	-4.50	-5.25	-5.75	-6.00	-5.25	-4.75	
38	-6.75	-8.50	-11.75	-11.75	-11.00	-8.75	-7.75	-9.00	-12.75	-11.50	-10.75	-9.75	-9.00	-10.75	-12.25	-12.00	-10.75	-10.00
39	-3.75	-4.25	-4.25	-4.25	-3.75	-3.75	-3.75	-3.75	-4.00	-3.75	-3.50	-3.50	-4.75	-5.25	-6.00	-5.75	-5.50	-5.00
40	-4.50	-5.25	-5.75	-4.50	-4.25	-4.00	-8.00	-8.75	-8.75	-8.25	-8.25	-7.75	-7.25	-8.50	-8.75	-8.25	-7.75	-7.25
41	-4.25	-4.50	-4.75	-5.00	-4.50	-4.00	-4.00	-4.75	-5.50	-5.75	-5.25	-4.00	-4.25	-5.25	-5.75	-5.75	-5.25	-4.25
*42							-6.00	-7.25	-8.50	-8.25	-7.75	-7.25	-8.50	-9.25	-10.00	-9.50	-8.75	-8.25
*43							-4.00	-6.25	-7.50	-7.75	-6.50	-5.50	-3.75	-4.50	-6.75	-6.75	-5.50	-4.00
44	-4.75	-5.50	-5.50	-5.75	-5.50	-3.75	-6.50	-7.25	-8.25	-7.25	-5.25	-4.75	-5.50	-8.50	-9.50	-9.50	-8.50	-5.75
*45							-8.50	-10.25	-11.50	-11.75	-11.25	-8.75	-8.00	-9.50	-11.25	-10.50	-10.50	-9.25
*46							-3.50	-7.50	-8.75	-8.50	-7.50	-5.50	-7.75	-9.00	-10.00	-9.25	-9.00	-7.75
47	-2.75	-3.25	-3.75	-2.50	-2.00	-1.75	-3.00	-3.50	-4.25	-3.75	-3.25	-3.00	-2.50	-3.50	-4.25	-4.25	-3.75	-3.00
48	-3.50	-4.75	-5.50	-5.75	-5.25	-4.75	-4.75	-6.00	-6.75	-7.00	-6.00	-5.25	-5.50	-6.50	-7.25	-7.75	-6.75	-5.50
**49																		
50	-2.00	-2.75	-3.00	-3.50	-3.50	-3.25	-3.75	-4.75	-5.50	-5.25	-5.25	-4.75	-4.25	-6.25	-6.75	-6.50	-6.00	-6.00
51	-3.00	-4.75	-5.75	-5.75	-5.00	-3.75	-5.75	-7.00	-8.50	-8.25	-7.50	-4.50	-3.75	-5.50	-8.25	-7.25	-6.50	-1.00
*52							-1.00	-2.00	-5.50	-5.25	-3.25	-1.00	-0.75	-3.25	-8.50	-8.50	-7.25	-1.75
*53							-2.50	-3.50	-4.25	-3.50	-3.50	-2.25	-6.25	-8.00	-10.00	-9.75	-8.25	-6.75
*54							-7.50	-7.50	-7.50	-7.25	-7.00	-6.50	-7.00	-7.50	-7.75	-7.25	-7.00	-6.50
*55							-7.25	-7.75	-8.00	-7.75	-7.75	-7.50	-7.50	-8.00	-8.50	-8.00	-7.25	-7.00
56	-5.50	-7.25	-7.75	-7.75	-6.50	-6.50	-6.00	-6.25	-7.50	-7.25	-7.25	-5.25	-6.75	-7.25	-8.25	-7.75	-7.25	-6.50
*57							-7.75	-8.75	-9.75	-9.50	-9.50	-7.75	-5.75	-9.25	-10.50	-9.75	-9.00	-7.75
*58							-4.00	-5.75	-7.25	-7.25	-7.25	-5.00	-3.00	-5.00	-6.50	-6.50	-6.25	-3.50
MEAN	-4.14	-4.91	-5.56	-5.33	-4.78	-4.08	-4.83	-5.99	-7.16	-6.88	-6.20	-5.19	-5.55	-6.68	-7.87	-7.50	-6.82	-5.50
STANDARD DEV	1.41	1.54	1.87	1.97	1.74	1.50	2.02	2.04	2.15	2.11	2.19	2.12	2.26	2.22	2.24	2.19	2.16	2.56

* Subject experienced diplopia during binocular testing (OU findings only excluded).
* * Subject excluded due to medications.
* * * Subject excluded due to accommodative spasm.

Table 2. Individual NRA subject data

SUBJECT #	20 BLUR OU	25 BLUR OU	30 BLUR OU	30 REC OU	25 REC OU	20 REC OU	20 BLUR OD	25 BLUR OD	30 BLUR OD	30 REC OD	25 REC OD	20 REC OD	20 BLUR OS	25 BLUR OS	30 BLUR OS	30 REC OS	25 REC OS	20 REC OS
1	3.00	3.25	3.25	3.00	2.75	2.75	3.25	3.25	3.75	3.25	3.25	3.25	3.50	3.50	4.00	3.50	3.00	2.75
2	3.25	3.75	5.00	4.25	4.00	3.25	3.50	4.00	4.25	4.00	3.50	3.00	4.25	4.25	4.50	4.25	4.00	3.50
3	3.00	3.25	4.00	3.50	3.25	3.00	3.25	3.50	3.75	3.25	3.00	2.75	3.50	3.75	4.00	3.50	3.00	2.75
4	3.50	3.75	4.00	3.75	3.75	3.50	3.75	4.00	4.00	3.75	3.75	3.25	3.50	3.75	3.75	3.50	3.50	3.25
5	3.25	3.25	3.75	3.50	3.00	3.00	3.00	3.00	3.25	3.00	2.50	2.50	2.75	3.25	3.50	3.00	3.00	2.50
6	2.75	3.25	3.50	3.00	2.75	2.50	2.75	3.25	3.50	2.75	2.75	2.50	2.75	3.00	3.25	2.75	2.25	2.25
7	3.00	3.50	3.50	3.50	3.00	2.75	3.25	3.25	3.25	2.50	2.50	2.50	3.25	3.50	3.75	3.25	3.00	3.00
8	3.00	3.25	3.75	3.25	3.00	2.75	3.00	3.00	3.50	3.25	2.75	2.50	2.75	2.75	3.00	2.75	2.50	2.25
9	3.25	3.75	4.00	3.75	3.25	2.75	3.75	3.75	4.00	4.00	3.75	3.50	3.00	3.25	3.50	3.50	3.00	2.75
10	3.00	3.25	3.50	3.25	3.00	2.75	2.75	3.00	3.25	3.00	2.75	2.50	3.00	3.25	3.50	3.00	2.75	2.50
11	2.00	2.50	3.00	2.50	2.25	2.00	2.50	2.50	3.00	2.75	2.25	2.00	2.75	2.75	3.00	2.50	2.25	2.00
12	3.00	3.50	4.00	3.75	3.50	3.25	3.00	3.50	3.75	3.50	3.25	3.25	3.25	3.75	4.25	3.75	3.75	3.25
13	3.50	3.75	4.25	3.75	3.50	3.25	3.50	3.50	3.50	3.25	3.00	2.75	3.50	4.00	4.00	3.75	3.25	3.00
14	3.00	3.00	3.25	2.75	2.50	2.50	2.75	3.00	3.00	2.75	2.50	2.50	3.00	3.25	3.50	2.75	2.50	2.50
15	2.50	2.50	3.00	2.75	2.25	2.00	2.50	2.75	2.75	2.50	2.25	2.00	3.00	3.00	3.25	2.75	2.50	2.50
16	2.75	3.00	3.25	2.75	2.50	2.60	3.00	3.00	3.25	2.75	2.50	2.25	3.00	3.00	3.25	2.75	2.75	2.50
17	2.25	2.75	3.00	2.50	2.25	2.25	2.25	2.50	3.00	2.50	2.00	1.25	2.00	2.25	2.50	2.00	1.50	1.00
18	2.75	3.75	3.25	3.25	3.25	3.25	3.00	3.00	3.25	2.75	2.75	2.75	3.50	3.50	4.00	3.00	3.00	2.75
19	2.50	2.75	3.25	3.00	2.75	2.50	2.50	2.75	3.25	3.00	2.50	2.25	2.50	3.00	3.25	3.00	2.75	2.25
20	3.25	3.25	3.75	3.50	3.00	2.75	2.75	3.25	3.50	3.25	2.75	2.25	3.00	3.00	3.50	3.25	2.50	2.00
21	3.00	3.25	4.00	3.25	3.00	2.50	2.75	3.00	3.50	3.00	2.00	2.00	3.00	3.00	3.00	2.25	2.25	2.25
22	2.25	2.75	3.00	2.50	2.25	2.00	2.25	2.50	2.75	2.25	2.00	1.75	2.50	2.50	2.75	2.50	2.50	2.25
23	4.00	4.50	5.00	4.00	3.75	3.50	3.75	4.25	4.25	3.75	3.50	3.25	4.00	4.00	4.25	3.75	3.50	3.25
24	3.25	3.50	3.50	3.50	3.00	3.00	3.25	3.25	3.50	3.25	3.00	3.00	3.25	3.25	3.50	3.25	3.00	2.75
25	2.75	3.25	3.50	3.25	2.75	2.50	2.75	3.50	3.75	3.25	3.00	2.75	3.25	3.50	3.75	3.25	2.75	2.50
26	2.50	3.00	3.25	2.50	2.50	2.50	2.50	2.50	2.50	2.25	2.00	1.75	2.50	3.25	3.50	3.25	2.75	2.75
27	3.00	3.50	3.75	3.50	3.50	3.00	3.25	3.50	3.75	3.50	3.50	3.25	3.25	3.50	3.50	3.25	3.25	3.00
28	2.75	3.25	3.75	3.25	3.00	2.50	2.25	2.75	2.75	2.50	1.75	1.50	2.00	2.25	2.75	2.75	2.00	1.50
29	3.75	4.00	4.50	4.00	3.50	3.50	3.75	4.00	4.50	4.00	3.50	3.50	3.75	4.25	4.75	3.75	3.50	3.25
30	3.00	3.25	3.25	3.00	3.00	2.75	2.50	2.75	3.00	2.75	2.50	2.25	2.75	3.25	3.25	3.25	3.00	2.25
*31																		
32	3.50	3.75	4.00	3.50	3.25	3.00	3.00	3.25	3.50	3.25	3.00	3.00	3.50	3.75	4.00	3.75	3.50	3.25
33	2.50	2.75	3.25	2.75	2.50	2.25	2.50	2.50	3.00	2.75	2.50	2.25	2.50	2.50	3.00	2.75	2.50	2.25
34	3.50	4.00	4.50	4.00	3.50	3.50	3.75	4.00	4.50	4.00	3.75	3.25	3.50	4.00	4.25	4.00	3.50	3.25
35	2.50	3.00	3.75	3.25	3.00	2.75	3.25	3.50	3.50	3.25	3.00	2.75	2.75	3.00	3.50	3.00	2.75	2.50
36	2.75	3.00	3.25	3.00	2.75	2.50	2.75	3.00	3.25	3.00	2.75	2.50	2.75	3.25	3.25	3.00	3.00	2.75
37	3.25	3.25	3.50	3.25	3.00	2.50	3.00	3.00	3.25	3.00	2.75	2.50	3.00	3.00	3.00	2.50	2.25	1.75
38	2.25	2.50	3.00	2.75	2.50	2.00	2.00	2.25	2.75	2.50	2.00	1.75	2.25	2.75	3.00	2.75	2.50	2.25
39	3.25	3.75	4.00	3.75	3.00	2.75	3.25	3.50	4.00	3.75	3.25	3.00	3.50	3.50	3.75	3.50	3.25	3.25
40	2.75	3.25	3.75	2.75	2.25	2.00	2.25	2.50	2.75	2.00	2.00	1.75	2.75	2.75	3.25	2.25	2.25	2.00
41	2.75	3.00	3.50	3.00	2.75	2.50	2.75	3.00	3.00	2.75	2.50	2.50	3.25	3.25	3.50	3.25	3.00	3.00
42	3.25	3.75	3.75	3.50	3.00	2.75	3.25	3.25	3.50	3.00	2.75	2.50	3.50	3.50	3.75	3.50	3.00	3.00
43	3.00	3.25	3.50	3.50	2.75	2.50	3.00	3.25	3.50	3.00	3.00	2.75	3.00	3.25	3.50	3.25	3.00	2.75
44	2.75	3.25	3.50	3.25	2.75	2.75	3.00	3.00	3.50	3.00	2.75	2.50	2.75	3.25	3.50	3.00	2.75	2.25
45	2.25	2.50	2.75	2.50	2.25	2.00	2.00	2.25	2.25	2.00	1.75	1.50	2.25	2.50	2.75	2.25	2.25	2.00
46	2.75	3.25	3.75	3.25	2.75	2.75	3.00	3.25	3.50	3.25	2.75	2.50	2.50	2.75	3.25	3.00	2.75	2.25
47	3.50	4.00	4.00	3.25	3.25	3.25	2.50	2.75	3.25	2.75	2.25	2.25	3.50	3.75	4.00	3.25	3.00	3.00
48	2.75	3.25	3.75	3.25	3.00	2.75	2.75	3.25	3.50	3.25	3.00	2.50	2.75	3.25	3.50	3.25	3.25	3.00
*49																		
50	2.50	3.00	3.50	3.00	3.00	2.75	3.00	3.25	3.50	3.25	2.75	2.75	2.50	3.00	3.25	3.00	2.50	2.50
51	2.75	3.25	3.75	3.25	3.00	2.75	2.75	3.00	3.25	3.00	2.75	2.50	2.75	3.25	3.50	3.25	3.00	2.50
52	3.50	3.75	4.25	3.75	3.25	3.00	3.25	3.50	3.75	3.25	3.00	2.75	3.25	3.50	3.75	3.50	3.00	2.75
53	3.25	3.75	3.75	3.00	2.75	2.00	3.50	3.50	3.75	3.00	2.75	2.75	3.75	4.00	4.50	3.00	2.75	2.25
54	3.00	3.25	3.50	3.00	3.00	2.50	3.00	3.25	3.50	3.00	2.75	2.75	3.00	3.00	3.00	2.50	2.50	2.50
55	2.75	3.25	3.50	3.25	3.00	3.00	2.75	3.00	3.25	3.00	2.50	2.50	3.50	3.75	4.00	3.50	3.25	3.25
56	1.50	1.75	2.25	1.75	1.50	1.25	1.25	1.50	1.75	1.25	1.00	1.00	1.50	1.75	2.00	1.50	1.25	1.25
57	2.75	3.00	3.50	2.75	2.50	2.25	2.50	2.75	3.25	2.75	2.50	2.25	2.50	3.00	3.25	3.00	2.25	2.25
58	3.75	4.00	4.50	4.25	3.75	3.25	3.50	4.00	4.50	4.25	3.75	3.25	3.75	4.25	4.50	4.25	3.75	3.50
MEAN	2.92	3.28	3.64	3.22	2.92	2.68	2.90	3.13	3.39	3.03	2.72	2.51	3.01	3.25	3.51	3.10	2.82	2.58
STANDARD DEV	0.46	0.48	0.51	0.49	0.46	0.46	0.50	0.51	0.53	0.55	0.56	0.55	0.53	0.52	0.53	0.53	0.52	0.53

* Subject excluded due to medications.

Table 3. PRA and NRA means and standard deviations

PRA

ACUITY DEMAND	MEAN	STANDARD DEVIATION
20/20 BLUR OU	-4.14	1.41
20/20 RECOVERY OU	-4.08	1.50
20/25 BLUR OU	-4.91	1.54
20/25 RECOVERY OU	-4.78	1.75
20/30 BLUR OU	-5.56	1.87
20/30 RECOVERY OU	-5.33	1.97
20/20 BLUR OD	-4.83	2.02
20/20 RECOVERY OD	-5.19	2.12
20/25 BLUR OD	-5.99	2.04
20/25 RECOVERY OD	-6.20	2.19
20/30 BLUR OD	-7.16	2.15
20/30 RECOVERY OD	-6.88	2.11
20/20 BLUR OS	-5.55	2.25
20/20 RECOVERY OS	-5.51	2.56
20/25 BLUR OS	-6.68	2.22
20/25 RECOVERY OS	-6.82	2.16
20/30 BLUR OS	-7.87	2.24
20/30 RECOVERY OS	-7.50	2.19

NRA

ACUITY DEMAND	MEAN	STANDARD DEVIATION
20/20 BLUR OU	+2.92	0.46
20/20 RECOVERY OU	+2.68	0.46
20/25 BLUR OU	+3.28	0.48
20/25 RECOVERY OU	+2.92	0.46
20/30 BLUR OU	+3.64	0.51
20/30 RECOVERY OU	+3.22	0.49
20/20 BLUR OD	+2.90	0.50
20/20 RECOVERY OD	+2.51	0.55
20/25 BLUR OD	+3.13	0.51
20/25 RECOVERY OD	+2.72	0.56
20/30 BLUR OD	+3.39	0.53
20/30 RECOVERY OD	+3.03	0.55
20/20 BLUR OS	+3.01	0.53
20/20 RECOVERY OS	+2.58	0.53
20/25 BLUR OS	+3.25	0.52
20/25 RECOVERY OS	+2.82	0.52
20/30 BLUR OS	+3.51	0.53
20/30 RECOVERY OS	+3.10	0.53

Table 4. PRA mean differences

MEAN COMPARISON	MEAN DIFFERENCE (D)	STANDARD DEVIATION OF DIFFERENCE	P-VALUE
20/20 to 20/25 OU BLUR	0.77	0.66	<0.0001
20/25 to 20/30 OU BLUR	0.65	0.49	<0.0001
20/20 to 20/30 OU BLUR	1.42	0.89	<0.0001
20/20 to 20/25 OU RECOVERY	0.70	0.45	<0.0001
20/25 to 20/30 OU RECOVERY	0.55	0.60	<0.0001
20/20 to 20/30 OU RECOVERY	1.25	0.94	<0.0001
20/20 to 20/25 OD BLUR	1.16	0.91	<0.0001
20/25 to 20/30 OD BLUR	1.17	0.79	<0.0001
20/20 to 20/30 OD BLUR	2.33	1.33	<0.0001
20/20 to 20/25 OD RECOVERY	1.01	0.70	<0.0001
20/25 to 20/30 OD RECOVERY	0.68	0.60	<0.0001
20/20 to 20/30 OD RECOVERY	1.69	0.99	<0.0001
20/20 to 20/25 OS BLUR	1.14	0.80	<0.0001
20/25 to 20/30 OS BLUR	1.19	0.84	<0.0001
20/20 to 20/30 OS BLUR	2.32	1.34	<0.0001
20/20 to 20/25 OS RECOVERY	1.31	1.22	<0.0001
20/25 to 20/30 OS RECOVERY	0.68	0.40	<0.0001
20/20 to 20/30 OS RECOVERY	2.00	1.38	<0.0001
20/20 BLUR: OU - OD	0.63	1.35	0.0171
20/25 BLUR: OU - OD	0.73	1.32	0.0054
20/30 BLUR: OU - OD	1.18	1.46	0.0001
20/20 RECOVERY: OU - OD	0.61	1.50	0.0006
20/25 RECOVERY: OU - OD	0.83	1.61	0.0090
20/30 RECOVERY: OU - OD	1.07	1.51	0.0346
20/20 BLUR: OU - OS	1.09	1.40	0.0002
20/25 BLUR: OU - OS	1.46	1.44	<0.0001
20/30 BLUR: OU - OS	1.80	1.67	<0.0001
20/20 RECOVERY: OU - OS	1.08	1.94	<0.0001
20/25 RECOVERY: OU - OS	1.49	1.64	<0.0001
20/30 RECOVERY: OU - OS	1.68	1.80	0.0048
20/20 BLUR: OD - OS	0.71	1.51	0.0009
20/25 BLUR: OD - OS	0.69	1.21	<0.0001
20/30 BLUR: OD - OS	0.71	1.24	<0.0001
20/20 RECOVERY: OD - OS	0.31	1.49	0.0013
20/25 RECOVERY: OD - OS	0.62	1.34	0.0012
20/30 RECOVERY: OD - OS	0.62	1.35	0.1232

Table 5. NRA mean differences

| MEAN COMPARISON	MEAN DIFFERENCE (D)	STANDARD DEVIATION OF DIFFERENCE	P-VALUE
20/20 to 20/25 OU BLUR	0.36	0.18	<0.0001
20/25 to 20/30 OU BLUR	0.36	0.26	<0.0001
20/20 to 20/30 OU BLUR	0.71	0.28	<0.0001
20/20 to 20/25 OU RECOVERY	0.24	0.18	<0.0001
20/25 to 20/30 OU RECOVERY	0.30	0.18	<0.0001
20/20 to 20/30 OU RECOVERY	0.54	0.25	<0.0001
20/20 to 20/25 OD BLUR	0.22	0.18	<0.0001
20/25 to 20/30 OD BLUR	0.27	0.17	<0.0001
20/20 to 20/30 OD BLUR	0.49	0.23	<0.0001
20/20 to 20/25 OD RECOVERY	0.21	0.17	<0.0001
20/25 to 20/30 OD RECOVERY	0.30	0.20	<0.0001
20/20 to 20/30 OD RECOVERY	0.51	0.26	<0.0001
20/20 to 20/25 OS BLUR	0.24	0.21	<0.0001
20/25 to 20/30 OS BLUR	0.26	0.15	<0.0001
20/20 to 20/30 OS BLUR	0.50	0.24	<0.0001
20/20 to 20/25 OS RECOVERY	0.25	0.19	<0.0001
20/25 to 20/30 OS RECOVERY	0.28	0.21	<0.0001
20/20 to 20/30 OS RECOVERY	0.52	0.28	<0.0001
20/20 BLUR: OU - OD	-0.02	0.30	0.5831
20/25 BLUR: OU - OD	-0.16	0.29	0.0002
20/30 BLUR: OU - OD	-0.25	0.30	<0.0001
20/20 RECOVERY: OU - OD	-0.17	0.35	0.0007
20/25 RECOVERY: OU - OD	-0.20	0.33	<0.0001
20/30 RECOVERY: OU - OD	-0.20	0.26	<0.0001
20/20 BLUR: OU - OS	0.09	0.32	0.0529
20/25 BLUR: OU - OS	-0.03	0.31	0.4472
20/30 BLUR: OU - OS	-0.13	0.37	0.0150
20/20 RECOVERY: OU - OS	-0.11	0.36	0.0298
20/25 RECOVERY: OU - OS	-0.10	0.30	0.0134
20/30 RECOVERY: OU - OS	-0.13	0.29	0.0019
20/20 BLUR: OD - OS	0.11	0.33	0.0172
20/25 BLUR: OD - OS	0.13	0.32	0.0050
20/30 BLUR: OD - OS	0.12	0.36	0.0152
20/20 RECOVERY: OD - OS	0.06	0.36	0.2002
20/25 RECOVERY: OD - OS	0.10	0.34	0.0364
20/30 RECOVERY: OD - OS	0.07	0.34	0.1211

Figure 2. Mean PRA Blur-out and Recovery Nets
Binocular and Monocular

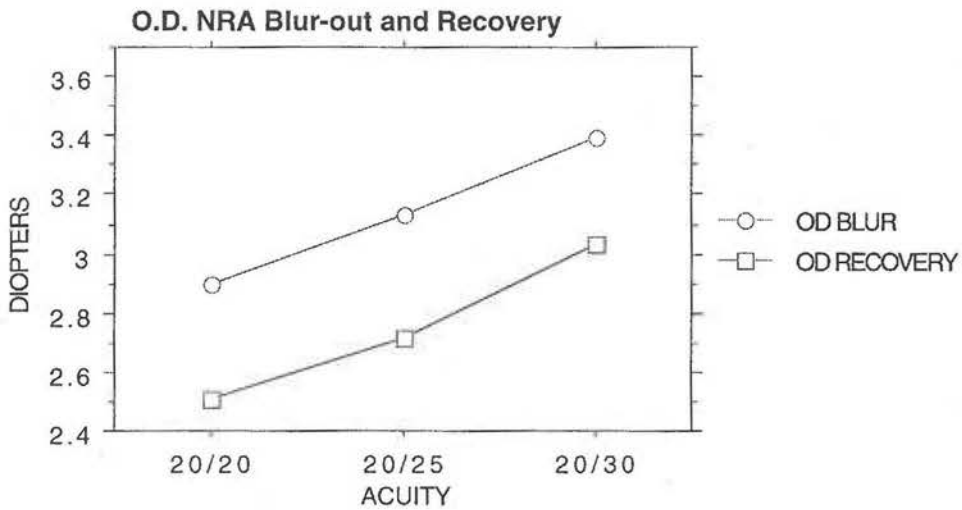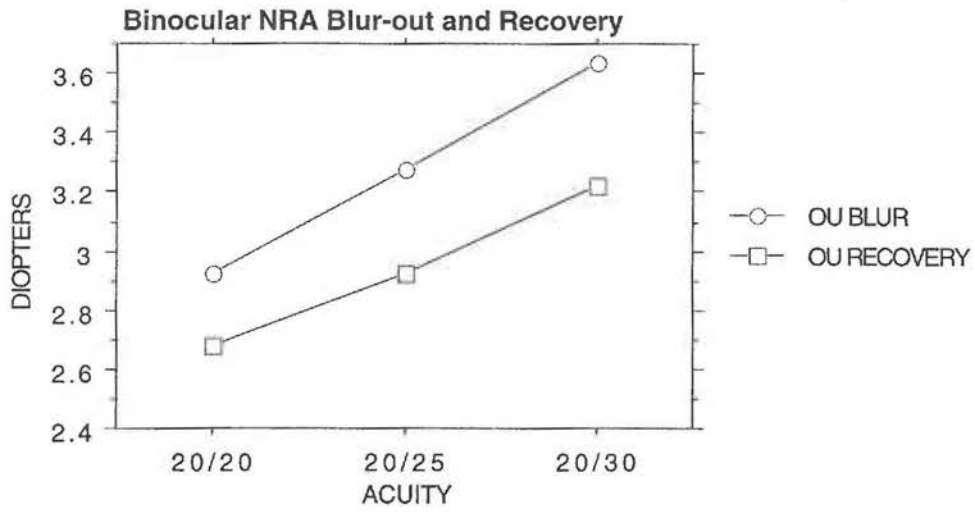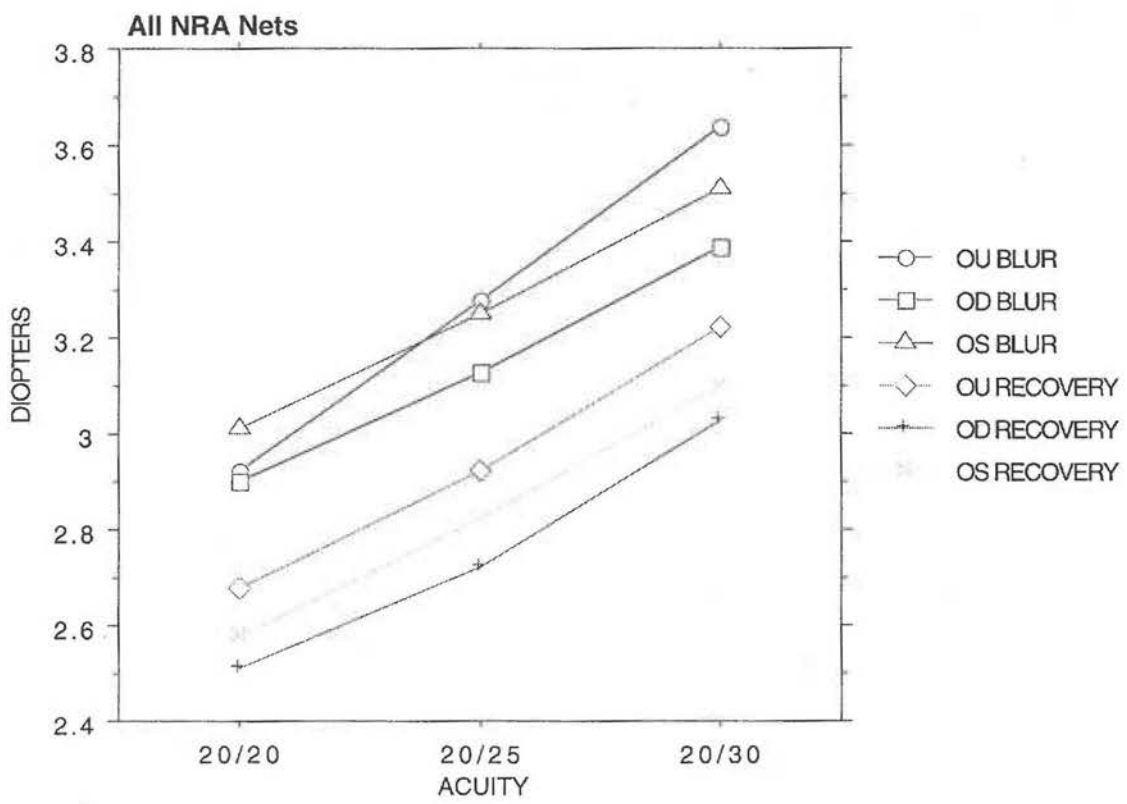**Binocular PRA Blur-out and Recovery**

O.D. PRA Blur-out and Recovery

O.S. PRA Blur-out and Recovery

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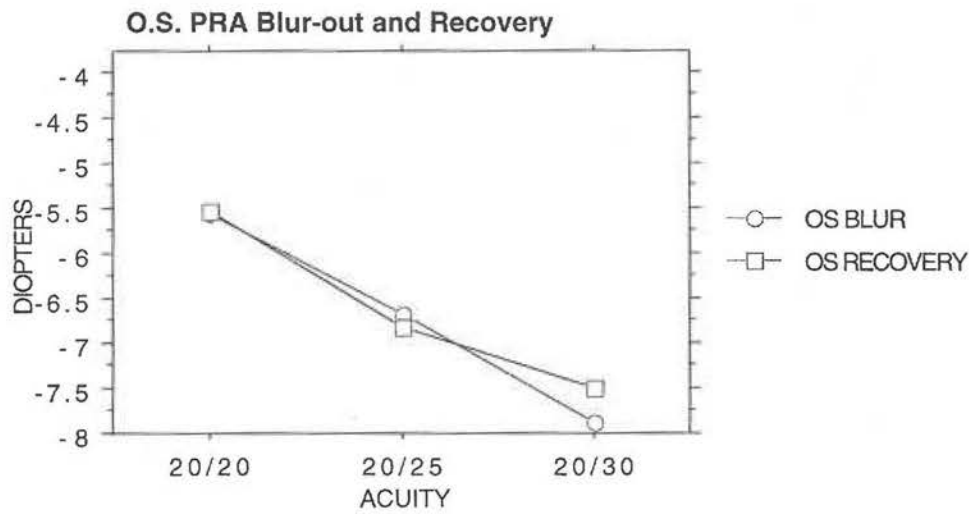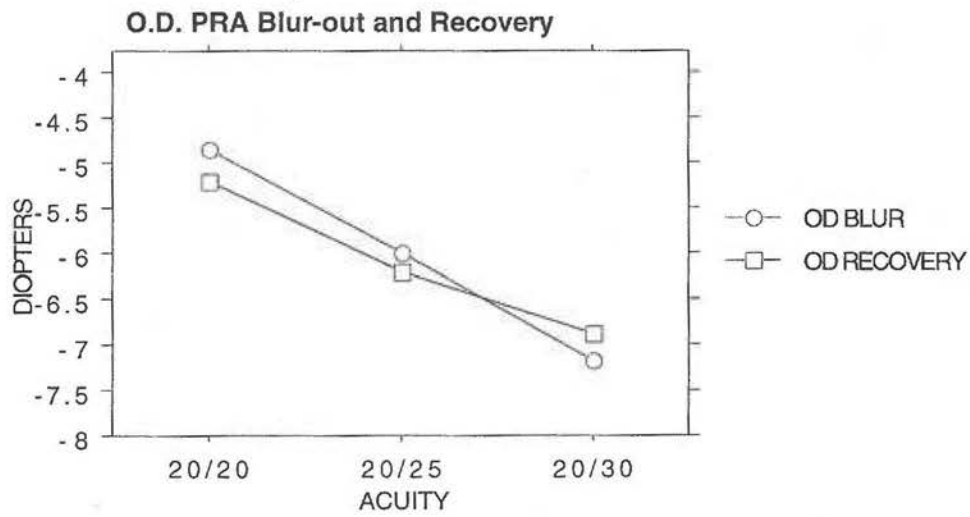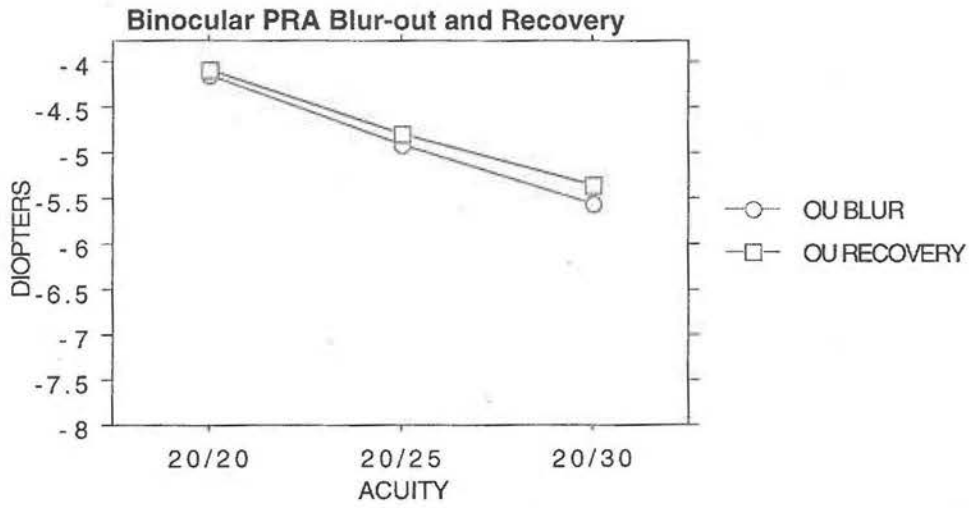
Figure 3. Mean NRA Blur-out and Recovery Nets
Binocular and Monocular

Binocular NRA Blur-out and Recovery

—○— OU BLUR
—□— OU RECOVERY

O.D. NRA Blur-out and Recovery

--○-- OD BLUR
--□-- OD RECOVERY

O.S. NRA Blur-out and Recovery

--○-- OS BLUR
--□-- OS RECOVERY
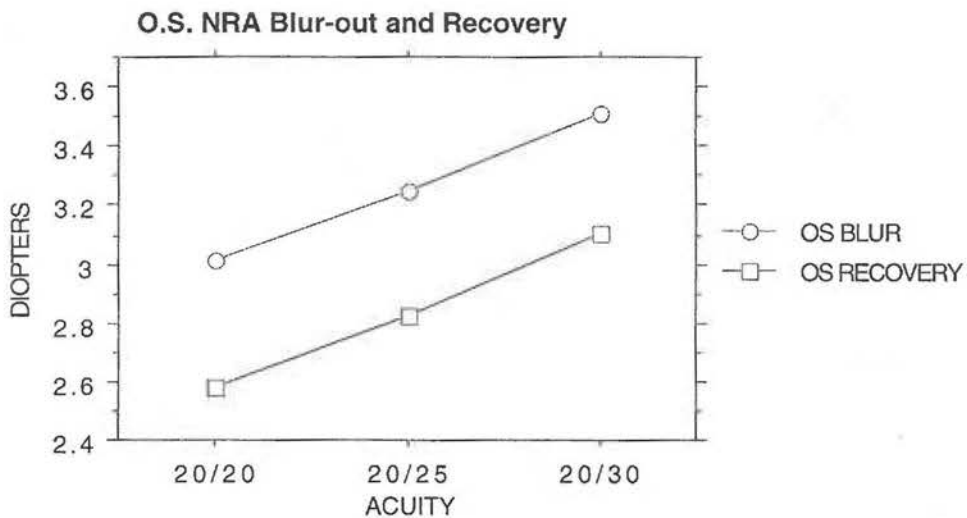
Figure 4. Mean PRA and NRA Nets
For Each Acuity Demand

All PRA Nets

DIOPTERS vs ACUITY (20/20, 20/25, 20/30)

Legend:
- —◯— OU BLUR
- —□— OD BLUR
- —△— OS BLUR
- —◇— OU RECOVERY
- —+— OD RECOVERY
- ✳ OS RECOVERY

All NRA Nets

DIOPTERS vs ACUITY (20/20, 20/25, 20/30)

Legend:
- —◯— OU BLUR
- —□— OD BLUR
- —△— OS BLUR
- —◇— OU RECOVERY
- —+— OD RECOVERY
- ✳ OS RECOVERY

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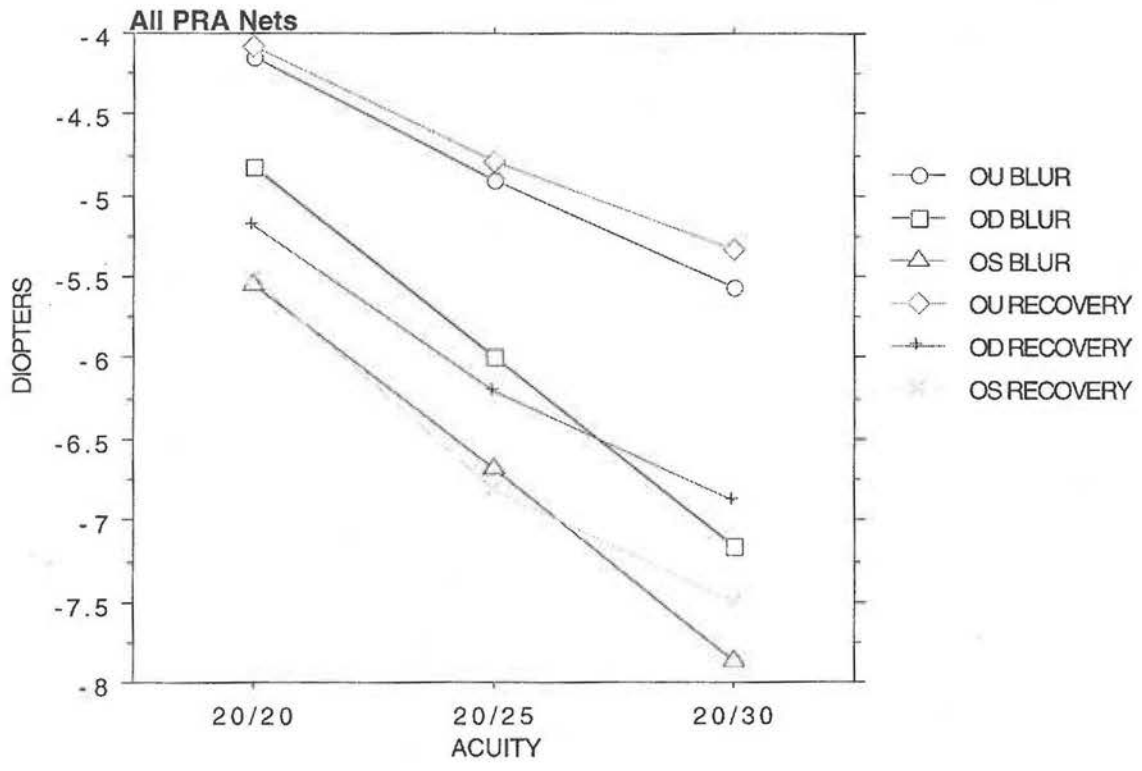
DISCUSSION

This experiment shows that PRA and NRA endpoints significantly differ when various acuity demands are used for testing. In the case of binocular blur-out means, PRA values differed by 0.77 D between 20/20 and 20/25 acuity demands, 0.65 D between 20/25 and 20/30, and 1.42 D between 20/20 and 20/30. NRA values differed by 0.36 D between 20/20 and 20/25 acuity demands, 0.36 D between 20/25 and 20/30, and 0.71 D between 20/20 and 20/30. Mean differences between PRA endpoints were larger than those of NRA, but standard deviations were also larger, showing greater variability in PRA testing. When comparing blur-out to recovery findings, differences among the various acuity demands were quite consistent. The results of this study therefore demonstrate that the use of nonstandard targets or acuity demands for accommodative testing can have definite clinical implications. Additionally, most comparisons made between monocular and binocular findings were also significantly different. Left eye means were consistently more minus in PRA testing and more plus in NRA testing. This could be due to the fact that each subject's left eye was always tested last, raising the possibility that a tonic accommodative factor was present during testing.

PRA and NRA means found in this study were considerably higher than those found in previous studies, most likely due to the optometry student population used in this experiment. Griffin and Lee[5] also found slightly higher PRA and NRA means in their study of college students, though not specifically optometry students. As in previous studies[7,12], accommodative response varied considerably between subjects. Again, there was greater variability (as well as higher means and standard deviations) in PRA than in NRA testing.

The Optometric Extension Program (OEP) protocol specifies that PRA should be measured prior to NRA in order to examine how well the accommodative system can relax after being stressed. However, to minimize any potential effects of accommodative hysteresis, we chose to reverse this testing order for our study. Clinically, many practitioners do the same. Those who use strict OEP guidelines for testing should be aware that their NRA results may differ slightly from this study.

Perceptual phenomena and the implication of blur threshold on PRA and NRA endpoints must be considered. The question of "how blurry is blur?" was posed by Layton, Dickinson, and Pluznick[15], who suggested that clinical data may be misleading if patients differ in the degree of blur needed to trigger their awareness of blur. Klein[16] describes a perceptual concept called the leveling-sharpening dichotomy, with levelers being persons who are unable or unwilling to perceive small perceptual differences, and sharpeners being persons who are able and delighted to perceive such differences. This difference in blur perception among patients may account, in part, for clinical variability in PRA and NRA testing, especially among the optometry student population, which may have an especially heightened threshold for blur.

The overall recommendation implicated by this project is to use a 20/20 nearpoint acuity demand for PRA and NRA testing whenever possible. Not only is this already considered standard in testing protocol and for case analysis purposes, but it also decreases variability between patients. However, should a clinician need to deviate from a 20/20 acuity demand, normative data derived from this study may be used.

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