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AGE RELATED CHANGES IN VISUAL ACUITY

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Abstract—Longitudinal visual acuity assessments of men, and cross-sectional assessments of men and women in the Baltimore Longitudinal Study of Aging are presented. The longitudinal data relate presenting far, uncorrected far, presenting near and uncorrected near visual acuities to age. The cross-sectional data relate presenting far acuity to age. The prevalence of cataract, glaucoma and retinal pathologies are reported for the longitudinal sample at the time of their last vision test. The effect of visual pathologies in general, and cataract in particular, upon presenting far visual acuity was examined. The longitudinal data are consistent with cross-sectional data from previously published reports. Older persons who were free from specific visual pathologies exhibited an age-related decline in presenting far acuity as did those with documented visual pathologies. Despite the demonstrated loss in acuity with age, the majority of persons maintain at least fair acuity (20/40 or better) into their 80's.

Key Words: aging, visual acuity

THE PRESENT paper describes longitudinal data on visual acuity collected in the Baltimore Longitudinal Study of Aging (BLSA) over a 21-year period. The report is timely for this special issue, for it is the first description of the longitudinal findings in visual acuity using the research plan devised by Nathan W. Shock.

Longitudinal evaluations of visual acuity have been reported by Anderson and Palmore (1974) using groups that were initially 60–69 and 70–80 years of age. Ten-year changes in acuity were reported for the better eye, with correction if any, and indicated increases of 13 and 32% in the percentage of the groups with 20/50 acuity or worse for the younger and older groups, respectively. Increases in the percentages with cataract, glaucoma and cornea guttata, also occurred. Milne (1979) used persons initially aged 63–90 years who were remeasured after one and five year intervals. Over the five-year interval, 12% of men and 14% of women exhibited worsened visual acuity. However, Milne also observed improvement in visual acuity in 15% of men and 10% of women. The prevalence of cataract in the sample also increased over five years from 15% in both men and women to 40% in men and 46% in women. The observed decline in acuity was associated both with age and the presence of cataract. Neither of the two studies provides information on acuity

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changes throughout the younger adult years, particularly as they relate to the level of acuity in earlier years. The present study provides such information.

Published results of cross-sectional studies of age differences in visual acuity provide comparisons to BLSA data that are useful in two ways. First, the BLSA participants represent a select group which may not be representative of the general population. Comparison with cross-sectional results will place the BLSA data in proper perspective relative to data from other representative samples. Second, results of longitudinal studies can complement those of cross-sectional designs with respect to specifying the antecedents of the observed cross-sectional results.

The target sizes employed in the present study correspond to nine Snellen fractions. To facilitate comparison of the data to other published findings, the acuity scores associated with each target level were converted from Snellen fractions to Snellen decimals, the decimal equivalent of the fraction (The decimal equivalent of 20/20 is 1.0, while that of 20/200 is 0.1.). The use of the Snellen decimal facilitates the graphic presentation of the serial observations reported; but placement of the Snellen decimals on an acuity scale is somewhat arbitrary inasmuch as the underlying scale is ordinal, nonlinear and without defined end points.

Noting that Snellen fractions can be represented on a logarithmic scale with 20/20 corresponding to zero, Weale (1978) presented a summary of cross-sectional studies of visual acuity and age using the logarithm of the Snellen decimal, while Pitts (1982) in a similar endeavor, employed Snellen decimals only. We have adopted the second, more frequently used convention, recognizing the limitations of each method. It should be clear that neither strategy alters the fact that successive rows of targets on vision charts do not increase in equal increments.

Weale's summary of cross-sectional studies of visual acuity and age, indicated that acuity is stable from about age 20 to 45. Loss of acuity begins at about age 45 and continues thereafter at a generally constant rate. Pitts' recent summary of age related decline in acuity incorporated additional cross-sectional data that provide confirmation of the pattern described by Weale.

The age related loss in accommodative power has been documented by Bruckner (1967). Although loss of accommodation is linear and proceeds over the lifespan, it becomes apparent to individuals during the age period from the late thirties to the mid-forties. Because of lost accommodative power, uncorrected near acuity declines abruptly between the ages of 40 and 45 and continues to decline thereafter at a slower rate.

The normal decline in the amount of light reaching the retina and the increase in the prevalence of certain visual pathologies are the most likely explanations for the changes that are observed in distance acuity with aging. Changes in the ocular system (such as senile miosis and opacification of the lens) cause the decline in the amount of light reaching the retina of the elderly. Cataract, glaucoma and various retinal disorders become more prevalent with advancing age. The decrease in the flexibility of the lens within the lens capsule is the main reason for the decline in accommodation that occurs with age. The present study investigates the impact that some of the aforementioned ocular changes have upon visual acuity.

METHODS

Data were obtained from male and female participants of the BLSA of the National Institute on Aging. The BLSA was initiated in 1958 in an effort to analyze physiological and behavioral changes that occur with age and to determine the character of their relationships with one another. BLSA participants are atypical in that their socioeconomic characteristics "are those of an upper-middle-class segment of the general population" (Shock *et al.*, 1984). The typical interval between successive visits in the BLSA is two years. Over the observation period, there was a time frame during which participants over 70 were reexamined every year and those 60–69 every 18 months. As a result, the span of time represented by a given number of successive visits is not the same for all cohorts.

Vision tests were administered with a Titmus Optical Vision Tester, a stereoscopic instrument designed for rapid measurement of visual performance. The distance tests were presented at an optical distance of 20 ft, the near tests at 14 in. The brightness of the target slide was between 10 and 15 foot-lamberts, diffused to give uniform illumination to the entire target area. Right and left monocular acuities were determined with Sloan letters. Individuals were first tested without correction and then with their available corrective lenses if they wore them. The testing levels were: 20/200, 20/100, 20/70, 20/50, 20/40, 20/30, 20/25, 20/20, and 20/15 for distance vision; and 14/140, 14/70, 14/49, 14/35, 14/28, 14/21, 14/17.5, 14/14 and 14/10.5 for near vision. Visual acuity was defined as the acuity level which corresponded to the line preceding the one in which two or more errors occurred. One or more errors at low acuity levels, i.e. 20/200, 20/100 and 20/70; and 14/140, 14/70, and 14/49, dictated that the acuity be recorded as that of the preceding acuity level due to the small number of target letters at each level, one, two, and four respectively. Acuities which were worse than 20/200 or 14/140 were assigned values of 20/400 and 14/280, respectively.

Acuities are reported for the better eye. Both acuity without correction and presenting acuity are reported. Presenting visual acuities are defined as acuities either without correction for those participants who do not normally use corrective lenses or visual acuity with correction for those who wear corrective lenses.

Data regarding visual pathology in the BLSA sample were gathered from diagnosis lists that are generated for each person at each visit. The typical source of diagnoses of visual pathology is a medical history. Diagnoses can be made or modified as a result of a physical exam performed each visit by a nonophthalmologist physician. Such ocular exams are done without pharmacologic mydriasis or cycloplegia. Objective determinations of refractive status are beyond the scope of the BLSA.

RESULTS

Table 1 presents characteristics of the sample from which the longitudinal data have been collected. This group is comprised entirely of 577 men, since women were only added to BLSA in 1978 and generally do not have sufficient visits for a longitudinal analysis. The mean ages of participants, grouped by five-year birth cohorts, are shown in the third column of Table 1.

Mean acuities on seven successive visits of each cohort are joined by a line and plotted against age for presenting distance acuity, uncorrected distance acuity, presenting near acuity and uncorrected near acuity in Figs. 1 and 2. The typical mean interval between successive tests for each cohort is two years with variations as shown in Fig. 1 and 2. The percentages of persons using corrective lenses at their last visit are 94, 96, 98, 100, 100, 98, 99, 98, 88, 73, and 66 for successively later cohorts with mean birthdates from 1895 to 1945.

Presenting distance acuity exhibits very little change until about age 60 when acuity

TABLE 1. SAMPLE CHARACTERISTICS.

Cohort	N	Mean Age	Mean Birthdate	Mean No. of Visits	Mean Visit Date
1895	34	78.4	1895.1	7.7	1973.5
1900	54	74.7	1899.9	8.2	1974.5
1905	48	69.5	1905.2	7.2	1974.6
1910	58	65.0	1910.1	8.3	1975.2
1915	70	60.4	1914.8	7.4	1975.1
1920	67	55.9	1919.7	7.3	1975.7
1925	78	50.7	1924.7	7.2	1975.4
1930	42	46.4	1929.8	6.2	1976.2
1935	35	41.7	1935.0	6.3	1976.7
1940	33	37.0	1940.1	5.5	1977.1
1945	58	33.7	1944.6	5.1	1978.3

Mean age and mean visit date represent means of each individual's mean age and visit date during the course of the study.

begins to decline. Uncorrected distance acuity, on the other hand, appears to decline in a linear fashion from age 30 to 80. The efficacy of therapeutic intervention is generally consistent over age, the mean difference between uncorrected and presenting acuity being +0.34.

The decline in presenting near acuity is also linear for the most part until about age 70. As expected, uncorrected near acuity displays a dramatic decline between the ages of 40

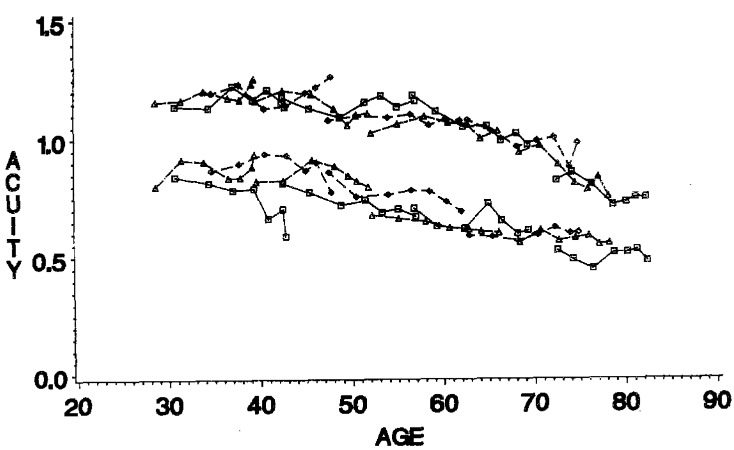

FIG. 1. Mean acuities (Snellen Decimal) on seven successive visits for 11 male cohorts. The upper plot represents presenting distance acuity; the lower, uncorrected distance acuity. Mean standard errors are 0.04 for presenting acuity and 0.07 for uncorrected acuity.

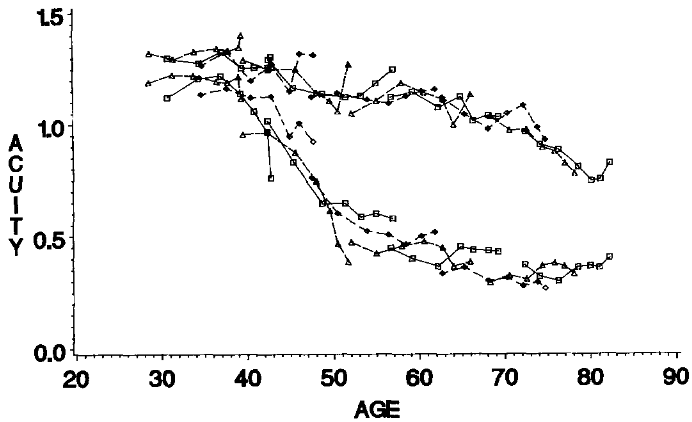

FIG. 2. Mean acuities (Snellen Decimal) on seven successive visits for 11 male cohorts. The upper plot represents presenting near acuity; the lower, uncorrected near acuity. Mean standard errors are 0.05 for presenting acuity and 0.06 for uncorrected acuity.

and 50, after which the decline lessens. Unlike distance vision, the degree to which corrective lenses or other therapies (e.g. surgery) are able to raise levels of acuity is not uniform over the years studied. Very little correction is needed between 30 and 40 years. Between 40 and 60 years, the amount of correction necessary and possible, as measured by the difference between uncorrected and presenting acuity, increases from about +0.20 to about +0.70. After 60 however, the improvement afforded by prescription lenses or other therapies decreases inasmuch as presenting acuity continues its decline.

It is interesting to note that although uncorrected near acuities are worse than uncorrected distance acuities after age 40, presenting acuities for near vision are consistently better than those for distance vision.

In terms of variability, the mean standard errors of the means on successive visits for presenting distance, uncorrected distance, presenting near and uncorrected near acuities are 0.04, 0.07, 0.05 and 0.06, respectively. For both presenting acuities, the variability was constant across all ages. For uncorrected distance and near acuities, however, there was a tendency for the standard error to decrease with advancing age from 0.11 and 0.09, in the youngest group, to 0.06 and 0.05, in the oldest group.

For purposes of statistical analysis, mean acuities were calculated over successive visits for each of the 577 participants. In addition, the change in visual acuity over successive visits was estimated for each of the participants using a linear regression procedure. The resulting mean acuities and slope estimates were used in the statistical analyses summarized in Table 2. One-way analyses of variance were performed on mean acuities and mean slopes of each acuity. The patterns suggested by Figs. 1 and 2 are corroborated by these data.

The longitudinal findings indicated that the amount and direction of change in acuity from first to last data point was related to the initial level of acuity. Persons with better vision at their first visit tended to change the most on subsequent visits. For those with good presenting distance acuity (20/15 and 20/20) initially, the average change from first to last visit is −0.15; for those with fair acuity (20/25 to 20/40) initially, +0.15; and for those with poor acuity (worse than 20/50) initially, +0.32 ($F = 50.79, p < 0.05$).

TABLE 2. MEAN ACUITIES AND MEAN SLOPES.

	Distance				Near			
	Presenting		Uncorrected		Presenting		Uncorrected	
Cohort/Age	Acuity	Slope	Acuity	Slope	Acuity	Slope	Acuity	Slope
1895/78.4	0.76	-0.03	0.51	-0.01	0.81	-0.03	0.35	0.00
1900/74.7	0.85	-0.03	0.55	-0.02	0.90	-0.04	0.34	0.00
1905/69.5	0.97	-0.02	0.57	0.00	1.02	0.00	0.32	0.00
1910/65.0	1.03	-0.01	0.62	-0.01	1.07	-0.01	0.40	0.00
1915/60.4	1.04	0.00	0.61	-0.01	1.10	0.00	0.42	0.00
1920/55.9	1.07	0.00	0.75	-0.01	1.12	0.01	0.55	-0.02
1925/50.7	1.13	0.00	0.70	-0.01	1.17	0.00	0.66	-0.04
1930/46.4	1.15	0.00	0.81	-0.01	1.22	-0.01	0.75	-0.04
1935/41.7	1.18	0.00	0.82	-0.01	1.24	-0.01	1.03	-0.03
1940/37.0	1.15	0.00	0.74	-0.01	1.26	0.00	1.06	-0.01
1945/33.7	1.18	0.00	0.80	-0.01	1.33	0.00	1.14	0.00
F	22.78	5.98	3.72	0.88	26.15	7.18	40.63	10.21
	p<.05	p<.05	p<.05	N.S.	p<.05	p<.05	p<.05	p<.05

In order to assess any effect that cohort may have upon observed acuities, one-way analyses of variance were performed using first visit data. Each analysis used only persons who could be placed in a five-year age group based on their age at first visit. In effect, age was held constant within five years for each analysis. The dependent variable was presenting distance acuity; the classifying variable, cohort. Each analysis took into consideration 2 to 5 cohorts. Of seven one-way analyses, only one indicated a significant effect of cohort upon presenting distance acuity ($F = 6.97, p < 0.05$). The cohorts which produced the significant effect were 55 at first visit. The variability among cohorts at that age is evident in the upper plot of Fig. 1.

Utilizing a method similar to Arenberg's (1982), regression analyses were performed to investigate any effect of time of measurement upon presenting distance acuity. Only first visit data were included for analysis. Persons were assigned to one of 11 five-year age groups according to age at first visit. Separate slopes estimating differences in presenting distance acuity over calendar time were calculated for each group. If there were a systematic effect of time of measurement, independent of age, a nonzero slope relating date of measurement to acuity would be expected. None of the eleven slopes relating time of measurement to acuity differed significantly from zero.

In order to compare these data to those of other studies and to look at sex differences in acuity changes with age, we have plotted cross-sectional data from this sample and an additional sample of BLSA women on the composite plot compiled by Pitts (Fig. 3). All data were from the person's most recent vision test at the BLSA. At their most recent visit, the

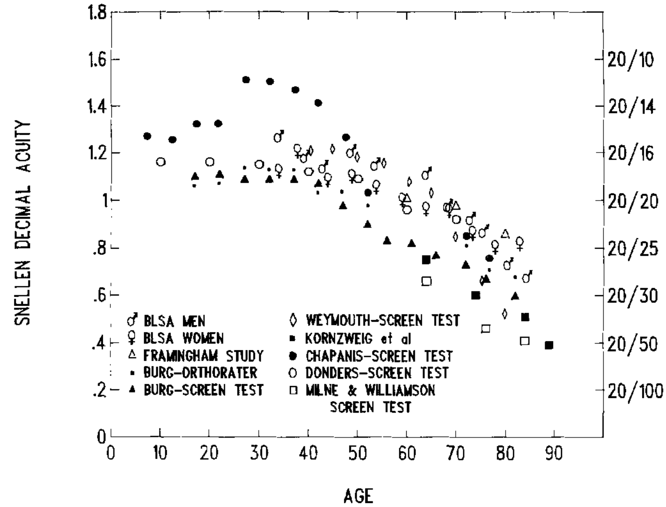

FIG. 3. Cross-sectional BLSA data added to Pitts' (1982) summary of age related differences in presenting distance acuity (Snellen Decimal). Data are from subjects' most recent visits.

male cohorts were 33.6, 38.8, 42.5, 48.1, 52.8, 58.3, 63.3, 67.6, 72.2, 75.1, 80.0, and 83.9 years old (One additional cohort born in 1950 has been added for this cross-sectional analysis). There are 27, 36, 27, 24, 26, 36, 42, 39, 51, 23, and 13 women in groups with mean ages of 33.4, 37.0, 43.1, 48.1, 53.1, 58.3, 63.3, 67.9, 72.7, 77.4, and 82.2 years, respectively. BLSA data are comparable to the other studies summarized by Pitts. There is a slight tendency for the older BLSA participants to be relatively closer to the top of the distribution. With the exception of the oldest women, acuities are slightly, but not significantly, better for men ($F = 3.62, p > .05$). This general finding held true for the other types of acuity as well.

The prevalence of visual pathology in the longitudinal sample of men is presented in Table 3. The percentages represent those who had a particular diagnosis appear in their diagnosis list by the time of their last vision test at the BLSA. The category, retinal pathologies, includes retinopathies as well as senile macular degeneration. Cataract and related groups are the most common visual pathologies in the BLSA (18%). The retinal pathologies classification is the second most reported pathology class (6%). Finally, about 3% of the sample are diagnosed as having glaucoma prior to their last vision test. As expected, the prevalence of cataract, retinal pathologies and glaucoma increases cross-sectionally with advancing age.

Figure 4 illustrates the effect of visual pathology upon presenting distance visual acuity by plotting a cross-sectional sample of acuities of persons who have no record of visual pathology with the remainder who have at least one diagnosis of visual pathology. Again, the diagnoses included in the morbidity group are cataract, aphakia, intraocular lens implant, glaucoma and retinal pathologies. Acuity data are from persons' most recent visits. In the seven oldest age groups (the 1925 cohort through the 1895 cohort), the percentages of each having at least one eye related diagnosis were; 12.8, 13.4, 31.4, 31.0, 54.2, 61.1, and 64.7, respectively. An analysis of variance performed on the means in Fig. 4 indicates that there are significant main effects of visual pathology ($F = 103.94, p < 0.05$) and age

TABLE 3. PERCENTAGE OF BLSA PARTICIPANTS HAVING DIAGNOSES OF VISUAL PATHOLOGY WHICH APPEARED AT OR BEFORE THEIR LAST VISION TEST.

	Lens pathologies			Glaucoma	Retinal Pathologies
Cohort/Age	Cataract	Aphakia	IO Implant		
1895/78.4	41.2	8.8	2.9	5.9	8.8
1900/74.7	42.6	9.3	0	9.3	13.0
1905/69.5	35.4	8.3	0	6.3	10.4
1910/65.0	12.1	1.7	1.7	8.6	10.3
1915/60.4	14.3	2.9	2.9	4.3	7.1
1920/55.9	7.5	1.5	0	1.5	3.0
1925/50.7	7.7	1.3	0	0	5.1
1930/46.4	0	0	0	0	4.8
1935/41.7	0	0	0	0	2.9
1940/37.0	0	0	0	0	0
1945/33.7	0	0	0	0	0
Totals	82	17	4	19	35

($F = 13.41$, $p < 0.05$), but no significant interaction between visual pathology and age ($F = 0.65$, $p < 0.05$). The conclusions to be drawn from this analysis are that even in the absence of documented visual pathology, most persons experience an age-related decline in acuity independently of the effect of visual pathology.

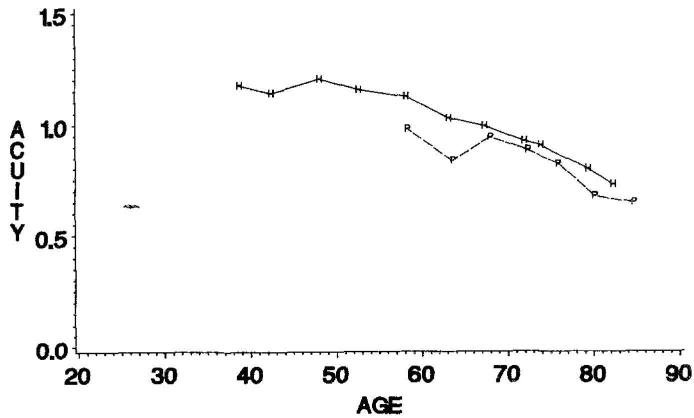

FIG. 4. Cross-sectional plots of presenting distance acuity (Snellen Decimal) obtained at the subjects' most recent visits. Subjects with apparently healthy eyes, represented by and "H", are compared with subjects, represented by a "P", who have at least one diagnosis of visual pathology. Mean standard errors are 0.04 for the healthy eye group and 0.06 for the group with ocular pathology.

TABLE 4. PRESENTING DISTANCE ACUITY FOR VARIOUS CATARACT GROUPS.

Cohort/Age		None	Present	Aphakic	Implant
1895/78.4	Mean	0.77	0.57	0.75	0.20
	N	16	14	3	1
1900/74.7	Mean	0.80	0.67	0.61	
	N	26	23	5	0
1905/69.5	Mean	0.87	0.79	1.04	
	N	27	17	4	0
1910/65.0	Mean	0.92	0.85	1.33	1.00
	N	49	7	1	1
1915/60.4	Mean	1.00	0.81	0.80	1.07
	N	56	10	2	2
1920/55.9	Mean	1.02	0.77	0.80	
	N	61	5	1	0
1925/50.7	Mean	1.12	0.91	1.33	
	N	71	6	1	0
1930/46.4	Mean	1.15			
	N	42	0	0	0
1935/41.7	Mean	1.21			
	N	35	0	0	0
1940/37.0	Mean	1.14			
	N	33	0	0	0
1945/33.7	Mean	1.18			
	N	58	0	0	0
Totals		474	82	17	4

The particular effect of cataract status on presenting distance acuity is summarized in Table 4. Acuities are from the person's most recent visit. Presenting distance acuities for persons placed in one of the three lens related categories were obtained from eyes which had no documented history of cataract in 12 cases. Therefore, acuities for persons in the column headed "Present" were for the eye with the opacity, or in the case where both eyes had cataracts, the acuity of the better eye. The acuities in the columns headed "Aphakic" and "Implant" were for the enucleated eye. For the 1925 and earlier cohorts, the mean clear lens acuity is 0.98 and that of the eyes with lenticular opacities is 0.74 ($t = 6.46, p < 0.05$). In the same cohorts, acuity in aphakic eyes, mean of 0.85, is slightly better than that of cataractous eyes ($t = 1.27, p > 0.05$), but is not as good as that of the eyes with clear lenses ($t = 1.40, p > 0.05$). Two out of the four implant cases, mean acuity of 0.83, achieved acuities of 20/20 or better. The individual in the 1895 cohort with an acuity of 0.20 (20/100), had bilateral implant surgery in 1975, but has no other history of visual pathology.

DISCUSSION

The degree of agreement among the illustrated acuity data in Fig. 3 is remarkable when one considers the variation in the control of variables that are known to affect acuity. Very few, if any of the previous studies used exactly the same techniques for measuring acuity or controlling variables related to acuity, e.g. distance from the target, time of exposure to the target, illumination of the target area, size of the target, contrast between the target and its background and refractive status of the eyes. In fact, this study, and the others referred to in Fig. 3, have focused on just two factors related to acuity, i.e. distance and size of target.

As indicated earlier, the scaling conventions used by various investigators have varied. To illustrate the problem with using Snellen decimals, a change in acuity from 20/20 to 20/40 converts to a difference in Snellen decimals of 0.5, whereas a change from 20/100 to 20/200 is equivalent to a difference of only 0.1. Using the logarithm of the acuities equalizes the separations on a scale between 20/20 and 20/40 and between 20/100 and 20/200. The mean logarithms of presenting distance acuity (men) from the cross-sectional BLSA data is 0.10 (Snellen Decimal equal to 1.27) for the youngest group and −0.20 (Snellen Decimal equal to 0.68) for the oldest group. Use of logarithmic scaling of these test values results in a 300% decrease in the logarithm of visual acuity. In contrast, without converting to a logarithmic scale, there is a 46% decrease. The choice of scaling does not change the fact of age related change in visual acuity, only the impression of its magnitude.

Anderson and Palmore observed ten-year increases of 13 and 32% in the percentage of two groups with 20/50 acuity or worse. The groups were initially 60–69 and 70–80 years of age. With BLSA data grouped in the same way as Anderson and Palmore's, we observed a decrease of 2% and an increase of 20% in the groups over a ten-year period. Using Milne's procedures and definitions, a group of BLSA participants initially aged 63–90 were reexamined after a five-year period. Six percent exhibited improved acuity while 18% experienced a decline in acuity as opposed to Milne's findings of 15% improved and 12% worsened. Our findings moreover indicate that those with improved acuity are likely to have had poor acuity initially. With some qualifications with respect to degree of change according to initial levels, the longitudinal data presented here confirm the patterns of change in acuity with age found in the previous longitudinal studies.

Weale (1961) has suggested that the light reaching the retina of a 60 year old is 1/3 that reaching a 20 year old's. Since the illumination of the target in this study was constant and low compared to environmental levels, older persons were at a disadvantage in terms of the amount of light reaching their retinas. If our illumination had been greater, there is a chance that we may not have observed as large a decline in acuity. Participants who are aphakic or who have intraocular implants should have more light reaching their retinas since clouded lenses have been removed. However, most of these persons have acuities similar to those at the same age without cataract, but not as good as those who are younger.

Cross-sectional comparisons of BLSA visual pathology data with those of Anderson and Palmore indicate that in the BLSA, the prevalence of lens pathology in groups over 60 ranges from 9 to over 50%, whereas Anderson and Palmore's observed rates range from 9 to 36%. In terms of glaucoma, BLSA prevalence in groups over 60 ranges from 2 to 9% as opposed to 0 to 3% in Anderson and Palmore's sample. A similar comparison is not possible for retinal pathologies. These statistics indicate that the prevalence rates of visual pathologies have not been underestimated in the BLSA.

There were 14 cases where a diagnosis appeared after the last vision test was performed. By definition these cases were assigned to the nonpathology groups, even though the individuals were probably in earlier stages of the disease at the time of their last vision assessment. Formal diagnosis of visual pathologies is somewhat dependent on factors unrelated to the disease itself; for instance, time between visits to a physician. Pathology data in studies such as the BLSA is problematic in that we rely on participant reports based in part on information given them by their physicians. The information from our physical exam is not definitive. Accordingly, our prevalence data may be subject to greater error than would be the case with a focussed ophthalmological examination.

In conclusion, these longitudinal data confirm and document definitively the relationship between age and visual acuity suggested by cross-sectional studies. Older persons who are thought to be free from visual pathology still experience a decline in acuity with age as do persons who have some visual pathology. Despite the decline in acuity with age, only about 12% of the persons 75 and older had acuities of 20/50 or worse at their most recent visits to the BLSA. The majority of BLSA participants maintain at least fair acuity (20/40 or better) into their 80's.

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REFERENCES

Anderson, B. and Palmore, E. Longitudinal evaluation of ocular function. In: *Normal Aging II*, Palmore, E., (Editor), pp. 24–32, Duke University Press, Durham, N.C., 1974.

Arenberg, D. Estimates of age changes on the Benton Visual Retention Test. *Journal of Gerontology* **37**, 87–90, 1982.

Bruckner, R. Longitudinal research on the eye. *Gerontologia Clinica* **9**, 87–95, 1967.

Milne, J.S. Longitudinal studies of vision in older people. *Age and Ageing* **8**, 160–166, 1979.

Pitts, D.G. The effects of aging on selected visual functions: Dark adaption, visual acuity, stereopsis and brightness contrast. In: *Aging and Human Visual Function*, Sekuler, R., Kline, D.W., and Dismukes, K., (Editors), pp. 131–159, Alan R. Liss, Inc., New York, 1982.

Shock, N.W., Greulich, R.C., Andres, R., Arenberg, D., Costa Jr., P.T., Lakatta, E.G., and Tobin, J.D. Design and Operation of the Baltimore Longitudinal Study of Aging. In: *Normal Human Aging: The Baltimore Longitudinal Study of Aging*, pp. 45–62, U.S. Government Printing Office, Washington, D.C., 1984.

Weale, R. Retinal illumination and age. *Transactions of the Illuminating Engineering Society* **26**, 95–100, 1961.

Weale, R. The eye and aging. In: *Interdisciplinary Topics in Gerontology*. Hockivin, O., (Editor), Vol. 13, pp. 1–13, S. Karger, New York, 1978.