1983

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Abstract

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Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

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Subject Categories

Optometry

Analysis of Refractive Endpoint Differences Between Directional and Non-directional Projection Screens

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Introduction

Pacific University College of Optometry recently installed a new type of projection screen in its clinic examination rooms. Anecdotal evidence has suggested that measurements of a patient's refractive error taken with the new screens are 0.25 to 0.75 D more plus than those taken with the screens used previously. This difference would be a significant factor in determining a patient's lens prescription. The goal of this research was to determine whether or not this difference existed by analyzing the results of several tests of refractive error, using both types of screens.

Review of the Literature

The basic difference between the two screens is the amount of light reflected back to the patient. The screens currently in use utilize 3M Projection Screen Sheeting Type 1463. The manufacturer refers to this as a "high gain" projection material because it reflects most of the light in a highly directional manner. The screens are mounted such that, across the horizontal meridian, most of the light is reflected within a very narrow viewing angle, dropping as much as 20 percent per one degree change in viewing angle. Within the vertical meridian the reflectance is more constant, dropping less than 10 percent per 12 degree change in viewing angle (Ellis, 1980)[2]. This arrangement suits the typical optometric exam room, since the patient-screen-projector geometry is fairly constant horizontally, but not vertically. Within the usable viewing angle the Type 1463 screen reflects 10 to 14 times the amount of light as the previously used 3M Type 7611 screen (Ellis, 1980)[2]. The contrast of the Type 1463 screen ranges from 61 percent to 99 percent, depending on the room illumination, at a nine degree viewing angle (Ellis, 1980)[2].

The Type 7611 screen is a so-called retro reflective screen (Roth, unpublished)[5], reflecting most of its light in the direction from which it comes. In spite of this fact, this screen does not have the highly directional characteristics of the Type 1463. As a result, the amount of light reflected in any given direction is less than that from Type 1463 at it's optimum viewing angle. The contrast

of the Type 7611 in the Ellis study ranged from 32 percent to 98 percent at a 9 degree viewing angle.

Several advantages result from the use of the Type 1463 screen. This screen reflects a higher percentage of light back to the patient, it maintains polarization of light better, and it is less affected by ambient room illumination. The first two advantages are especially necessary for projecting vectographic slides.

Many authors have described how the characteristics of the acuity target affect the results of acuity measurements. Luckiesh[4] has described how acuity increases with increasing target luminance (or, more accurately, stearance). Augsburger et al (1979)[1] points out the increase in relative contrast sensitivity with increasing stearance, and advocating as high a target luminance as practical.

From these considerations, it seems reasonable to suggest that the more light reflected by a screen, the closer to optimum testing conditions are obtained (assuming contrast is maintained). The Type 1463 screen, by virtue of its "high gain" characteristics, should perform well for patient testing. Experience with this screen, however, reveals several unexpected problems primarily due to the increased stearance of the screen. Brighter reflections from the optical surfaces of the phoropter produce multiple images of the target, which distract the patient. Reflections also tend to wash out the retinoscopic reflex, making the procedure much more difficult. Finally, the possibility that the screen alters the results of refractive tests poses a serious problem.

The source of any influence the screens have on the subjective

refraction cannot be determined from the literature. Despite an extensive search, no information was found regarding refractive test endpoints and target characteristics. Voluminous information exists concerning visual acuity and target characteristics; however, their relationship to measurements of refractive status remains unclear. One might expect that increasing the obtainable acuity would reduce the variability of test results, but there is nothing to lead one to expect a consistent shift in the direction of the results. Clinical results, however, have suggested such a shift has occured, with its direction towards extra plus sphere. This project was undertaken to test the hypothesis that this difference exists.

Methodology

Data Collection

The experiment was run using a rotation system, with two of the three experimenters conducting a given examination. One researcher would conduct the examination while the other recorded the test data. The data collected served as a random preset for those areas of the exam sequence in need of random preset. Completing the double blind, the phoropter sphere windows were masked to avoid allowing the examiner knowing the value of any endpoint. Data was collected on data recording sheets designed specifically for the testing procedures this experiment followed. Each subject was tested under two conditions (directional and non-directional screens). The order of the presentation was randomized.

Equipment

Subject testing took place in a standard Pacific University clinic examination room (room no. B4). Test charts were projected by an AO Project-O-Chart onto the 3M Type 1463 screen (currently standard in the clinic) and onto the 3M Type 7611 retro reflective screen previously used in the clinic. The projector-to-chart distance was held constant for all sessions. The stearance at the plane of the phoropter for the Type 1463 and 7611 screens were 463.0 nits and 34.8 nits respectively, at standard room illumination and maintained so by constant projector-chart-patient angle. Periodic checks were made to insure the constant relationship between projector, chart, and

patient. The phoropter used was an AO Ultramatic which was serviced periodically to insure clean optics. All examiners used Welch Allyn retinoscopes during the exams. Ambient illumination was set at 7 footcandles for all acuity tests. For all other testing, illuminations were set to levels commonly considered appropriate for that test. These levels were held constant for each subject in the course of the experiment.

Examination Sequence

1) Visual acuities at distance with and without correction were taken. Patients with substandard acuities (less than 20/20 best correctable) or with other visual anomalies were rejected from the experiment. Patients wearing contact lenses were tested only with the lenses on.

2) Distance retinoscopy was performed using a 66.67 cm working distance between the phoropter and retinoscope by all examiners. Visual acuities were taken following retinoscopy.

3) A spherical monocular subjective to best visual acuity was used as a starting point for the Jackson Cross Cylinder test. Astigmatic correction was determined to the nearest 0.25 D. Final cylinder power was the highest amount accepted to equality.

4) Cylinder correction was verified by either a sunburst pattern or an AO Paraboline. The decision of which test to use was determined by the patient's sensitivity and response to each test. A 0.50 D plus fog was used for these tests.

5) To balance binocularly the refractions a 20/40 equalization

was run using equal blur as the endpoint criterion.

**6) Sequencing proceeded to reduce lens powers from a high plus fog to first binocular 20/20 acuity (#7). Criterion for endpoint was any four letters or better correctly recognized in the 20/20 line.*

7) Step six flowed into step seven, which was a binocular subjective to best visual acuity (#7A).

**8) We conducted a binocular bichrome test, the endpoint of which was the single response of "equal" or the average of more than one "equal" response by the patient.*

**9) Finally, a distance binocular cross cylinder test was performed using the same criteria as for the bichrome test. The test target was the AO Four Diamond chart.*

** Asterisk denotes those tests which were randomly preset by the data collector to maintain the double blind design.*

Results

The subjects consisted of 17 males aged 21 to 30 years old and 27 females age 18 to 23 years old (N_{total}=44). Excluded from the study were one subject with substandard acuity and one subject with non-binocular vision.

Tables 1 and 2 show the results of our investigation. The statistics in the last row of the table relate to a value referred to as the "P-lens". Essentially, the P-lens averages the results of refractive tests after adjusting them for their expected difference from test number 7A. These correction factors have been norm referenced in studies by Haynes et al (1981)[3]. We calculated our (modified) P-lens as follows:

$$P = \frac{(\#7 - .50) + (\#7A) + (\text{bichrome}) + (\text{cross cyl.} + .25)}{4}$$

The data presented is for right eyes only, although all tests were conducted binocularly. Only sphere values were analyzed as cylinder was maintained constant between the two conditions for each subject.

As shown in Table 1, the mean results for tests conducted on the two screens show a difference of 0.05 to 0.20 diopters, with the Type 1463 (directional) screen yielding the most plus sphere value for all tests. More importantly, as shown in Table 2, the mean of the differences between the raw scores ranges from 0.12 to 0.20 diopters, again in the direction predicted. A t-test for related measures shows these differences to be statistically significant at the .01 level for tests 7A and binocular cross cylinder, or at the .0005

level for tests 7, binocular bichrome, and P-lens. Critical values of the t-statistic, one-tailed, are shown in Table 3.

Table 1

Mean Sphere Value Obtained From Two Screen Types

Test	$\overline{X}_1$ Type 1463	$\overline{X}_2$ Type 7611
#7	+0.057	-0.151
#7A	-0.651	-0.787
Bichrome	-0.697	-0.747
Cross Cylinder	-1.023	-1.148
P-lens	-0.640	-0.788

Table 2

Mean of the Differences Between Screen Types for All Subjects

Test	Mean Difference $\frac{\sum(X_1-X_2)}{N}$	Std. Deviation of Differences	t-statistic
#7	+0.207	0.287	+4.790
#7A	+0.130	0.301	+2.874
Bichrome	+0.186	0.305	+4.059
Cross Cylinder	+0.125	0.337	+2.454
P-lens	+0.133	0.228	+3.860

Table 3

Critical t-Values (one-tailed, df=40)

Level of Significance	.05	.25	.01	.005	.0005
Critical t	1.684	2.021	2.423	2.704	3.551

Discussion

The hypothesis of this research stated more plus sphere should be expected at the end of a subjective refraction sequence when using the 3M 1463 directionally reflecting screen versus the 7611 non-directionally reflecting screen. Statistical analysis supports this hypothesis, though the difference is not as great as originally speculated by these investigators.

In looking at possible explanations for this difference, we can describe three main factors: 1) contrast effects, 2) changes in pupil size, and 3) changes in the tonic level of accomodation. One needs to ask, is one of these primarily responsible for our results or do they all contribute in part?

Examining the results for #7, we find a greater difference here than for any of the other tests. This test comes from a plus fog to a first lens giving 20/20 acuity. Increasing the contrast would enable 20/20 resolution through relatively greater fog, resulting in a finding of higher plus.

Contrast should not influence the results of the binocular cross cylinder or the 7A tests, however. The midpoint of the astigmatic interval produced by the cross cylinder lens is independant of contrast, as is the subjective to best vision, which looks for maximum clarity. If the greater amount of light from the Type 1463 screen produces a smaller pupil, it seems reasonable to assume a reduction in the positive spherical abberation of the eye could result. This would leave only the less convergent central rays to form the

image, requiring more plus to achieve optimal correction. This could explain the presence of a smaller change in the binocular cross cylinder and 7A tests than for the others.

A dilemma presents itself when we consider the bichrome test. Why should the results for this test be different from those for the cross cylinder? The chromatic interval produced in the bichrome test should be affected the same as the the astigmatic interval in the cross cylinder test, unless some characteristics of the Type 1463 screen causes different wavelengths to be reflected differently. This could result in more plus sphere at the endpoint. We do not know, of course, if the wavelength dependant effects exist; this explanation is purely speculation.

As far as any differential effects on the tonic level of accomodation, we find no reason to suspect that one test would be influenced more than another by this factor. If it exists, it probably affects all the tests equally.

We have discussed several possible factors that may explain the results of our study. It seems likely that a combination of all of them, rather than any one, is ultimately responsible. Other factors are likely to be uncovered as well, before a causal relationship is established.

Whatever the explanation, the results of this project give credence to the reports of clinicians in the PUCO clinics who state the highly directional screens have a tendancy to result in more plus in a subjective refractive endpoint than may be found on the non-directional screens. This points to a rather serious implication

relative to which of the two screens tested actually give an endpoint lens which will be best accepted by the patient as a distance best visual acuity lens. In a clinical situation, the apparatus used for testing must give results as close as possible to those needed by the patient in a "real world" situation; that is to say that the endpoints are directly transferrable to the patient's natural environment. This is important in terms of expediency of exam sequence regarding, for example, trial framing, and of the validity of subsequent tests reliant upon the refractive endpoint. Any systematic error interferes with a valid determination of test endpoints and prescribing criteria.

Finding this degree of difference between these two screens raises the question as to the difference between all other different types of screen surfaces currently in use in general practice, and the possible need for standardization of projection surfaces throughout the optometric profession.

Conclusion

Our research has established that a difference exists between the 3M directional and the non-directional screens, with the 3M directional screen producing endpoints of more plus value. The mean difference range was 0.12 to 0.20 diopters

Three major questions have arisen from this difference: What is the validity of interdependant tests? What is the validity of final subjective prescriptions? Are there possible differences between other projection surfaces currently in use? It must be determined if the observed differences between the two types of screens is inherent in the screen surfaces or if the differences are physiological effects within the patients caused by the screen.

The most significant implication for the average clinician is that these differences must be taken into account when formulating his prescription philosophy.

References

1) Augsburger, A., Sheedy, J.E., and Schoessler, J.P. "Reflectances of Visual Acuity Screens", Jnl. of Opt. and Physiol. Optics, (1979) v. 56 pp. 531-37.

2) Ellis, E.A. "Evaluation of the Suitibility of 3M Type 1463 Projection Sheeting for Optometric Testing", Doctoral Thesis, Pacific University College of Optometry, June, 1980.

3) Haynes, H.M., "Calculation of the P Factor", (Unpublished) Course notes, Optometry 533: Advanced Case Analysis; 1981

4) Luckiesh, M., Light, Vision, and Seeing, D. Van Nostrand Co., Inc. New York, 1944

5) Roth, N., "Modification of a Retro-reflective Projection Screen for Vision Testing", (Unpublished) Presented at the annual meeting of the American Academy of Optometry, Dec. 1978, Boston, MA.

Bibliography

British Standards Institute, "Test Cards for Determining Distance Visual Acuity", BS4274:1968

Comerford, J.P., "Contrast Sensitivity Functions for Clinical Optometry", JAOA (1979) v. 50 pp. 683-86

Haynes, H.M., "Calculation of the P Factor", (Unpublished) Course notes, Optometry 533: Advanced Case Analysis; 1981

Richards, O.W., "A Literature Review of Retinoscopy", Opt. Jnl. and Review of Opt., May, 1977, pp. 69-73

Richards, O.W., "Effects of Luminance and Contrast on Visual Acuity, Ages 16 to 90 Years", Am. Jnl. Opt. and Physiol. Optics (1977), v. 54 pp. 178-84

Richards, O.W., and Roth, N., "Lighting an Examination Room to Avoid Error", Am. Jnl. Opt. and Arch. Am. Acad. Opt. (1973), v. 50 pp. 178-84

3m Product Information, "3M Projection Screen Sheeting - 1463", Traffic Controls Materials Division/3M, St, Paul, MN, rec'd Sept. 1981