MEASURE OF FUNCTIONAL VISION UNDER SIMULATED CONDITIONS OF COMMON VISUAL IMPAIRMENTS

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ABSTRACT:

It is difficult for the average person with normal vision to understand how the ability to perform normal daily functions is nagatively affected with any visual impairment. Therefore, the following study was conducted in which three types of visual impairments were simulated. They included general blur, a central scotoma, and hazy media opacification. Under these conditions, the maximum distance at which a subject could perform the three ordinary tasks of facial recognition, reading the face of a wall clock, and watching television were recorded. From these measurements of distances, one can see how functional ability is reduced with various types of visual impairment; and also how different types of visual impairment affect functional vision in various ways.

INTRODUCTION:

It is estimated that there are 1.6 to 6 million partially sighted people in the U.S. These are people with 20/70 or worse best corrected visual acuity. This breaks down to 5 to 10 people out of every 10,000, having partial sight.

The blind or visually impaired patient experiences much frustration when he cannot see what he is doing, particularly when he remembers what it is like to see. This feeling of frustration is a constancy in their daily life, and it is only exacerbated by the lack of understanding by those around them, of what it is like to try to function normally in daily life with impaired vision. As a result of this lack of understanding, this study was conducted in order to demonstrate how functional ability is decreased with various types of impairments to different degrees.

The low vision patient is the person with an eye disorder whose visual performance is decreased as a result of decreased acuity, abnormal visual field, reduced contrast sensitivity, or the ocular dysfunctions that prevent performance to full capacity compared to a normal person of the same age and sex.[1] There are many causes of blindness or impaired vision--conditions which affect the pupil, cornea, lens, vitreous, or retina. They include such conditions as glaucoma, diabetic retinopathy, keratoconus, traumatic scars, age-related maculopathy, and cataracts to name only a few.

Visual impairments occur in the young and old alike, but are more common in the geriatric population. There are many ocular changes that are common in the aged population. Some of these include decreased hue discrimination, decreased light transmission, loss of retinal receptors, longer dark adaption times, and media opacification.

It has been shown that Snellen visual acuity measurements may be misleading in assessing the degree of functional vision a patient may have. A person may be able to easily distinguish fine detail, or high spatial frequency, on a high contrast Snellen chart, but be unable to distinguish the edge of a step or curb, for example. Most visual stimuli in daily life have much lower contrast and lower spatial frequency (coarser detail) than the standard Snellen optotypes.

Contrast sensitivity testing, on the other hand, provides much more useful information on functional vision. Contrast sensitivity tests present stimuli of various spatial frequencies at low contrast levels. Contrast sensitivity is a subjective measurement of a patient's ability to detect pattern stimuli at low contrast.[2]

Almost everyone with an opacity anywhere in the refractive media is glare sensitive. They report their vision is hazy outdoors or things look "washed out". They may also have reduced acuity outdoors on bright sunny days, but generally, their Snellen acuity will often be measured near normal in the examination setting.

Eye conditions that involve the media result in blurring, distortion, and reduced acuity throughout the entire field.

Discrete dense media opacities cause little reduction in image contrast if sufficient clear space exists around them. With media opacification, rays of light are scattered in a random fashion--Raleigh Scatter--which can create veiling glare decreasing the contrast of an image. If the opacity if diffuse it generally decreases the overall image contrast.

Lighting plays a major role with conditions of media opacification, in functional vision. Greater illumination causes greater scatter of light resulting in increased glare sensitivity. The increased illumination also results in pupillary constriction which can be detrimental with dense central opacification. Thus, changing overall illumination and using filters or visors can significantly enhance the visual resolution ability.

Decreased visual acuity may be the result of impaired macular function, and the consequent use of eccentric foveal areas. Visual fields may be impaired as a result of decreased macular function, which also results in decreased visual acuity. They may also be impaired through a restriction of peripheral vision. Reduced contrast sensitivity is a loss of visual discrimination (detail and contrast) across the visual spectrum form lowest to highest contrast levels. This loss tends to be very significant since contrast perception is more important to visual function than visual acuity is.[3]

It has been found that visual acuity decreases normally as a function of increasing age. Acuity peaks at the age of ten, stabilizes through the age of 45, then it begins to decline after that.[4] Undoubtedly, it will require more than the natural aging process to reduce vision significantly enough for levels of low vision.

Foveolar vision is the sharpest. Any damage to this area will result in rapid reduction of visual acuity. Visual acuity within a radius of 2.5 degrees from the fovea is 20/40 or better. 5.0 degrees out from the fovea it is approximately at 20/75. A lesion occupying an area with a diameter of 10 degrees around the fovea may reduce visual acuity to approximately 15/100. At 15 degrees out from the fovea, visual acuity is measured at 9/100, and at 20 degrees out it is measured to be 7/100.[5] With these central defects, the reduction in image quality in the retinal periphery is nowhere near as severe as the reduction in acuity.

It is also important to remember that under conditions of central scotomas, the visual field defect becomes enlarged in effect, the farther away the patient is from the object of regard; i.e., the farther away from the object of regard the subject is, the greater the area of central scotomatous field loss. This is demonstrated in figure 1.

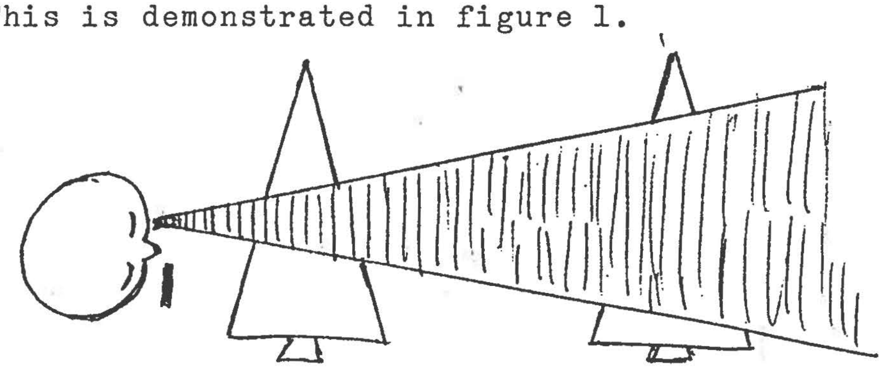


Figure 1: Central scotomatous field defect in relation to distance form object of regard.

METHODS:

Three common situations of visual impairment were simulated including general blur of varying degrees, a central scotoma, and hazy media opacification. This was done on a group of Ferris State University students with no uncorrectable visual defects. These three situations were simulated since they comprise most common visual defects. Under these simulated conditions, visual acuity was measured using Feinbloom and Snellen acuity testing methods. Then the subjects performed the ordinary tasks of reading the face of a wall clock, watching television, and recognizing a face. The maximum distances, to the nearest 1/2 foot, at which each subject could perform such tasks were measured. The range of distances measured between the group of subjects for each task and condition, and the mean of the distances were also recorded.

To produce the various blur levels of approximately just readable 20/100, 20/200, and 20/400, sufficient convex power lenses were used over the habitual Rx's. Then each subject was asked to perform two ordinary daily tasks of reading the face of a wall clock accurately and recognizing a face.

To simulate a central scotoma, a round cut-out of an opaque material was placed centrally at the major reference point of a pair of plano glasses in front of the dominant eye, and of a size that produced a 10 degree central scotoma plotted at one meter on a tangent screen visual field tester. The Snellen visual acuities were measured on each subject. The subjects, using eccentric viewing techniques, were asked to perform the ordinary tasks of reading a wall clock accurately, watching television comfortably, and recognizing a face.

General hazy media opacification was simulated using two pair of VISTECH haze simulator glasses worn simultaneously. Contrast sensitivity curves were generated on each subject without the haze glasses on, with them on, and with a 3 1/2-inch visor worn with the haze glasses on, on each subject. Snellen visual acuity was also measured. Then under the simulated hazy media conditions, the subjects were asked to perform tasks of facial recognition and watching television.

To read a white-faced wall clock, 12 1/2 inches in diameter with black numbers 1 1/4 inches high and 1/8 inch thick, the subjects were required to read correctly, three out of four predesignated trial times. The times tested for at the various blur levels and with the central scotoma were standard for each subject. (See table 1.)

CLOCK TIMES TESTED

Blur level	Monocularly	Binocularly
20/100	4:05, 7:20, 10:40, 1:50	7:00, 3:10, 9:30, 5:30
20/200	2:45, 10:30, 1:15, 4:00	5:10, 3:50, 12:40, 6:40
20/400	5:00, 8:00, 9:20, 1:35	2:00, 3:30, 7:45, 12:45
Scotoma	10:00, 5:40, 3:15, 12:45	

Table 1: Clock times tested under simulated blur and scotoma conditions.

If the subject did not respond correctly to three of four given clock times, the distance measurement data collected from the subject in that particular visual impairment category was disregarded for the study. It was stressed to each subject that they should correctly read the clock times at the greatest distance they could, but at close enough distance to be able to read the clock time with moderate certainty. The illumination of the clock face was 25.0 footcandles for each subject tested.

It is difficult to determine the ability of one to recognize a face. Therefore, in this study, the ability of facial recognition was tested by the subjects determining whether or not the examiner was wearing a pair of gold metal-rimmed spectacles with clear lenses. The illumination of the examiner's face was 24.0 footcandles. The subjects under the generalized blur conditions and with hazy media opacification were tested in their functional ability of facial recognition. Each subject, again, was required to respond correctly in three out of four trials, or the data collected from them under the particular simulated condition was omitted from the study.

Each subject under the conditions of hazy media opacity and 10 degree central scotoma was asked to determine the maximum distance at which he or she could comfortable and with moderate ease view a standard 25-inch color television in a room with moderate ambient illumination produced from fluorescent track lighting.

RESULTS:

Under the simulated condition of 20/100 blur levels, to accurately read the face of a clock monocularly, subjects had to be at an average distance of 25.56 feet away with a range of distances measured among the subjects of 18.17 feet to 29.0 feet. Binocularly at this level of blur, subjects could read the time on the clock at an average of 29.22 feet with a range of 20.33 feet to 30.67 feet. (See Table 2.)

Table 2: READING CLOCK AT 20/100 BLUR LEVEL

Subject	Monocular Distance Measurements	Average	Binocular Distance Measurements	Average
C.B.	28', 30', 29'	29'	31', 30', 33'	31.33'
S.S.	30', 28', 29'	29'	30', 30', 31'	30.33'
J.M.	28', 29.5', 30'	29.17'	30', 32', 30'	30.67'
T.L.	23', 26', 24'	24.33'	22', 25', 23'	23.33'
R.C.	16', 20', 18.5'	18.17'	18', 22', 21'	20.33'
J.B.	20', 22', 21'	21.0'	30', 33', 33'	32.00'

Monocular Mean: 25.56 feet; range of 18.17 to 29 feet.
Binocular Mean: 29.22 feet; range of 20.33 to 30.67 feet.

At the 20/200 blur levels the subjects could accurately read the times of the clock monocularly at an average of 19.69 feet, with a range of 14.5 to 24.67 feet between the subjects. Binocularly, they could read them at an average of 18.42 feet with a range of 18.17 to 29.33 feet. (See Table 3.)

Under simulated conditions of 20/400 blur, the subjects could read the clock times monocularly at an average of 13.8 feet with a range of 11.5 feet to 14.67 feet. Binocularly the average distance to read the clock times accurately was 14.03 feet with a range of 10.67 feet to 16.17 feet. (See Table 4.)

Table 3: READING CLOCK AG 20/200 BLUR LEVEL

Subject	Monocular Distance Measurements	Average	Binocular Distance Measurements	Average
C.B.	22', 23', 22'	22.33'	27', 31', 30'	29.33'
S.S.	18', 22', 21'	20.33'	22', 23', 24'	23.00'
J.M.	23', 27', 24'	24.67'	26', 28', 27.5'	27.17'
T.L.	15', 19', 18'	17.33'	18', 22', 20.5'	27.17'
R.C.	14', 15', 14.5'	14.5'	17', 19', 18.5'	18.17'
J.B.	18', 20', 19'	19.00'	23', 23', 22'	22.67'

Monocular Mean: 19.69 feet; range of 14.5 to 24.67 feet.
Binocular Mean: 18.42 feet; range of 18.17 to 29.33 feet.

Table 4: READING CLOCK AT 20/400 BLUR LEVEL

Subject	Monocular Distance Measurements	Average	Binocular Distance Measurements	Average
C.B.	16', 15', 13'	14.67'	12.5', 16', 15'	14.5'
S.S.	9', 13', 12.5'	11.5'	10', 13', 9'	10.67'
T.L.	12', 16', 14.5'	14.17'	14', 18', 16.5'	16.17'
R.C.	14', 15', 14'	14.33'	14', 17', 16'	15.67'
J.B.	15', 15', 13'	14.33'	14', 13', 14'	13.67'

Monocular Mean: 13.8 feet; range of 11.5 to 14.67 feet.
Binocular Mean: 14.03 feet; range of 10.67 to 16.17 feet.

With a 10 degree central scotoma, monocularly tested, subjects read the clock times accurately at an average of 16.92 feet with a range of 16.33 feet to 17.33 feet. (See Table 5.)

Table 5: READING CLOCK WITH CENTRAL SCOTOMA

Subject	Snellen V.A.	Monocular Distance Measurements	Average
C.B.	20/200	18', 15', 16'	16.33'
J.B.	20/400	15', 18', 17'	16.67'
R.C.	20/400	16', 19', 17'	17.33'
J.M.	20/200	17', 18', 17'	17.33'

Mean: 16.92 feet; range of 16.33 to 17.33 ft.

With a 10 degree central scotoma, the test subjects had to move in to a mean distance of 4.10 feet with a range of 2.5 feet to 6.0 feet in order to comfortable watch a 25-inch color television. This was tested monocularly; i.e., a 10 degree central scotoma simulated in the dominant eye with the non-dominant eye occluded. (See Table 6.)

Under simulated conditions of binocular hazy media opacification, to comfortably watch the 25-inch color television, the test subjects had to be at least within 10.62 feet of the television screen. There was a range of 7.5 feet to 12.5 feet measured. (See Table 6.)

With a central scotoma, the functional ability to recognize a face by using eccentric viewing techniques and determining whether or not the examiner had gold metal-rimmed glasses on, was measured at an average distance of 3.83 feet, with a range of 3.0 feet to 5.0 feet tetween the subjects. (See Table 7.)

Table 6: WATCHING TELEVISION WITH CENTRAL SCOTOMA AND HAZY MEDIA OPACIFICATION.

Subject	Central Scotoma	Average	Media Opacity	Average
J.M.	2.5'	---	11.5'	---
R.C.	6.0'	---	11.0'	---
S.S.	4.0'	---	12.5'	---
C.B.	3.5'	---	-----	---
P.S.	4.5'	---	-----	---
J.B.	----	---	7.5'	---
total:		4.1'		10.62'

Range with Scotoma: 2.5 to 6.0 ft.
Range with Media Opacity: 7.5 to 12.5 ft.

Table 7: FACIAL RECOGNITION WITH CENTRAL SCOTOMA

Subject	Snellen Acuity	Distance Measurements	Average
J.M.	20/200	3', 4', 3.5'	3.5'
R.C.	20/400	2.5', 3', 3.5'	3'
J.B.	20/200	3.5', 3', 5'	3.83'
S.S.	20/400	5', 5.5', 4.5'	5'

Mean: 3.83 feet; range of 3 ft. to 5 ft.

Under the simulated condition of hazy media opacification, the functional ability to recognize a face was determined to be an average distance of 27.96 feet with a range of only 27.33 feet to 28.5 feet between the subjects. (See Table 8.)

Table 8: FACIAL RECOGNITION WITH MEDIA OPACIFICATION

Subject	Snellen Acuity	Distance Measurements	Average
J.M.	20/25+2	27', 30', 28.5'	28.5'
R.C.	20/25+1	26', 28', 28'	27.33'
J.B.	20/25+2	28', 29', 28'	28.33'
S.S.	20/23	29', 28', 26'	27.67'

Mean: 27.96 feet; range of 27.33 to 28.5 feet.

Under the conditions of 20/100 general blur, the monocular functional ability to recognize a face was determined to be at a mean distance of 17.43 feet, and a range of 15.33 feet to 20.83 feet between the subjects. At the level of 20/200 blur, it was determined to be an average of 14.43 feet, with a range of 11.33 feet to 18.67 feet. At the 20/400 general blur levels, the average maximum distance at which the subjects could recognize the face with or without glasses on was at 7.57 feet with averages ranging between 7.0 feet and 8.33 feet between the subjects. (See Table 9).

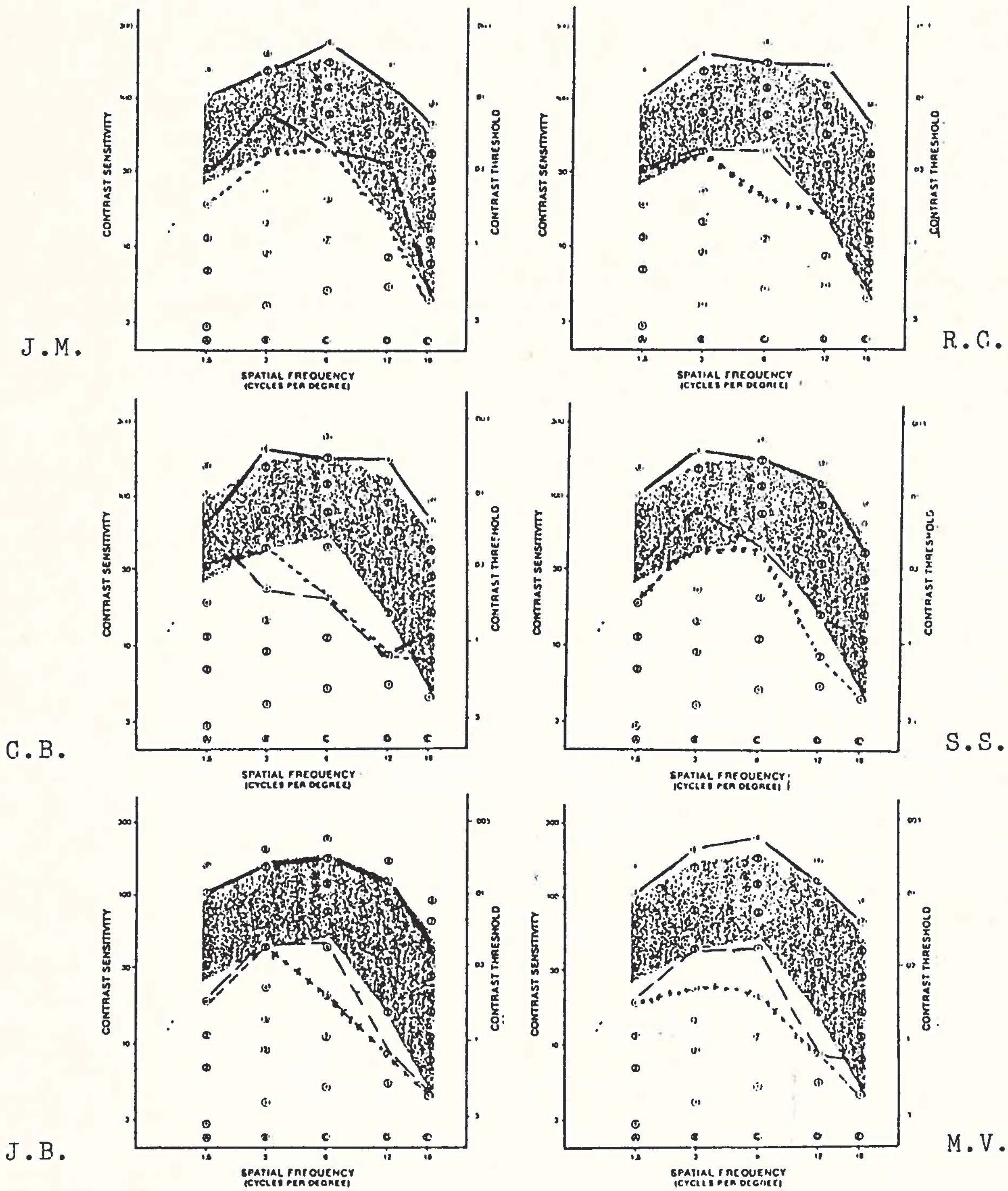
Lastly, as was mentioned before, VISTECH Contrast sensitivity was measured on a group of subjects under their normal visual conditions, and under the simulated conditions of bilateral hazy media opacification with and without a visor. It was found that wearing the "haze" glasses reduced contrast sensitivity significantly at all spatial frequencies on each subject. It was also determined that the wearing of a visor to shield the overhead lighting helped improve contrast sensitivity at least at some of the spatial frequencies with each of the subjects. (See Figure 3.) It is also important that one compare the minimal reduction in Snellen visual acuity of the subjects with media opacification with the significant reductions in their contrast sensitivity. (See Table 10.)

Table 9: FACIAL RECOGNITION UNDER GENERAL BLUR CONDITIONS

Snellen Blur Level	Subject	Distance Measurements	Average	Overall Average
20/100	C.B.	20', 22', 20.5'	20.83'	----
20/100	S.S.	14', 18', 17'	16.33'	----
20/100	J.M.	13', 17', 16'	15.33'	----
20/100	T.L.	18', 21', 19'	19.33'	----
20/100	R.C.	15', 14', 17'	15.33	----
Total:	----	-------------	------	17.43'
20/200	C.B.	17', 20', 19'	18.67'	----
20/200	S.S.	10', 15', 13'	12.67'	----
20/200	J.M.	12', 15', 13.5'	13.5'	----
20/200	T.L.	15', 17', 16'	16'	----
20/200	R.C.	9', 13', 12'	11.33'	----
Total:	----	--------------	-----	14.43'
20/400	C.B.	7', 8', 7.5'	7.5'	----
20/400	S.S.	6', 8', 7'	7'	----
20/400	J.M.	7', 10', 8'	8.33'	----
20/400	T.L.	6', 10', 7'	7.67'	----
20/400	R.C.	7', 8', 7'	7.33'	----
Total:	----	-------------	-----	7.57'

20/100 Range: 15.33 to 20.83 feet
20/200 Range: 11.33 to 18.67 feet
20/400 Range; 7.0 to 8.33 feet

Figure 3: CONTRAST SENSITIVITY UNDER NORMAL VISION, HAZY MEDIA, AND HAZY MEDIA WITH VISOR WORN CONDITIONS.



Normal Contrast Without Haze Glasses

Contrast With Haze Glasses

Contrast With Haze Glasses and Visor

Table 10. SNELLEN VISUAL ACUITY WITH MEDIA OPACIFICATION CORRESPONDING TO CONTRAST SENSITIVITY SUBJECTS (Figure 3)

Subject	Snellen V.A.
J.M.	20/25+2
R.C.	20/25+1
C.B.	20/25+1
S.S.	20/25+1
J.B.	20/25+3
M.V.	20/30+3

DISCUSSION:

It was made obvious through this simulation study that different visual impairments affect functional vision in very different ways. Under conditions of general blur, to perform ordinary tasks, one must be at closer ranges than an individual with normal vision. With increased retinal image size, one can overcome the blur produced in a generally blurred visual system, and with greater levels of blur, the less will be the distance required for one to visualize the object of regard.

General blur has greater negative affect when dealing with objects of low contrast and coarser detail. This was evident with the results of ability to recognize a face verses reading the time on a wall clock of high contrast, under the same blurred levels of visual acuity. The subjects were required to be at significantly closer range to recognize a face of low contrast and coarse detail than a clock face of high contrast at each of the tested blur levels.

A central scotoma was found to negatively affect functional vision in more aspects than general blur or hazy media opacification. This was true in tasks that required high contrast sensitivity as well as those tasks that didn't. However, it was shown that tasks requiring high contrast sensitivity, such as watching television and recognizing a face were more profoundly negatively affected than the task of reading a wall clock which didn't. The subjects with the simulated central scotomas could read clock times at a functional level somewhere between the functional levels of the 20/200 and 20/400 blur subjects. However, these subjects with central scotomas had to be at much closer ranges to perform the tasks of watching television and recognizing a face--tasks, again, requiring fine contrast sensitivity.

The subjects with simulated hazy media opacification were not tested for functional vision capability with high contrast targets. It is evident, however, through the measured Snellen acuities in comparison with the contrast sensitivity test results, that even with significant reduction in contrast sensitivity due to dense media opacification, there often is little effect on the visual acuity measured with the standard Snellen visual acuity chart. It was also evident that measured functional vision for tasks requiring optimal contrast sensitivity is not negatively affected to significant degrees. However, the reduction in contrast seemed to result in marked increase of subjective visual complaints and reduction in visual comfort.

SUMMARY:

Different visual impairments do affect different visual functions. Impairments that affect macular function, resulting in central visual field defects tend to affect functional visual capabilities requiring high contrast sensitivity, and those that do not. However, they tend to more significantly impair the functional vision in tasks requiring ability to see low contrast and coarser detailed objects.

Generalized blur also affects many visual functions. It was also found to more negatively affect tasks requiring the ability to see coarse detail and low contrast as opposed to high contrast fine detailed targets just as with the central scotomatous visual defect.

Media opacification was determined to have the least effect on objectively measured functional vision in all the visual tasks tested, for all the simulated conditions. However, this condition does tend to cause more subjective visual complaints than many other conditions of visual impairment.

REFERENCES:

1. Faye, Eleanor E., M.D. Clinical Low Vision, Second Edition. Little, Brown, and Company. 1984: 6.

2. Faye, Eleanor E., M.D. Clinical Low Vision. Second Edition. Little, Brown, and Company. 1984: 233.

3. Faye, Eleanor E., M.D. Clinical Low Vision. Second Edition. Little, Brown, and Company. 1984: 233.

4. Hirsch, Monroe, O.D., PhD, and Wick, Ralph E., O.D. Vision and Aging--General and Clinical Perspectives. 1960: 37-62.

5. Borish, Irvin M. Clinical Refraction, Third Edition. Professional Press. 1970: 401.