The peripheral visual field through the autofocal

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Abstract
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Degree Type
Thesis

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The Peripheral Visual Field Through the Autofocal

Submitted by
Dan Edwards
Pacific University College of Optometry
Forest Grove, Oregon

April 14, 1978

Adviser
Dr. Petersen

For credit for Optometry 692
Wesley-Jessen offers PMMA contact lenses to optometry students at Pacific University College of Optometry at reduced cost, and their assistance in minimizing the cost of this project is greatly appreciated. Dr. Peterson's role as an advisor was helpful, since he is skilled with contact lenses, well acquainted with Wesley-Jessen, and familiar with investigations of this type.
ABSTRACT

From a fitting standpoint, the centro-symmetric bifocal contact lens designs represent the simplest approach to fitting presbyopic hard lens patients with multi-focal lenses. The Wesley-Jessen Autofocal can be ordered from PEK photographs, and the lens performs reasonably well with respect to comfort, centration, and tear exchange. This study was designed to determine empirically if the Autofocal lens design could produce undesirable peripheral field restrictions. No significant predictable field changes were observed in the seven subjects tested in this study. This lens cannot, therefore, be contra-indicated on the basis of altering peripheral form detection.
When a contact lens patient ages and begins to enter presbyopia, a need to render clear, comfortable full-time vision without the use of spectacles may arise.

While several types of bifocal contact lenses are available, the lens of interest in this study is the concentric design, which does not require prism, ballast, or truncation. Wesley-Jessen, using the trademark Autofocal, manufactures such a lens. Less than 3mm of the central optic zone of this lens is used for distant vision. The remainder of the optic zone incorporates the near add in graduated form. From ophthalmic optics, it is known that the visual field through a plus lens is smaller than the visual field through no lens. Is it possible that a net increase in plus power off the visual axis could produce a diminished field of vision?

It is the goal of this research to clinically determine if the peripheral visual performance while wearing this bifocal lens is significantly different from the peripheral visual field performance through a conventional single vision PMMA contact lens.
IV SURVEY OF RELATED LITERATURE

A. Visual field performance through single vision contact lenses compared to the visual field performance through spectacle lenses.

Brombach\(^1\) first compared the visual fields of patients with single vision contact lenses and spectacles. He found significant improvements with contact lenses in only ten percent of the 100 cases considered. Franz and Edwarthy\(^2\) found "very little difference" in horizontal motion and form fields through contact lenses and spectacles. Towne and Schmitt\(^3\) found that contact lens wearers on the average obtained an increase of less than two degrees of peripheral vision over their spectacle prescriptions. McDonell and Peterson\(^4,5\) obtained similar results noting that the most significant improvements were obtained with aphakic corrections; however, only one patient was in the aphakic class.

B. General bifocal contact lens survey

Bifocal contact lenses are not new. Feinbloom is credited with the invention of the first bifocal scleral lens in 1936\(^6\), and John de Carle in England created the first bifocal corneal lens in 1957.\(^7\)

Though they have been available for some time, both Mandell and Grosvenor feel that the bifocal contact lens is one of the most difficult to fit successfully.\(^8,9\)

There are three general categories of bifocal lens designs: pinhole and stenopaic slit types, where the depth of focus is increased; non-rotational (via prism, ballast, and/or truncation) segmented types with upper distance prescription and lower near prescription; and symmetric concentric forms with the distance prescription in the central zone of the lens and the near prescription in an annular peripheral region.
The symmetric concentric forms are also made with the near prescription in the central zone, and the distance correction in the peripheral portion of the lens.

The designs are based on one of two principles: bi-vision or simultaneous vision where the lens remains centered at all times and light always passes through both the distance and near zones of the lens onto the retina; and alternating vision, where the lens is positioned by lid action so the majority of the pupils is covered by the appropriate zone of the lens. The simultaneous vision principle in practice tends to compromise acuity from stray unfocused light, and the alternating vision principle generally requires a large, loose lens that can be easily moved by the lower lid margin.\textsuperscript{10,11}

C. The Wesley-Jessen Autofocal

The Autofocal is manufactured by Wesley-Jessen. It is one of their DynaCurve aspheric back surface lenses. No prism, ballast, truncation, or segment is used. Plus for near is generated as a function of the flattening of the aspheric back surface. The front surface is spherical, and its curvature is selected to provide the appropriate lens power for distance vision. The principle used in this lens is the alternating vision principle, described earlier.\textsuperscript{12}

The lens was developed by analyzing results obtained with the Photo-ekstro-keratoscope (PEK) System 2000. The Autofocal is fit ideally, according to the manufacturer, via System 2000 PEK photographs. A success rate of 83 percent is claimed by the manufacturer in a survey of five practitioners "selected at random".\textsuperscript{13}
Wesley-Jessen is currently marketing these lenses with a money back guarantee.
The goal of this thesis project is to determine if the Autofocal alters the angular extent of the horizontal temporal peripheral form field. If it does so to a significantly detrimental degree, then use of this lens when peripheral vision is important, such as driving or flying, should be reconsidered.

The approach used will be the following:

1. Clinically evaluate the horizontal temporal peripheral form field through the subject's habitual single vision hard contact lens,
2. Similarly evaluate the same area of the visual field with the Autofocal in place, and
3. Compare the results.
VI METHODOLOGY

A. Patient selection criteria and rationale

Only fully adapted, full-time (10 hours or more continuous daily wear) PMMA lens wearers were fit with the Autofocal and tested in this study. Problems of initial and long-term adaptation might have confounded the results. Patients were selected without regard to age, pupil diameter, or refractive error, as the experimental method manipulates only one independent variable, lens design.

B. Fitting procedure to be used

The System 2000 PEK is available for general clinic use in the Forest Grove clinic of the Pacific University College of Optometry. Therefore, all Autofocal lenses will be fit, as the manufacturer recommends, via PEK photographs. All adds were +1.50 diopters.

C. Field measurement technique

This study differs from previous similar ones done at this institution in the way the peripheral visual field is measured. An automated visual field screener, the Biotronics Auto-Field $^R$ is currently available for general clinic use in the Forest Grove Clinic. Biotronics' Auto-Field 1 is self-attendant, automatic recording visual field screening instrument. The instrument has been designed to minimize supervision required by professional personnel in administering a visual field examination. A patient is accommodated to the instrument, and instructed to depress the patient response switches when a stimuli appears in the hemisphere. As the first eye test is concluded, an audible tone is emitted and a light is illuminated on the control panel to indicate the test is concluded.
The attendant must change the recording chart in the printer and readjust the patient's head position for the second eye to be tested. By using a modified fixation target near the periphery of the hemispherical field, it is possible to use the closely spaced targets normally used for central field screening to accurately evaluate the extent of the peripheral form field. Advantages of this procedure include rapid testing, uniform test conditions, and accurate simplified recording of the results.

The fixation targets, black X's, 5X 5mm, will be located on the horizontal meridian, 80 degrees to the right of the central fixation target, for testing the left eye, and 80 degrees to the left of the central fixation target for testing the right eye. The diagram below is included for clarity.

![Diagram showing normal and modified fixation targets for testing OS and OD.](image)

The instrument settings were the same for each subject. With minimum field intensity, white stimuli of maximum intensity were presented for a duration of 3½ seconds at an interval of 3½ seconds.

While some one hundred targets are presented in the automated testing sequence, only thirty data points will be considered as related to the temporal peripheral form field.
The targets considered are those near the horizontal meridian at angles from sixty to one hundred twenty degrees with respect to the fixation axis. The relevant targets lie on, or very near six meridians. For example, the portion of the field under consideration when testing the right eye is shown below on the recording form normally used with the Auto-Field 1.

For the purposes of this investigation, the "temporal peripheral form field" was determined by averaging the four most temporal relevant responses closest to the horizontal meridian. If a new scale is plotted on the recording form, as above, with the new fixation point as a
reference, it becomes apparent that a test target will be presented every five degrees from sixty to one hundred degrees, and every ten degrees from one hundred to one hundred-twenty degrees. A sample of the data analysis is presented for clarity. This is temporal peripheral form field data for the right eye.

The four most temporal findings closest to the horizontal meridian correspond to angles of 100, 95, 100, and 100 degrees from the fixation axis; the mean finding, rounded to the nearest degree, is 99 degrees. Therefore, for this experiment, the horizontal temporal form field measurement would be 99 degrees.

To test the repeatability of these measurements, and hence the
validity of the experimental design, five subjects were tested, then re-tested, with no controlled changes. The tabulated results are:

<table>
<thead>
<tr>
<th></th>
<th>S-1</th>
<th>S-2</th>
<th>S-3</th>
<th>S-4</th>
<th>S-5</th>
<th>(\bar{X} \pm \sigma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>99</td>
<td>105</td>
<td>80</td>
<td>105</td>
<td>95</td>
<td>96.8 (\pm) 10.3</td>
</tr>
<tr>
<td>Test 2</td>
<td>98</td>
<td>105</td>
<td>84</td>
<td>103</td>
<td>97</td>
<td>97.4 (\pm) 8.2</td>
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<tr>
<td>#2 - #1</td>
<td>-1</td>
<td>0</td>
<td>+4</td>
<td>-2</td>
<td>+2</td>
<td>1</td>
</tr>
</tbody>
</table>

With this data sample, the mean difference in findings was less than two degrees. This degree of consistency in the findings insures that if changes in the visual field greater than ten degrees occur, they will probably be detected with this field measurement technique.

In this study, each eye of each subject was tested with the Autofocal in place, and the results recorded. Then, the Autofocals were removed, single vision contact lenses were inserted, and both eyes tested again.

D. Analysis of results

The hypothesis of interest was: "There is a significant difference in the visual field obtained when Autofocals are compared with single vision contact lenses." Therefore, a "null hypothesis" was:
"There is no significant difference in the visual field obtained when Autofocals are compared with single vision contact lenses." Mathematically, if \(M\) = field measured with a single vision contact lens, and if \(M'\) = field measured with the Autofocal, then the null hypothesis becomes \(M=M'\), or \(M:M'=1:1\). By testing the results obtained on the basis of probability using the Chi square (\(X^2\)) test, a decision was made to not reject(accept) the null hypothesis. The equation \(X^2 = \sum_{j=1}^{14} \frac{(M_j-M')^2}{M_j}\) was evaluated and \(X^2 = 1.4646\), with 13 (14-1) degrees of freedom. (The fit of the data with respect to the null hypothesis was good and could be expected at least 99.5% of the time.)
E. Equipment required

1. Wesley-Jessen System 2000 PEK and film
2. Biotronics Auto-Field 1 and recording forms
3. Any contact lens modification equipment necessary to obtain a satisfactory fit with the Autofocal.
4. Miscellaneous recording forms and human subject release forms.
### VII DATA

<table>
<thead>
<tr>
<th>subject</th>
<th>eye</th>
<th>M</th>
<th>((\bar{X}_M - M)^2)</th>
<th>M'</th>
<th>((\bar{X}_{M'} - M')^2)</th>
<th>((M' - M)^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-1</td>
<td>OD</td>
<td>84</td>
<td>53.29</td>
<td>86</td>
<td>33.64</td>
<td>0.0476</td>
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<td></td>
<td>OS</td>
<td>88</td>
<td>10.89</td>
<td>88</td>
<td>14.44</td>
<td>0.0000</td>
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<td>S-2</td>
<td>OD</td>
<td>98</td>
<td>44.89</td>
<td>94</td>
<td>4.84</td>
<td>0.1633</td>
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<tr>
<td></td>
<td>OS</td>
<td>94</td>
<td>7.29</td>
<td>95</td>
<td>10.24</td>
<td>0.0106</td>
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<td>S-3</td>
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<td>1.69</td>
<td>87</td>
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<tr>
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<td>28.09</td>
<td>90</td>
<td>3.24</td>
<td>0.1860</td>
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<td>10.89</td>
<td>93</td>
<td>1.14</td>
<td>0.2841</td>
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<tr>
<td></td>
<td>OS</td>
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<td>22.09</td>
<td>100</td>
<td>67.24</td>
<td>0.1667</td>
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<tr>
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<td>100</td>
<td>75.69</td>
<td>97</td>
<td>27.04</td>
<td>0.0900</td>
</tr>
<tr>
<td></td>
<td>OS</td>
<td>94</td>
<td>7.29</td>
<td>90</td>
<td>3.24</td>
<td>0.1720</td>
</tr>
</tbody>
</table>

\[
\bar{X} = 91.3 \quad 91.8 \quad X^2 = 1.4646
\]
\[
S^2 = 25.45 \quad 15.86
\]
\[
S = 5.0 \quad 4.0
\]
\[
\bar{X}_{OD} = 91.0 \quad 91.7
\]
\[
S_{OD} = 6.5 \quad 3.7
\]
\[
\bar{X}_{OS} = 91.6 \quad 91.9
\]
\[
S_{OS} = 3.7 \quad 4.5
\]

With \((14-1)\) degrees of freedom, probability that:

\(M : M' = 1 : 1\)

exceeds .995
IX DISCUSSION AND CONCLUSION

This field measurement technique has a finite limit for accuracy, since a finite number of targets are available for projection. An accuracy of ± 2.5 degrees is available with the technique described. While this is not ideal, it seems to be adequate when possible sources of error are considered.

Several possible sources for error exist in any experiment involving quantification of the visual field. Several variables were not manipulated which could produce variations in the peripheral visual field magnitude measurements. Perfect fixation on the fixation target throughout the test sequence is almost impossible, even for the best subjects. No attempt was made to control pupil size. The state of retinal adaptation was presumed to be in the mesopic zone, but was unknown. Small differences in lens diameter were noted between the subject's single vision contact and the Autofocals, but were not considered as a significant factor here. The gaze position required to view the fixation target tended to slightly decenter temporally the contact lenses, especially with the subjects who had narrow interpapillary fissures. The rhythmic, automated nature of the testing sequence led most subjects to commit response errors due to anticipation.

Mean values ± 1 standard deviation were observed as

<table>
<thead>
<tr>
<th></th>
<th>OD Single vision</th>
<th>OS Single vision</th>
<th>OD Bifocal</th>
<th>OS Bifocal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>90.7 ± 6.5</td>
<td>91.3 ± 3.7</td>
<td>90.5 ± 4.2</td>
<td>90.9 ± 4.2</td>
</tr>
</tbody>
</table>

This data indicates that there is little reason to expect a significant change in peripheral form detection when the Autofocal is worn.

Possibly, the zone of the cornea which refracts light for the peripheral field is outside the zone covered by the contact lens.
This study could be repeated with a different stimulus source. Perhaps a color field would give results corresponding to macular function. The optic zones of these two lens designs might then be evaluated in a different manner.
10. Grosvenor, Ch. 15.
11. Mandell, Ch. 29.
FIGURE 1

- Fixation Monitor Assembly
- Head Rest
- Chin Cup
- Slide Bar Locking Knob
- Head Rest Elevation Adjustment Ass'Y
- Patient Response Switch
- Hemisphere Background Illuminator
- Control Panel
- Locking Handle
- Printing Door
- Forehead Adjustment Knob
- Patient Response Switch
1. **Institution:**
   A. Title of project: The Peripheral Visual Field through the Autofocal
   B. Principle investigator: Dan Edwards
   C. Advisor: Dr. Peterson
   D. Location: Pacific University College of Optometry, Forest Grove, Oregon
   E. December 14, 1977

2. **Description of Project:**

   This project is designed to evaluate peripheral vision through a bifocal contact lens. The results are compared with those obtained when conventional single vision lenses are used.

3. **Description of Risks:**

   There have been rare instances reported when the infra-red eye position monitor causes slight discomfort to the anterior eye segment. Risks from wearing the contact lens are minimal and no greater than the risk taken with any "hard" contact lens fitting procedure.

4. **Description of Benefits:**

   This study will serve to increase the basic understanding of how this bifocal contact lens affects peripheral vision.

5. **Alternatives Advantageous to Subjects:**

   If vision through this bifocal lens is not satisfactory for general use, consideration should be given to a different type of bifocal contact lens design.

6. **Offer to Answer Any Questions:**

   The experimenter will be happy to answer any questions that you may have at any time during the course of this study.

7. **Freedom to Withdraw:**

   You are free to withdraw your consent and to discontinue participation in this project at any time without any prejudice to you.

   I have read and understand the above. I am 18 years of age or older.

Signed: ___________________________ Date: ____________