Pacific University

CommonKnowledge

College of Optometry

Theses, Dissertations and Capstone Projects

5-2005

A comparison between traditional monocular refraction and the biocular Humphriss technique

Bret Provost
Pacific University

Marcelo Saldivia
Pacific University

A comparison between traditional monocular refraction and the biocular Humphriss technique

Abstract

The standard approach for determining refractive error is monocular subjective refraction. In this technique the optometrist or ophthalmologist uses a phoropter to determine the endpoint at which the patient achieves best visual acuity (VA). The eye being tested is exposed to the VA chart, while the other eye is occluded. However, we view the world with two eyes (i.e., binocularly), and therefore a refraction technique conducted under binocular viewing conditions conceivably may yield more accurate results. Whereas several binocular refractive techniques exist including the Turville Infinity Balance and Vectographic Slide, they are used infrequently in standard clinical practice, and while included in optometric curriculum, are not emphasized and therefore rarely utilized by optometric students and recent optometric graduates. One such binocular technique is the Humphriss method, in which both eyes view the VA chart during refraction, but one eye (the eye not being actively tested) is defocused by a moderate degree. This creates a situation in which viewing is binocular such that focusing and eye alignment are determined by binocular perception. The technique is very quick, accurate and generally well-tolerated by the patient The purpose of this study is to conduct a systematic comparison of the binocular Humphriss technique to standard monocular refraction. The results will help determine the efficacy of the Humphriss technique, as well as providing clinical guidelines for application in optometric and ophthalmologic settings.

Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

Jeff Rabin

Keywords

binocular refraction, humphriss technique, small letter acuity, traditional refraction, alternative refractive techniques

Subject Categories

Optometry

A Comparison Between Traditional Monocular Refraction and the Binocular Humphriss Technique

By:
Bret Provost
Marcelo Saldivia

A thesis submitted to the faculty of the
College of Optometry
Pacific University
Forest Grove, Oregon
for the degree of
Doctor of Optometry
May 2005

Advisor:
Jeff Rabin, OD, MS, PhD, FAAO

Contact:
Bret Provost
College of Optometry
Pacific University
2043 College Way
Forest Grove, Oregon 97116
bretprovost@pacificu.edu

Submitted: December 17, 2004

Bret Provost

Marcelo Saldivia

Jeff Rabin, OD, PhD

Bret Provost graduated from Georgia State University with a Bachelor's in Business Administration with a concentration in Finance. He was active with the campus radio station and an avid sailor. He went on to a successful, yet brief, career in real estate consultation. He then pursued a career in the financial securities industry holding the Series 7 & 63 broker licenses. It was in 1999 when he poured all his efforts into pursuing Optometry. He hopes to join, or form, a group practice in Oregon or sunny central coast California.

Marcelo Saldivia attended Piedmont College in Demorest, GA where he was recipient of the Presidential Scholarship. He was an active member of the men's soccer team and the Association of Scientific Students. Upon graduating in 1999 with a Bachelor of Science degree, he went on to work as an ophthalmic technician at a large and successful Ophthalmology/Optometry practice in Snellville, GA which helped to solidify his goal of becoming an optometric physician. Marcelo plans on pursuing a residency program in primary care or ocular disease, upon completion of his Doctor of Optometry degree at Pacific University. He looks forward to practicing in a partnership setting somewhere on the west coast.

ABSTRACT

The standard approach for determining refractive error is monocular subjective refraction. In this technique the optometrist or ophthalmologist uses a phoropter to determine the endpoint at which the patient achieves best visual acuity (VA). The eye being tested is exposed to the VA chart, while the other eye is occluded. However, we view the world with two eyes (i.e., binocularly), and therefore a refraction technique conducted under binocular viewing conditions conceivably may yield more accurate results. Whereas several binocular refractive techniques exist including the Turville Infinity Balance and Vectographic Slide, they are used infrequently in standard clinical practice, and while included in optometric curriculum, are not emphasized and therefore rarely utilized by optometric students and recent optometric graduates.

One such binocular technique is the Humphriss method, in which both eyes view the VA chart during refraction, but one eye (the eye not being actively tested) is defocused by a moderate degree. This creates a situation in which viewing is binocular such that focusing and eye alignment are determined by binocular perception. The technique is very quick, accurate and generally well-tolerated by the patient.

The purpose of this study is to conduct a systematic comparison of the binocular Humphriss technique to standard monocular refraction. The results will help determine the efficacy of the Humphriss technique, as well as providing clinical guidelines for application in optometric and ophthalmologic settings.

Key Words

Binocular refraction
Humphriss technique
Small letter acuity
Traditional refraction
Alternate refractive techniques

The authors wish to thank Dr. Jeff Rabin for his continued support and advisement. He has provided not only his valued time but also his handiness of resources, ideas and solutions. Thank you Dr. Rabin.

Thank you to all the students who volunteered their time to participate in the study.

INTRODUCTION

The standard approach for determining refractive error is monocular subjective refraction. In this technique the optometrist or ophthalmologist uses a phoropter to determine the endpoint at which the patient achieves best visual acuity (VA). The eye being tested is exposed to the VA chart, while the other eye is occluded. However, we view the world with two eyes (i.e., binocularly), and therefore a refraction technique conducted under binocular viewing conditions conceivably may yield more accurate results. Whereas several binocular refractive techniques exist including the Turville Infinity Balance[7-9] and Vectographic Slide[7-9], they are used infrequently in standard clinical practice, and while included in optometric curriculum, are not emphasized and therefore rarely utilized by optometric students and recent optometric graduates.

One such binocular technique is the Humphriss method,[1-3, 7-9] in which both eyes view the VA chart during refraction, but one eye (the eye not being actively tested) is defocused by a moderate degree (e.g., +0.75 D) such that larger letters (top row of chart) are visible to both eyes, while smaller letters are visible only to the eye being tested. This creates a situation in which viewing is binocular such that focusing and eye alignment are determined by binocular perception, but the patient attends to vision of the eye in better focus, making it possible for the doctor to measure and refine the refractive error. The technique is very quick, accurate and generally well-tolerated by the patient.

The purpose of this study is to conduct a systematic comparison of the binocular Humphriss technique to standard monocular refraction. The results will help determine the efficacy of the Humphriss technique, as well as providing clinical guidelines for application in optometric and ophthalmologic settings.

METHODS

This research was conducted by third-year optometric interns, under the direct supervision of the principal investigator. All testing was conducted in a standard optometric examination room, using a phoropter and projected visual acuity chart. Standard monocular refraction, Humphriss binocular refraction, and post-refraction testing were conducted on each subject. Half of the subjects were tested first with the standard monocular refraction, while the other half was tested initially with the Humphriss technique to control for order effects. Each refraction was followed by the post-refraction test series in Table 1.

Monocular refraction was initiated with retinoscopy on each eye. The left eye then was occluded, and the standard refraction conducted on the right eye, including determination of maximum VA with spherical lenses, followed by astigmatic error using the Jackson Cross Cylinder (JCC) technique. The right eye then was occluded, the left eye exposed to the chart, and the monocular refraction repeated for the left eye. A standard binocular balance was then conducted using 3 base-down prism before the right eye, and 3 base-up before the left eye while viewing the 20/40 Snellen line. This creates separate images of the VA line for each eye, and allows the clinician to equalize (i.e., *balance*) the perceived clarity of the two lines by adding or subtracting spherical power to each eye.

Binocular refraction was conducted using the Humphriss Technique, as follows: with the retinoscopy estimate in the phoropter, the left eye was defocused by +0.75 D. A portion of the chart showing the 20/40 to 20/20 VA lines was projected, and the experimenter covered the right eye briefly and asked, "Do the letters appear blurry here?" The experimenter then occluded the left eye, uncovered the right, and asked, "Do the letters appear clearer here?" This step demonstrates to the subject that the letters appear defocused (blurry) with one eye but clearer with the other eye. The experimenter then stated, "I will be working with your right eye first, but try to keep both eyes open at all times." The experimenter then proceeded to determine best VA using spherical lenses, followed by Jackson Cross Cylinder determination of astigmatic power. Next, sphere endpoint was refined using the 20/20 or 20/15 line. The right eye then was defocused by +0.75, the +0.75 defocus lens was removed from the left eye, and the refraction procedure repeated on the left eye.

Following each refraction, additional phoropter tests were conducted (see Table 1), after which the prescription was placed in a trial frame, and the additional tests listed in Table 1 were conducted. Each test quantifies different aspects of monocular and binocular vision, which was compared between the two methods of refraction (standard vs. Humphriss).

Table 1: Post-refraction Tests of Visual Performance

Visual Performance Measure	Vision Test	Relevant Parameter
Monocular and binocular high contrast VA	Log MAR Test	Levels achieved and enhancement achieved binocularly
Monocular and binocular low contrast VA	Log MAR Test	Levels achieved and enhancement achieved binocularly
Monocular and binocular large letter contrast sensitivity	Small letter contrast test	Levels achieved and enhancement achieved binocularly
Red-green monocular endpoint (in phoropter)	Chromatic endpoint following refraction	Chromatic endpoint and difference between eyes
Stereoacuity	Clinical stereopsis test	Stereo-threshold
Accommodative amplitude (in phoropter)	Phoropter push-up test	Comparison between monocular accommodative amplitudes
Equality of accommodative response (phoropter)	Associated cross cylinder technique	Interocular difference in lens power to achieve endpoint
Time required for refraction	Electronic timer	Efficiency of technique
Patient response	Brief questionnaire	Comfort level and ease of participation during refraction

All subjects were recruited from the College of Optometry student body. Recruitment was limited to subjects with ages ranging from 20-40 years old, with corrected visual acuity of at least 20/20 in each eye, and no history of eye disease, strabismus or amblyopia ("lazy-eye"). All subjects provided informed consent following protocol approval by our institutional review board.

RESULTS

Post-refraction Tests of Visual Performance:

Our intent was to determine which refracting method provides the highest level of acuity as measured by traditional Snellen VA, log MAR VA, and small letter contrast sensitivity; the best stereopsis; engages the largest ranges as measured by plus and minus to blur out, NRA, PRA and BCC; has the best control of accommodation as evaluated by red/green balance; and finally, is most time efficient. The participants subjectively evaluated the refractions and gave their impressions on the ease of understanding instructions, time efficiency and endpoints.

Alternative Binocular Refraction Techniques:

The Humphriss Technique was utilized in this study. There are several other binocular methods of binocular refraction, but application of these techniques is limited. The Turville Infinity Balance and Vectographic Slide polarized filter technique are the two most commonly used methods. Both preparation and execution of these methods poses challenges. The Turville technique requires a septum to present separate images to each eye, correct alignment (once aligned, the septum may interfere with other procedures), and sufficient time to properly calibrate the charts. The Vectographic Slide method requires polarization and requires that the patient tolerate an unnatural stimulus, which can be confusing. Both eyes are open, but one eye views one side of the chart and the fellow eye observes the other side. Unless prompted continuously, the patient is unsure where and what to attend to.

Other methods found in the literature utilize a form of color dissociation, similar to the red/green balance found in the traditional refraction and blurring as used in the Humphriss Technique evaluated herein.

Visual Acuity and Contrast Sensitivity:

The letter charts used in this study included: Snellen, LogMAR and the small letter contrast test. Snellen is not practical for scientific studies due to the inconsistent step size, change in tasks with acuity level, and difficulty quantifying the result. The LogMAR chart was used because of its design and ease of use in the scientific setting. The layout allows for easy mathematical calculations. Finally, the small letter chart provided a clinically expedient measure of contrast sensitivity for high spatial frequencies (fine detail), serving as an adjunctive measure of resolution. The following grid compares and contrasts the three charts:

	Letters/Line	Spacing within a Line	Spacing between Lines	Size of Letters
Snellen	Variable	Variable	Variable	Variable
LogMAR	Consistent	Consistent	Consistent	Decreases by the same rate
Small Letter	Consistent	Consistent	Consistent	Does not change

Accommodative Measurements:

Negative and Positive Relative Accommodation, NRA and PRA, are measures of accommodative range. Both eyes are focused on a line at a fixed distance, 40 cm while minus (PRA) or plus (NRA) lenses are added until the image is blurred. During this testing convergence is held constant while accommodation is pushed to its limits. It is assumed that the corrected refractive error that provides for the largest range (largest split between the NRA and PRA) is the optimum lens in place, at least for providing the best zone of clear and comfortable accommodation. Plus and minus to blur out are similar measures but the lens changes are only made to one eye while the other eye is occluded. Here convergence is not in play since both eyes are not being used. Minus to blur was used in this thesis because it is a measure of taxing accommodation thus simulating the act of accommodating versus plus lenses that would relax accommodation and is not a very common goal in everyday visual functioning.

Stereopsis:

Stereopsis is an essential measurement of muscle teaming and fine binocular function. It is measured at 40cm but at that distance all but those with tropias, high phorias or high anisometropia would be able to achieve 50 arc seconds or better. To make this measurement meaningful the distance was doubled to 80cm which makes each marking of stereoacuity twice as sensitive, following a linear relationship. Therefore, a participant who achieves 30 arc seconds on the random dot chart at 80cm is truly appreciating 15 arc seconds of stereopsis. The randot circles were used since it measures stereoacuity to a very sensitive level. The random dot chart is the best chart since it utilizes not only global stereopsis but local stereopsis. Random dot charts are limited to large targets and not small targets therefore the randot circles were ultimately used.

Quantitative Analysis of Results

Patient set:

There were 33 total participants. There were only two hyperopes in the study, one of which is a high hyperope and had problems with the testing. The hyperopes could not be blurred up enough. Fourteen were considered emmetropes based on retinoscopy of the right eye being between plano and -0.50D. This left 17 myopes (-0.75 to -7.12; equivalent sphere).

Refraction:

The mean refractive endpoint was more minus with the Humphriss technique (0.29D and 0.22D more minus for right and left eyes, respectively). This myopic shift with the Humprhiss technique was significant (paired t-test, $p<0.001$). Consistent with this finding, the red-green duochrome endpoint was shifted toward green for the Humphriss technique ($p<0.005$).

Time:

The binocular refraction is faster. The average binocular refraction time was 3.25 minutes compared to the monocular refraction time of 4.07 minutes, and this difference was significant (paired t-test, $p<0.001$). The time achieved on either type of refraction was not dependent on the refractive error.

Visual Acuity:

Log MAR:

51.5% (17/33) of patients fared better with the Humprhiss OD
48.5% (16/33) of patients fared better with the Humprhiss OS
54.5% (18/33) of patients fared better with the Humprhiss OU
Mean log MAR in the left eye and with both eyes was slightly better with the Humphriss technique, and the differences were significant ($p<0.02$).

Snellen:

Snellen is a less precise measurement due to the inconsistent step size and different number of letters per line as compared to Log MAR. Many measurements were the same between binocular and monocular testing with the Snellen.

63.6% (21/33) were equal between the Humphriss & traditional method OD
30.3% (10/33) were better with the traditional method OD
72.7% (24/33) were equal between the Humphriss & traditional method OS
21.2% (7/33) were better with the traditional method OS

Small Lette Contrast Test:

OD: 60.6% (20/33) were better with Humprhiss
With an average of 14% better; range 1-37% better
This difference was significant ($p<0.005$).
39.4% (13/33) were better with the traditional method
With an average of 5% better; range 1-31% better

OS: 57.6% (19/33) were better with Humprhiss
With an average of 18% better; range 1-44% better
36.4% (12/33) were better with the traditional method
With an average of 17% better; range 3-40% better
The difference was significant ($p<0.01$).

OU: 69.7% (23/33) were better with Humprhiss
With an average of 5% better; range 1-12% better
18.2% (6/33) were better with the traditional method
With an average of 2% better; range 1-5% better
This difference was not significant ($p>0.4$).

NRA:

69.7% (23/33) with Humphriss had a slightly smaller NRA (mean=0.08D)
This difference was not significant ($p>0.08$)

PRA:

54.5% (18/33) with the Humphriss had a slightly larger PRA (mean=0.07D)
This difference was not significant ($p>0.28$)

Stereo:

57.6% (19/33) had equal stereoacuity measurements
24.2% (8/33) with Humphriss measuring finer acuity
With an average of 40% better, range 20-60% finer

18.2% (6/33) with traditional measuring finer acuity

With an average of 46% better, range 20-64% finer

No significant differences were observed for stereopsis.

DISCUSSION AND CONCLSUIONS

Overall the Humphriss technique is a more efficient and faster technique for refraction, allowing for an expedient binocular refraction without the need to balance or dissociate vision. Results for both log MAR acuity and small letter contrast sensitivity point to slightly enhanced performance with this binocular approach, but differences were small and only bordered on clinical significance. Comparison between binocular and monocular results revealed no clear enhancement with Humphriss compared to standard refraction.

The refractive endpoint was approximately 0.25D more minus with the Humphriss approach compared to standard refraction. Interestingly, the standard refraction yielded endpoints which were slightly less minus than the subject's habitual correction (mean decrease=0.09D), while the Humphriss provided endpoints which were slightly more minus (mean increase in minus power=0.17D). Insofar as the subjects were all young adults, a change in the more myopic direction seems more likely than a decrease in myopic correction, and presumably would yield a more successful clinical result. Longitudinal comparison of the clinical efficacy of the two techniques would be necessary to support this assumption.

Considering the small portion of test participants that were hyperopic, it is not possible to derive conclusions from the results reported herein. Nevertheless, our experience indicates that in latent hyperopia it is often necessary to increase the degree of blur before the non-tested eye beyond +0.75. The Humphriss should be preceded by an accurate retinoscopy to derive a suitable starting point, and +1.00 to +1.50D should be considered for use before the non-tested eye, depending on the estimated hyperopic latency. As more positive power is accepted by the eye undergoing refraction, the degree of fogging (i.e., amount of positive power) before the non-tested eye can be increased proportionately.[10]

As primary care providers it is important to constantly strive to provide the best care to our patients. In terms of refractions the Humphriss technique is a viable and useful alternative that has potential for gaining popularity and use within the eye profession.

References

1. Humphriss D. The psychological septum. An investigation into its function. American Journal of Optometry and Physiological Optics 1982;59:639-41.
2. Humphriss D. The refraction of binocular vision. Ophthalmic Optician, 5 Oct 1963, pp 987-1001.
3. Humphriss D, Woodruff EW. Refraction by immediate contrast. British Journal of Physiological Optics 1962;19:15.
4. Bailey IL, Lovie JE. New design principles for visual acuity letter charts. Am J Optom Physiol Opt 1976; 53:740-5.
5. Rabin J. Small letter contrast sensitivity: an alternative measure of visual resolution for aviation candidates. Aviat Space Environ Med 1995; 66:56-8.
6. Rabin J. Luminance effects on visual acuity and small letter contrast sensitivity. Optom Vis Sci 1994; 71:685-8.
7. Amos JF. Binocular Subjective Refraction. In: Eskridge J, Amos J, Bartlett J, eds. Clinical Procedures in Optometry. Philadelphia: Lippincott Williams & Wilkins; 1991: 189-193.
8. Grosvenor T. The Binocular Vision Examination. In: Grosvenor T. Primary Care Optometry. 4th Edition. Boston: Butterworth Heinemann; 266, 294-298.
9. Benjamin W, Borish I. Monocular and binocular subjective refraction. In: Benjamin W., ed. Borish's Clinical Refraction. Philadelphia: W.B. Saunders Company; 679-689.
10. Rabin J. Personal communication. Pacific University College of Optometry.