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Visual performance with monovision correction based on ocular dominance and patient preference

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Abstract
Monovision is a popular treatment modality for the refractive correction of presbyopia, where one eye is corrected for distance viewing and the other eye is corrected for near. Opinions differ among practitioners for the ideal method to select the eye to wear the distance correction, with the majority of practitioners correcting the dominant eye for distance. Twenty five pre-presbyopes participated in a study to investigate the relationship between patient preference for monovision correction and ocular dominance. The purpose of the study was to determine whether subject preference, or ocular dominance, or both, are predictable for optimum visual performance and success in a monovision correction. Each subject underwent a manifest refraction, followed by measurement of binocular distance visual acuity using both high-(100%) and low-(10%) contrast Bailey-Lovie visual acuity charts. Ocular dominance testing was performed using five different dominance tests, and subject preference of placement of distance and near correction was evaluated on the basis of visual clarity and comfort. Subjects’ eyes were identified as either near-preferred or distance-preferred. High- and low-contrast distance visual acuity was re-measured once alternately with additional plus power over each eye. The results show that visual acuity was worse with the non-dominant eye corrected to the distance compared to the dominant eye corrected to the distance. Acuity was also worse with the near-preferred eye wearing the distance correction compared to the distance-preferred eye having the distance power. This was true for both high- and low-contrast visual acuity, but only statistically significant for high-contrast acuity. Among the different monovision scenarios studied, the one providing the best acuity (both high- and low-contrast) was that of distance-preferred eye wearing the distance correction. This indicates that patient preference for the placement of the near and far powers may be of clinical use in successfully assigning power with monovision correction.

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VISUAL PERFORMANCE WITH MONOVISION CORRECTION
BASED ON OCULAR DOMINANCE AND PATIENT PREFERENCE

BY

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MATTHEW D. GEORGESON

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Advisor: Patrick J. Caroline, C.O.T., F.A.A.O.
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BIOGRAPHY OF AUTHORS

Rhett Veater was born and raised in Panguitch, Utah. He received a Bachelor of Science degree in biology from Southern Utah University in Cedar City, Utah. Upon graduation from Pacific University College Optometry, he will serve in the U.S. Army for four years, and subsequently plans on owning a private family practice.

Matthew D. Georgeson was born and raised in Boise, Idaho. He received a Bachelor of Science degree in human biology from Brigham Young University in Provo, Utah. Upon graduation from Pacific University College of Optometry, he plans on owning a private family practice in a western state.
ABSTRACT

Monovision is a popular treatment modality for the refractive correction of presbyopia, where one eye is corrected for distance viewing and the other eye is corrected for near. Opinions differ among practitioners for the ideal method to select the eye to wear the distance correction, with the majority of practitioners correcting the dominant eye for distance. Twenty five pre-presbyopes participated in a study to investigate the relationship between patient preference for monovision correction and ocular dominance. The purpose of the study was to determine whether subject preference, or ocular dominance, or both, are predictable for optimum visual performance and success in a monovision correction. Each subject underwent a manifest refraction, followed by measurement of binocular distance visual acuity using both high-(100%) and low-(10%) contrast Bailey-Lovie visual acuity charts. Ocular dominance testing was performed using five different dominance tests, and subject preference of placement of distance and near correction was evaluated on the basis of visual clarity and comfort. Subjects’ eyes were identified as either near-preferred or distance-preferred. High- and low-contrast distance visual acuity was re-measured once alternately with additional plus power over each eye. The results show that visual acuity was worse with the non-dominant eye corrected to the distance compared to the dominant eye corrected to the distance. Acuity was also worse with the near-preferred eye wearing the distance correction compared to the distance-preferred eye having the distance power. This was true for both high- and low-contrast visual acuity, but only statistically significant for high-contrast acuity. Among the different monovision scenarios studied, the one providing the best acuity (both high- and low-contrast) was that of distance-preferred eye wearing the distance correction. This indicates that patient preference for the placement of the near and far powers may be of clinical use in successfully assigning power with monovision correction.
INTRODUCTION

Monovision is a popular treatment modality for the refractive correction of presbyopia, in which one eye is corrected for distance viewing and the other eye is corrected for near. This provides presbyopic patients with clear vision at all distances by utilizing retinal correspondence and ocular blur suppression. It is an attractive option for presbyopic patients seeking an alternative to reading glasses or bifocal adds. Contact lens correction has traditionally been the most common method of inducing monovision, however permanent monovision options such as LASIK and PRK are becoming popular for those refractive surgery candidates age 45 and older.

Although monovision correction leaves the eyes in an unbalanced refractive condition, 70 to 80% of all monovision trials are successful\textsuperscript{1,2} with an initial adaptive period of up to three weeks.\textsuperscript{1,3} Proven predictors of monovision success include patient motivation and personality type\textsuperscript{2} as well as proper selection of which eye to correct for near and distance viewing. Although opinions differ among practitioners as to the selection of the eye to carry the distance correction, the majority of practitioners correct the dominant eye for distance. This is due to a belief that suppression of the non-dominant eye is more likely to occur thus increasing performance in tasks requiring good spatial perception.\textsuperscript{4,5,6}

It is important to note that no experimental evidence has been able to relate ocular dominance with blur suppression.\textsuperscript{2} Robby et al. investigated visual function in monovision correction finding no significant difference between visual acuity function when comparing the dominant and non-dominant eye.\textsuperscript{4}

A possible reason for the appeal of determining correction placement based on motor ocular dominance results is the relative ease of sighting dominance testing compared to other determinants such as sensory ocular dominance, which often requires unfamiliar instrumentation and can be relatively more time consuming. Other methods of monovision include correcting the left eye for distance,\textsuperscript{7} correcting the less myopic eye for distance, and allowing the patient to decide which eye to correct for distance. Despite the lack of scientific evidence supporting the use of the dominant eye for distance, one review of the scientific literature found that out of 13 articles on monovision correction,
95% of all subjects were corrected using the dominant eye for distance with an average success rate of 75%.

The purpose of our study was to investigate the relationship between patient preference for monovision correction and ocular dominance. Our effort was to determine whether patient preference, or ocular dominance, or both, are predictable for optimum visual performance; and therefore visual success in a monovision correction. We examined visual performance with the dominant eye receiving the distance correction and non-dominant eye receiving the distance correction, the distance-preferred eye wearing the distance correction and the near-preferred eye wearing distance correction, as well as comparing different dominance and preference monovision scenarios. Performance was evaluated using both high- and low-contrast distance visual acuity.

**METHODS**

Twenty five (15 male, 10 female) pre-presbyopic optometry students were recruited for the study. Each of these subjects met the criteria for participation with no history of strabismus or amblyopia, best corrected visual acuity of each eye of 20/20 or better, and no difference more than one line (0.10 logMAR) of visual acuity between the two eyes.

A manifest refraction was performed on each subject to determine best distance spectacle correction. The refraction sequence was: 1) 20/40 blur, followed by the addition of -1.00D; 2) Jackson Cross-Cylinder; 3) binocular balance; 4) binocular forced choice to 20/20. The resultant correction was then worn by each subject in a trial frame for the remainder of the testing to determine baseline data as well as visual performance and preference with monovision correction.

Baseline binocular distance visual acuity was determined using both high-(100%) and low-(10%) contrast Bailey-Lovie visual acuity charts at 20 feet. Ocular dominance testing was performed using the following sequence of sighting tests:

1) Lensometer sighting test, with the subject being asked to view a target through a lensometer and the examiner noting which eye was used.
2) Near point of convergence, with the examiner identifying the fixating eye upon break of motor fusion.

3) Hole-in-card test #1, with the subject maintaining sight of a target at 16 feet while bringing the card from arm’s length in towards the dominant eye.

4) Hole-in-card test #2, with the subject sighting a target at 16 feet through the card held at arm’s length and the examiner performing alternate occlusion to identify the fixating eye.

5) Finger pointing test, with the subject being asked to point with either hand at the open eye of the examiner, and the examiner noting which of the subject’s eyes is aligned with the finger.

The eye used in three or more of the above tests was designated as the dominant eye. Preference of placement of distance and near correction was then evaluated using a swinging plus lens test with a +1.50D loose lens placed alternately before either of the subjects’ eyes. Subjects viewed a Snellen acuity chart at 16 feet with the 20/25 to 20/15 lines visible. Subjects were instructed to state which lens placement was preferred on the basis visual clarity and comfort. Based on the preferred placement, the eyes were identified as either near-preferred (with additional plus) or distance-preferred (without additional plus).

After ocular dominance and preference of plus were determined, examiners re-measured high- and low-contrast distance visual acuity once alternately with the plus lens over each eye.

RESULTS
Baseline Data

Best-corrected binocular high-contrast visual acuity for our subjects without monovision simulation ranged from -.04 to -.30 logMAR (20/20 to 20/10 Snellen) with a mean of -.18 (20/12.5 Snellen), and a standard deviation of .06 logMAR. Baseline low-contrast visual acuity ranged from .22 to -.08 logMAR with a mean of .05 (SD: .08 logMAR).
Based on the previously mentioned criteria for determining eye dominance, 60% of subjects were right-eye dominant and 40% were left-eye dominant.

Two subjects offered no preference for power placement. The remaining 23 individuals fell into one of the following categories in comparing eye dominance with preference of distance and near power placement (see Figure 1):

Forty-eight percent (48%) were right-eye dominant AND right-eye distance preferred (preferred the right eye to receive the distance prescription). Those with right-eye dominance who were left-eye distance preferred were only 8% of the total. Similarly, those found to be left-eye dominant and preferring the right eye to wear the distance correction were 12% of the total. Twenty-four percent (24%) of subjects were left-eye dominant and preferred the distance correction over the left eye.

The dominant eye and the distance-preferred eye were the same for 72% of subjects. Dominance and preference for distance were assigned to a different eye for only 20% of subjects.
Visual Performance and Dominance

Paired t-test analysis was performed to determine the significance of visual performance changes with a monovision correction (see Table 1). Both high- and low-contrast visual acuity were significantly decreased with a monovision correction compared to no monovision, regardless of which eye received the additional plus power.

Table 1

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Mean Difference (logMAR)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dominant Eye Distance-corrected Compared to Baseline</td>
<td>.062</td>
<td>.0002</td>
</tr>
<tr>
<td>Non-Dominant Eye Distance-corrected Compared to Baseline</td>
<td>.081</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Dominant Eye Distance-corrected Compared to Non-Dominant Eye Distance-corrected</td>
<td>.019</td>
<td>.3141</td>
</tr>
<tr>
<td>Dominant Eye Distance-corrected Compared to Low-contrast Baseline</td>
<td>.049</td>
<td>.0164</td>
</tr>
<tr>
<td>Non-Dominant Eye Distance-corrected Compared to Baseline</td>
<td>.078</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Dominant Eye Distance-corrected Compared to Non-Dominant Eye Distance-corrected</td>
<td>.029</td>
<td>.1329</td>
</tr>
</tbody>
</table>

With the dominant eye corrected for distance (non-dominant eye wearing the additional +1.50D), mean high-contrast visual acuity was decreased to -.12 logMAR (20/16+1 Snellen), a mean difference of .062 logMAR units (about 3 Snellen letters) from baseline (P-value .0002) (see Figure 2). With the non-dominant eye wearing the distance correction, mean high-contrast visual acuity was -.10 logMAR (20/16 Snellen), worse by a mean difference of .081 logMAR (4 Snellen letters) compared to baseline (P-value <.0001). Comparing high-contrast visual acuity with the dominant eye corrected for distance to the nondominant eye corrected for distance, the difference was not statistically significant (mean difference of .019 logMAR and P-value .3141).
Mean low-contrast visual acuity with the dominant eye corrected to the distance was reduced with statistical significance to .10 logMAR, a mean difference of .049 logMAR from baseline (P-value =.0164). With the non-dominant eye corrected for distance, mean low-contrast acuity was .13 logMAR for a difference of .078 logMAR compared to baseline (P-value <.0001). Low-contrast visual performance was not significantly different with the dominant eye distance-corrected compared to the non-dominant eye corrected for distance (mean difference of -.029 logMAR and P-value =.1329).

Visual Performance and Preference

Of all different monovision scenarios, whether based on dominance or power preference, the best mean high-contrast visual acuity was found with the distance-preferred eye corrected with the distance power (-.13 logMAR or 20/16+1). Comparing this value to baseline shows a significant mean difference of .048 logMAR (P-value = .0013) (see Table 2). With the near-preferred eye corrected for the distance, mean high-contrast acuity was decreased to -.08 logMAR (20/16-1), a mean difference of .091 logMAR from baseline. High-contrast acuity was significantly different with the
distance-preferred eye receiving the distance correction compared to the near-preferred eye corrected for distance (mean difference of 0.043 logMAR and P-value = 0.0272).

Table 2

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Mean Difference (logMAR)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance-preferred Eye Distance-corrected Compared to Baseline</td>
<td>0.048</td>
<td>0.0013</td>
</tr>
<tr>
<td>Near-preferred Eye Distance-corrected Compared to Baseline</td>
<td>0.091</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Distance-preferred Eye Distance-corrected Compared to Near-preferred Eye Distance-corrected</td>
<td>0.043</td>
<td>0.0272</td>
</tr>
</tbody>
</table>

High-contrast Visual Acuity

Low-contrast Visual Acuity

The monovision scenario which gave the best mean low-contrast visual acuity was with the distance-preferred eye wearing the distance correction (.09 logMAR). This value showed a mean difference of 0.048 logMAR compared to baseline (P-value = 0.0200). With the near-preferred eye corrected for the distance, mean low-contrast visual acuity was .12 logMAR, a mean difference of 0.077 from baseline (P-value < 0.0001). The difference in low-contrast visual acuity between monovision with the distance-preferred eye corrected to the distance and the near-preferred eye corrected to the distance was not significantly significant (mean difference 0.030 logMAR and P-value = 1.550).

Domiance versus Preference

Mean high-contrast visual acuity with the dominant eye corrected for the distance was not significantly different from that with the distance-preferred eye wearing the distance correction (mean difference of 0.01 logMAR and P-value = 0.2411) (see Table 3).
The difference in low-contrast visual acuity for these two monovision scenarios was also insignificant (mean difference of .006 logMAR and P-value = .5804).

Table 3

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Mean Difference (logMAR)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-contrast Visual Acuity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominant Eye Distance-corrected Compared to Distance-preferred Eye</td>
<td>0.010</td>
<td>0.2411</td>
</tr>
<tr>
<td>Non-dominant Eye Distance-corrected Compared to Near-preferred Eye</td>
<td>0.010</td>
<td>0.2411</td>
</tr>
<tr>
<td>Low-contrast Visual Acuity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominant Eye Distance-corrected Compared to Distance-preferred Eye</td>
<td>0.006</td>
<td>0.5804</td>
</tr>
<tr>
<td>Non-dominant Eye Distance-corrected Compared to Near-preferred Eye</td>
<td>0.003</td>
<td>0.8283</td>
</tr>
</tbody>
</table>

Also showing no statistical significance was the difference in high-contrast visual acuity with the non-dominant eye being distance-corrected as compared to the near-preferred eye corrected for distance (mean difference of .010 logMAR and P-value = .2411). Likewise, the difference in measured low-contrast acuity was insignificant for these two monovision scenarios.

CONCLUSIONS

Monovision correction creates a reduction in both high- and low-contrast binocular distance visual acuity, as compared to no monovision correction. Among the different monovision scenarios, visual acuity was found to be worse with the non-dominant eye corrected to the distance compared to the dominant eye corrected to the distance, although this difference was not found to be statistically significant for either high-or low-contrast acuity. With the near-preferred eye wearing the distance correction, acuity was worse than with the distance-preferred eye having the distance power. This was true for both high- and low-contrast visual acuity, but only statistically significant for the former.
The monovision scenario providing the worst visual performance was different between our studied indicators of high- and low-contrast visual acuity. For high-contrast, performance was worst when the near-preferred eye was corrected for the distance. Low-contrast acuity was most reduced with the non-dominant eye wearing the distance prescription. The reason for this difference is unclear, but the difference is echoed in the unequal significance between the two measures for visual performance in distance-versus near-preference of the near and far monovision powers. High-contrast visual acuity was significantly better with the distance-preferred eye receiving the distance correction compared to the near-preferred eye receiving the distance correction. Low-contrast visual acuity showed no difference between the distance-preferred eye wearing the distance correction and the near-preferred eye wearing the distance correction. Overall, our testing shows no significantly unique benefits to testing both high- and low-contrast visual acuity. Because the difference in visual acuity between the distance- and near preferred eye wearing the distance correction was only significant with high-contrast testing, and because high-contrast testing is more common among primary vision care professionals, it may be the measuring tool of choice in determining placement of monovision correction.

Among the different monovision scenarios studied, the one providing the best acuity (both high- and low-contrast) was that of distance-preferred eye wearing the distance correction. This fact indicates that patient preference for the placement of the near and far powers may be of clinical use in successfully assigning power with monovision correction. This isn’t to say that eye dominance is an invalid consideration in determining placement of monovision powers. In fact, there was no statistically significant difference in high- or low-contrast visual acuity between the dominant eye and the distance-preferred eye carrying the distance prescription. In fact, the correlation between dominance and preference for distance correction is apparent, with most subjects preferring the dominant eye to wear the distance power. Using the patient preference method has unique advantages over using dominance testing. These include the lack of gold standard for measuring ocular dominance and the variability in results between tests for many patients. Also, the preference method gets the patient more involved in the decision of correction placement, allowing them to feel that they have strong input in the
decision, which could increase the likelihood of adaptation to and acceptance of the modality. More research is needed to explore the nuances of monovision, so that vision care practitioners might utilize it with greater success in their recommendation to and treatment of presbyopes.

REFERENCES


