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# Static aspects of accommodation: age and presbyopia

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## Abstract

Although the progressive reduction in accommodative amplitude with increased age is well documented, little is known about several other aspects of static or steady-state accommodation to provide a comprehensive assessment of changes related to age and presbyopia. Static components of accommodation (tonic accommodation, depth-of-focus, slope of the stimulus/response function, and accommodative controller gain) were assessed objectively using an infrared (IR) optometer in 30 human subjects aged 21–50 years; depth-of-focus was also determined psychophysically as was accommodative amplitude. Tonic accommodation and the amplitude of accommodation decreased with increased age, whereas the subjective depth-of-focus increased; the other parameters remained unchanged. The decrease in tonic accommodation and amplitude of accommodation was attributed to biomechanical factors, whereas the increase in subjective depth-of-focus was believed to result from increased tolerance to defocus related to the gradual onset of presbyopia. Constancy of the objective depth-of-focus suggested absence of age effects on the neurologic control of reflex accommodation, whereas the lack of systematic change in slope and controller gain provided support for the Hess–Gullstrand theory of accommodation and presbyopia.

*Keywords:* Presbyopia; Aging; Modelling; Hess–Gullstrand theory; Duane–Fincham thoery; Accommodation

## 1. Introduction

Accommodation refers to the lenticular-based change in overall refractive power of the eye to obtain and maintain an in-focus retinal image [1–3]. One factor which has received considerable attention in this area, at least with respect to the maximum output of accommodation, i.e. the amplitude of accommodation, has been age and the development of presbyopia. Numerous studies dating back over 150 years have clearly and consistently demonstrated a progressive decline in accommodative amplitude ranging from approximately 0.2 to 0.45 D/year [4–10]. This age-related decline starts at ≈5 years-of-age [11,12], and it extends to zero at ≈52 years-of-age in the laboratory studies [6]. This decline appears to extend to 60 years or greater in clinic reports [4,5,13,14,10], but this is due to a depth-of-focus contamination effect [6].

Over the past decade, others have investigated additional components of steady-state accommodation as related to age and presbyopia (see [25] for a brief overview). This has primarily included tonic accommodation which decreased with age [16–18,9,19] and slope of the accommodative stimulus/response function which appeared to decline primarily after age 45 years in the one subject tested longitudinally [9].

However, there has been no comprehensive study of static aspects of accommodation as related to age and the development of presbyopia, with all parameters being measured in each person of a relatively large subject pool. Therefore, the purpose of the present investigation was to determine age-related changes in the various components contributing to the overall static or steady-state accommodative response cross-sectionally in a relatively large group of subjects with primary reliance on objective assessment. This was done within the context of the Hung–Semmlow model of accommodation [20].

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## 2. Methods

### 2.1. Subjects

Thirty human adults aged 21–50 years, who freely volunteered their time and effort, participated in the study. The experiments were undertaken with the understanding and written informed consent of each subject per our campus' IRB guidelines. These subjects were derived from the faculty, staff and student body of SUNY/State College of Optometry. Each subject was prescreened and found to be free of any obvious systemic and ocular diseases, as well as drugs and medications that could compromise accommodation. Each had corrected distance and near visual acuity of 20/25 or better and normal binocularity. Full distance correction was worn during all testing. They were divided into six age subgroups: 21–25, 26–30, 31–35, 36–40, 41–45 and 46–50 years, with five individuals in each subgroup.

### 2.2. Apparatus and procedures

An infrared (IR) optometer based on the principle of retinoscopy and incorporating model eye absolute calibrations was used to obtain an objective record of most of the measured static accommodative parameters. It has been described in detail elsewhere [21]. The optometer has a bandwidth from dc to 5 Hz, a noise level of $< 0.12$ D, a linear range of $\pm 6$ D, and a range of insensitivity to eye movements of 4 deg horizontally and 2 deg vertically [22]. The high contrast target consisted of a Maltese cross (8 deg diameter) along with a series of thin concentric circles (2, 4 and 8 deg diameters). The test stimulus was centered within a Badal optical system. The IR dynamic optometer was used to record all responses from the subject's right eye, while the left eye was fully occluded.

All of the static parameters of accommodation [20], with the exception of the amplitude of accommodation and the subjective depth-of-focus, were determined objectively. The procedures are described below.

#### 2.2.1. Amplitude of accommodation

The monocular amplitude of accommodation was determined in free space by the standard clinical push-up method [23]. The criterion of 'first slight sustained blur' was adopted as the endpoint, with the target slowly increasing ( $\sim 0.5$ D/s) in dioptric demand. Three measurements were averaged to determine the mean amplitude of accommodation. Although this parameter and its age-related effect have been studied extensively in the past [1,2], it was included here for completeness as well as to assure its normalcy in each subject.

#### 2.2.2. Slope of the stimulus/response function (closed-loop gain)

The target was slowly moved from optical infinity to a mechanically-limited nearpoint position of 4.75 D. An empirically-determined (by examination of several preliminary ramp–response records for each subject) ramp rate of 0.2–0.35 D/s was found to be optimal for the subject population. These values agreed with earlier findings of others who used similar methodologies [24]. Response records were obtained on a high-speed oscillographic recorder. These were then used to determine manually the slope (gradient of the best-fit line to the response) of the steep midlinear region (300 ms or longer response segment samples) of the stimulus/response function [1,2]. Estimated error based on repeated trials on the same data samples was $< 10\%$. Care was taken not to use any of the non-linear response regions in the calculations, as this would result in an artefact that would reduce the true slope value. Two such measurements were taken from each record for each subject and averaged.

#### 2.2.3. Tonic accommodation

All light sources were extinguished, so that only the very dim reddish glow of the IR source was visible to the subject who was instructed to relax but to 'look through' the center of the red field. After remaining in the dark for 2 min to allow for dissipation of accommodative transients [25], a 30 s record of accommodation was obtained and later used to determine manually (by visual inspection of the oscillographic record) the average steady-state level of accommodation. Two such measurements were taken from each record for each subject and averaged.

#### 2.2.4. Depth-of-focus

*2.2.4.1. Objective.* The target was initially positioned at the midpoint of the linear region of the individual subject's stimulus/response function, as derived earlier from the objective slope determination. The subject was instructed to fixate its center and to keep the target in focus. An initial steady-state baseline response was first established. Then the target was very slowly ramped at a rate of 0.09 D/s, first towards the subject (increasing stimulus dioptric magnitude) until the point when a clear and consistent change in the baseline level of reflex accommodation was observed (by on-line visual inspection of the oscillographic record), indicating that the target had exceeded the proximal end of the depth-of-focus. The target was then returned to the initial midpoint position and the process repeated in the direction of decreasing stimulus dioptric magnitude until the target exceeded the distal end of the depth-of-focus. This was repeated twice in each direction and averaged, with compensation for their individual average accom-

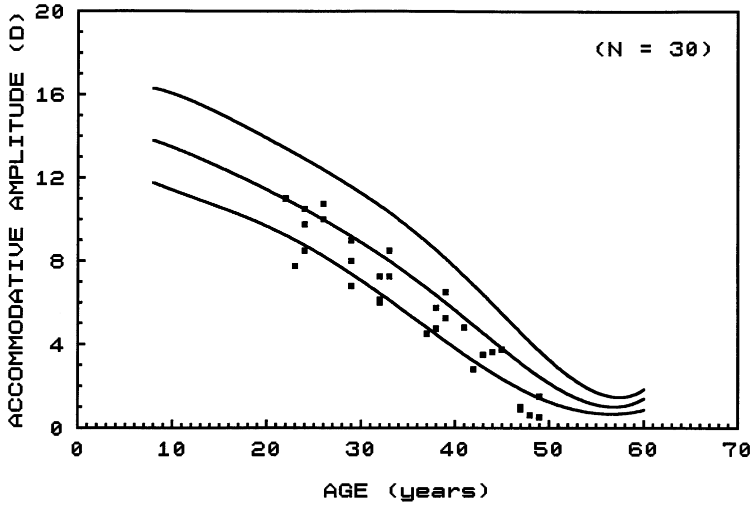

Fig. 1. Scatter plot of amplitude of accommodation as a function of age for individual subjects in the present study. Upper and lower range and mean response curves were derived from Duane's [5] accommodative amplitude clinic study.

modative response latency ( ~ 400 ms; this perception-to-motor response time had been determined earlier as part of a related study [22]). The estimated precision was better than 0.04 D.

*2.2.4.2. Subjective.* The apparatus consisted of a back-illuminated, high contrast target presented within a Badal optical system [26]. The target was composed of black-and-white, pie-shaped sectors arranged in a circular fashion. The sectors subtended an angle of 48 min arc at their extreme peripheral ends and tapered to a fine point ( < 1.5 min arc) centrally. Moreover, they were superimposed on three thin black concentric circles of increasing diameters, with the inner, middle, and outermost circles subtending angles of 2.0, 4.8 and 8.0°, respectively. The target was physically bisected, with the two vertical halves juxtaposed to one another. The left hemifield was fixed at a stimulus value that represented the midpoint of the linear region of the accommodative stimulus–response function for the subject. The subject's head and chin were positioned in their respective rests. The left eye was fully occluded, and the subject was instructed to fixate and maintain focus on the central portion of the target. The experimenter then moved the right hemifield target in depth, while the subject signaled (by depressing an audible switch) to indicate the initial very slight loss in clarity of the displaced right hemifield target. By very slowly moving the target ( ~ 0.05 D/s) both towards and away from the subject, the proximal and distal ends of the subjective depth-of-focus were obtained. This was repeated twice in each direction, and the total extent was determined and averaged. This was similar to the apparatus and technique developed by Campbell [27].

### *2.3. Accommodative controller gain (ACG)*

The open-loop gain of the system, i.e. ACG, was also determined. This involved substitution of the accommodative error and response (derived from the ramp stimulation described earlier) from several (i.e. three or more) central portions (300 ms or longer segments) of the manifest midlinear region of the accommodative stimulus/response curve, as well as the measured tonic accommodation and objective depth-of-focus as discussed earlier, into the following equation: $ACG = [(AR - ABIAS)/AE - DSP]$, where AR is the mean steady-state accommodative response, ABIAS the tonic accommodation, AE the mean steady-state accommodative error and DSP is one-half the subjective depth-of-focus. The average ACG for each subject was then calculated [20]. This accommodative component is related to the closed-loop slope or gain by the following equation: $gain = ACG/1 + ACG$.

## 3. Results

### *3.1. Amplitude of accommodation*

Fig. 1 presents a scattergram showing the age-related clinical push-up amplitude of accommodation results for the present study superimposed on Duane's [5] clinical amplitude range and mean distribution. The present results were consistent with and confirmed these as well as other earlier findings, which demonstrated that the amplitude of accommodation progressively declined with age [23]. The individual subject amplitudes for the present study fell within the lower two-thirds of Duane's [5] distribution profile. At each age, the range of amplitude values was 2–4 D. Note that

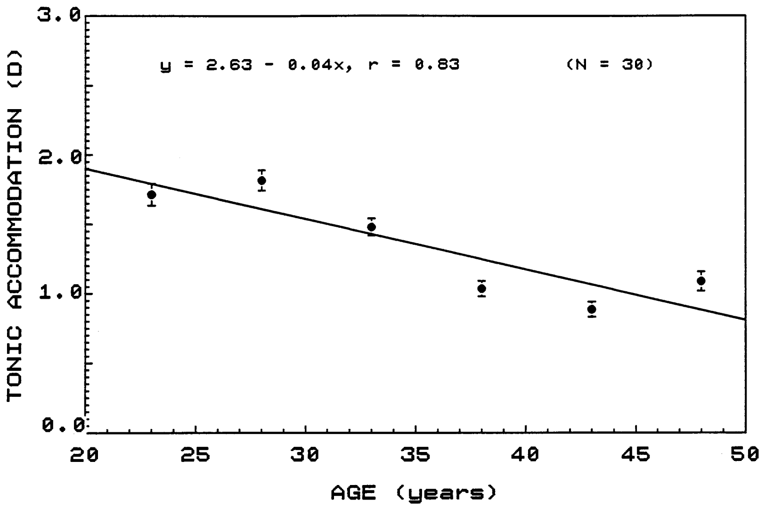

Fig. 2. Tonic accommodation as a function of mean subgroup age. Plotted is the mean ± 1 S.E.M. The linear regression equation and correlation coefficient are given.

just prior to 50 years-of-age, the measured accommodative amplitude approached a value of zero.

Regression analysis on the group data clearly demonstrated that the relation between the clinical amplitude of accommodation and age could be described well by a linear fit over this age range. It declined at the rate of 0.34 D/year, with a predicted maximum value of ≈ 18 D in early infancy and a predicted minimum value of zero diopters at 52 years-of-age. The one-way ANOVA on the group data was statistically significant [$F(5, 24) = 36.93917$, $p < 0.00001$], thus confirming the change with age. The Neuman–Keuls multiple-paired subgroup comparison $t$-test was significant ($p < 0.05$ level) for all pairs of comparisons, except between age subgroups 21–25 and 26–30 years.

### 3.2. Tonic accommodation

The group results are summarized in Fig. 2. Tonic accommodative values for the group had a mean of $1.34 \pm 0.42$ D, with a range of 0.70–2.5 D and fell within acceptable limits [28–30]. It declined at a rate of about 0.04 D/year, from a linear regression-based predicted mean value of 2.55 D in infancy to a predicted mean value of 0.6 D at 50 years-of-age. The one-way ANOVA for the group data was statistically significant [$F(5, 24) = 8.4168$, $p < 0.0002$], thus confirming the regression analysis result. The Neuman–Keuls multiple-paired comparison $t$-test revealed several pairs of significant subgroup mean differences ($p < 0.05$); however, a minimum age separation of 10 years was required for a significant difference to be found.

### 3.3. Depth-of-focus

Data for the objective and subjective depth-of-focus as a function of age are presented in Fig. 3. Individual subject values for the objective depth-of-focus ranged from a minimum of $\approx \pm 0.20$ D to a maximum of $\pm 0.64$ D, with a group mean value of 0.38 D. Based on the regression analysis, it was evident that the objective measure did not reveal a trend to change with age, while the subjective measure appeared to increase (0.027 D/year). The one-way ANOVA for the group subjective depth-of-focus confirmed this notion [$F(5, 20) = 2.89812$, $p = 0.0394$]. However, the one-way ANOVA for the group objective depth-of-focus [$F(4, 20) = 3.33654$, $p = 0.0298$], while also being of statistical significance, clearly only reflected the single subgroup decreasing outlier at 31–35 years-of-age.

Finally, there was a strong positive correlation between total objective and subjective depth-of-focus ($p < 0.01$) (Fig. 4). However, the average subjective depth-of-focus (across subgroups) was ≈ 40% greater than that found for the objective depth-of-focus.

### 3.4. Slope of the stimulus/response function

Representative objective response records in a younger and older subject to slowly-moving, optimal ramp accommodative stimuli (0.2–0.35 D/s) are presented in Fig. 5. Such records were used to obtain the slope of the manifest midlinear region of the stimulus/response function for each subject.

Fig. 6 presents the average maximum ramp-derived slope of the stimulus/response curve as a function of age for the group. The slope was relatively constant with increased age. In the oldest subgroup (46–50 years), there were no detectable ramp responses from which to determine slope values, as accommodation was so much reduced. The one-way ANOVA on the group data indicated significant differences [$F(4, 20) = 4.113355$, $p = 0.013$]. However, the Neuman–Keuls multiple-subgroup comparison $t$-test revealed that a

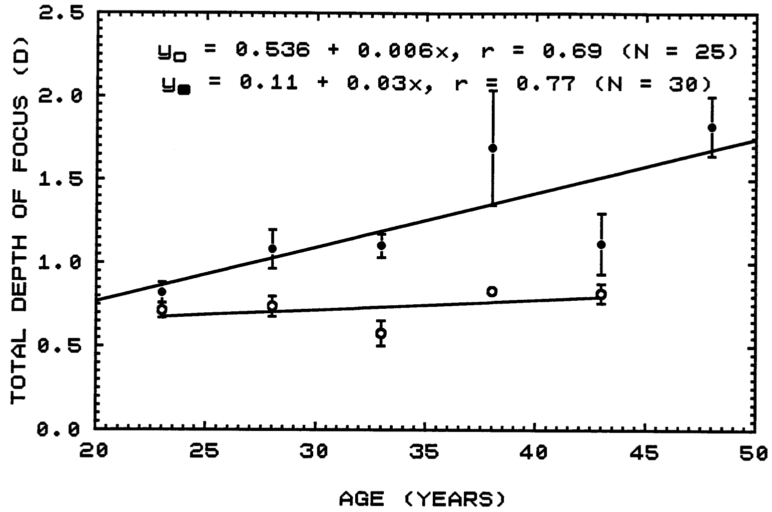

Fig. 3. Total depth-of-focus as a function of mean subgroup age. For objective (○) and subjective (●) measurements. Plotted is the mean ± 1 S.E.M. Linear regression and correlation coefficients are given.

significant difference ($p < 0.05$) was only found by comparing the oldest responding subgroup with the youngest subgroup. This confirmed the absence of any systematic age-related trend.

### 3.5. Accommodative controller gain

The ACG value for the subgroups, which ranged from eight to 11 with a group mean of 9.67, are plotted as a function of age and show considerable intersubject variability (Fig. 7). The slope of the regression equation for the group data indicated that ACG remained relatively constant with increased age. The relative constancy of this parameter was confirmed by the one-way ANOVA on the subgroup data, which was not statistically significant [$F(4, 20) = 0.25954, p = 0.899$]. Therefore, ACG did not exhibit any systematic change with age.

## 4. Discussion

### 4.1. Amplitude of accommodation

The results of the present study clearly show a linear decline in accommodative amplitude with increased age, as found by Duane and all others in their normative cross-sectional studies [4,6,13,14,10]. Duane's curve [5] derived from his clinic patients has become the standard for comparison. The data in the present experiment were biased somewhat towards the lower end of Duane's normal distribution. This may be attributed to a better understanding of the notion of slight blur with the presumably more sophisticated subjects (rather than clinic patients) tested in the present study.

### 4.2. Tonic accommodation

The present study also clearly demonstrated that tonic accommodation decreased linearly with increased age. These results confirm and extend those of Simonelli [17] and others [16,18,9,19]. The rate of decline was approximately eight times slower than found for the accommodative amplitude.

The gradual and progressive loss of both the accommodative amplitude and tonic accommodation appear to reflect primarily age-related changes in the peripheral accommodative apparatus. This has traditionally been accounted for by lenticular factors, namely:

1. a decrease in Young's modulus of lens capsular elasticity throughout the entire life-span [31]; it progressively acts like a less stiff spring, resulting in less springiness and therefore reduced ability to mold the lens,
2. an increase in the modulus of lens elasticity especially after 30 years-of-age [32]; it begins to act like a stiffer spring, therefore requiring more energy to deform it,
3. an increase in lens size and mass [33,34] and therefore also requiring more energy to deform it [35,36].

A possible molecular basis for the increase in the lens modulus of elasticity may reside in the age-related increase in the number of cross-link disulfide bridges which have been reported [37,38] and add rigidity to the lens. In addition, scanning electron microscopic studies have revealed the presence of junctional complexes (interdigitations, ball-and-sockets, and ridges and grooves) [39] along the lens fiber lengths. For example, in the rabbit lens, it was found that the younger superfi-

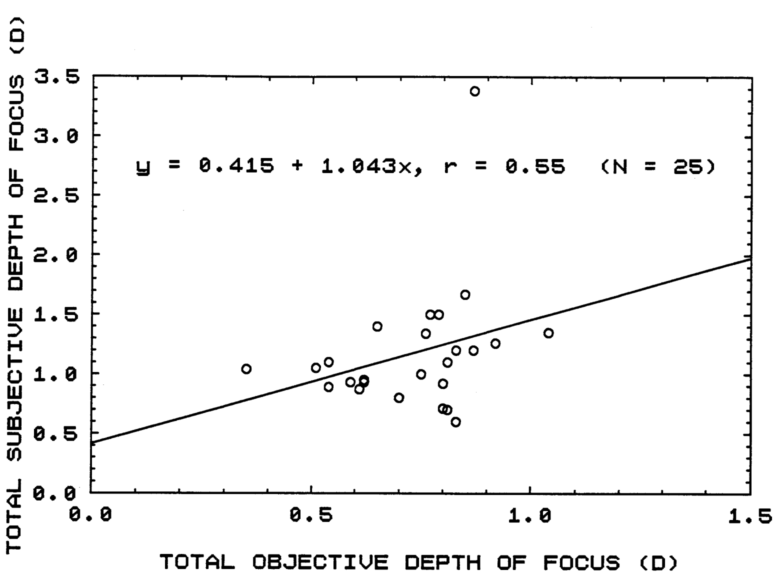

Fig. 4. Correlation plot of total subjective versus objective depth-of-focus. Linear regression equations and correlation coefficients are given. Objective results from the oldest subgroup could not be obtained.

cial cortical lens fibers have many interdigitations, whereas the older and deeper fibers lose these ball-and-socket arrangements on their sides [40]. It was thus proposed that a greater force would be required to deform (or alter the shape of) such older lens mass components, since less intercellular 'gliding' would apparently occur during the process of accommodation [39,41]. Hence, this would effectively increase the modulus of lens elasticity.

It has been proposed that the three above mentioned lenticular factors may account for as much as 99% of the presbyopic loss according to Fisher [42,32,36]; also see Adler-Grinberg [43], Pierscionek [44] and Gilmartin [45] for excellent reviews.

However, there are extralenticular factors worthy of consideration. First, the number of equatorial zonules is less in old age than in middle age [46]. Furthermore, these zonular bundles become less dense, and fragments of fibers which are often electron-dense are present between the bundles [47]. Such changes would result in loss of effectiveness of the zonular fiber tension-release mechanism [47]. Although these changes primarily occur at an age ( ~ 45 years) when accommodation is very much reduced, such changes would result in less available energy to deform the lens at this critical stage. Furthermore, it is possible that such changes may occur, but be of a more subtle nature at a slightly earlier age, and therefore have some degree of adverse effect on accommodative ability during early presbyopia.

Second, there is it a shift in the zonular insertion primarily after 45 years-of-age, with it moving from the equatorial region to a more anterior location as a result of lens growth, effectively pulling this capsular region forward and inward [46]. Such a change in the zonular geometry would also contribute to the final stages in the loss of amplitude and the development of absolute presbyopia [48,49]. From a mechanical viewpoint, a vector force applied perpendicularly to a load is more effective than the same amount of force applied at an oblique angle approximating parallelism with the attached capsular surface. However, zonular elasticity itself does not change with age [50,51].

Third, the choroid loses its elasticity and therefore becomes stiffer with age [52], especially during the first 35 years of life [53]. This change may require slightly more ciliary muscle force/contraction to attain a specific dioptric level with increased age. Such compensation appears to occur up to 45 years-of-age, with a slow decline thereafter [54,53].

Fourth, and lastly, there is the question of the ciliary muscle and its ability to exert (indirectly) force on the crystalline lens, as there are some who believe the ciliary muscle 'weakens' and therefore loses its functional capacity with increased age [55,56]. There are at least four pieces of evidence in humans that do not support this notion.

1. Using the physiological technique of impedance cyclography which provides an indirect indicator of ciliary muscle contraction [57], the consistent finding has been the absence of any such age-related decline [58–60], even when stimulated beyond the accommodative amplitude provided that the effort to accommodate was fully exerted [59].
2. Using a biomechanical approach, Fisher [32] found that the maximum ciliary muscle force actually increased up to age 45 years or so when little residual accommodation remains.

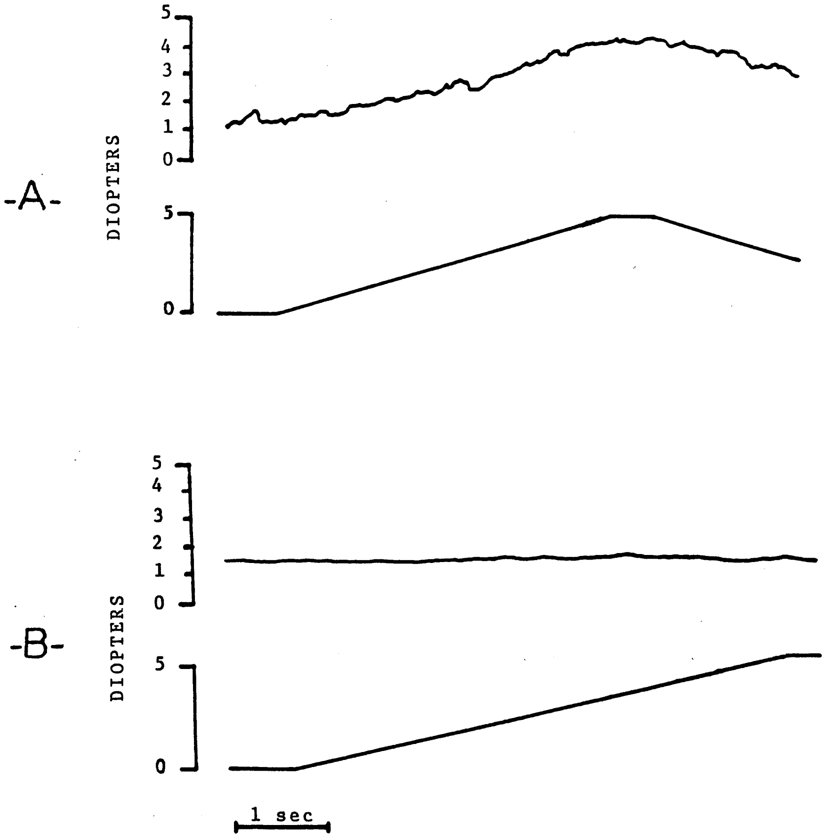

Fig. 5. Representative objective dynamic ramp-derived records from a younger (top; 27-year-old) and older (bottom; 47-year-old) subject from which subgroup accommodative stimulus/response function slopes were calculated. The upper record is the accommodative response and lower record is the accommodative stimulus for each subject.

3. Using a pharmacological approach, van Alphen [61] found that isolated strips of human ciliary muscle from a 2-year-old and an 82-year-old eye exhibited the same order of magnitude of contractile force.
4. When using motor response techniques that indirectly assess ciliary muscle innervation, the response AC/A ratio [62] progressively increased by only a very small amount ( $\sim 0.1^{\triangle}$/D/year or less) with age, suggesting little reduction in efficiency and effectiveness of the ciliary muscle [15,63–65].

On the other hand, there are at least two pieces of histological data which suggest that the ciliary muscle may exhibit some age-related changes. Firstly, there was increased presence of connective tissue in the muscle, which could limit or reduce its ability to contract fully [66,67]. However, this was most prominent in subjects over 40 years-of-age, when only a modest amount of accommodation remained. And, secondly, there was a decrease in area and length of certain portions of the ciliary muscle in subjects aged 20–45-years-old, but such changes could not contribute to a $> 30\%$ reduction. Clearly, even this appeared not to be the case, as from the above four earlier arguments, its effective physiological function showed little evidence of any decline.

Thus, presbyopia appears to be a multi-factorial lenticular and extra-lenticular problem [34,68,69]. Furthermore, some of these factors only appear to play a predominant role in the process over specific stages of life, i.e. the choroid in the early years and the zonular shifts in the later years, with many such as capsular elasticity decreasing over the entire life-span.

### *4.3. Depth-of-focus*

There does not appear to be any previous systematic investigation of depth-of-focus as a function of age. In the present study, it was found that the objectively-determined total depth-of-focus remained relatively constant, suggesting lack of any systematic age-related decline in neurosensory detection of small amounts of retinal defocus. The smallest values compared reasonably well with that found objectively by Kotulak and Schor [70] ( ± 0.14 D) and Winn et al. [71] (±0.19 D) in their small samples using experienced subjects. The average subjective value ( ± 0.64 D) compared reasonably well with that of Campbell [27], who found a mean of ± 0.43 D in his small and highly-experienced population of young adults. The age-related reduction in natural pupil size could account for no more than

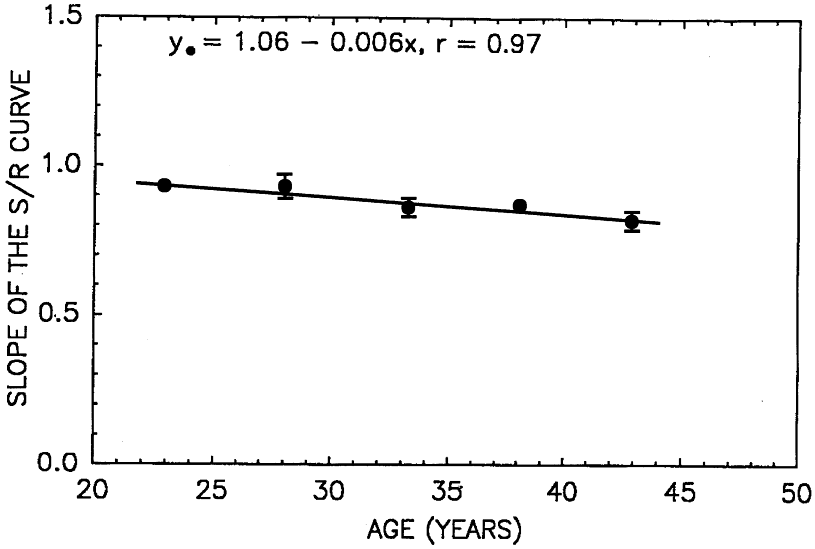

Fig. 6. Ramp-derived slope of the stimulus/response curve as a function of mean subgroup age. Plotted is the mean ± 1 S.E.M. The linear regression equation and correlation coefficient are given.

one-third of this increase [68]. This residual difference between the subjective and objective depth-of-focus is consistent with the results of others [72,73,70], with Fincham [72] suggesting that the accommodative system is capable of responding more or less 'reflexively' to small degrees of defocus–blur stimulation (as little as 0.1 D; [73]), which may in fact be below the perceptual threshold for blur [70].

In contrast, the subjectively-determined depth-of-focus clearly increased with advancing age and was on average 40% greater. Such an increase might serve a useful function. With ever-advancing presbyopia, an individual may develop a true 'tolerance to defocus'. Thus, what might have been reported as 'slightly blurry' at 20 years-of-age with respect to the amount of retinal-image defocus present, might at 40 years-of-age be regarded as 'acceptably clear' due to gradual habituation to such slight and more frequent periods of retinal defocus during the intervening 20 or so year interval. Thus, the subjective depth-of-focus would effectively increase with age, whereas the objective depth-of-focus would not, as found in the present study. This subjective change might represent a neurosensory adaptive phenomenon designed to reduce the perception of blur as near focusing becomes progressively more difficult and less accurate during early presbyopic development.

### *4.4. Slope of the stimulus/response function*

There are two basic theories of presbyopia [55,59,74,44]. In the first, the Hess–Gullstrand theory which is purely lenticular-based, the slope of the accommodative stimulus/response function should remain relatively constant with increased age, since the same amount of innervation is required to produce a unit change in accommodation anywhere over the midrange manifest linear region. In the second, the Duane–Fincham theory which is purely ciliary muscle-based, the slope of the accommodative stimulus/response function should progressively decrease with increased age (assuming constancy of accommodative effort), since the innervation required to produce a unit change in accommodation would increase with advancing age. The present results support the Hess–Gullstrand theory.

Ramsdale and Charman [9] reported that the slope of the accommodative stimulus/response curve decreased with increased age in their one subject tested periodically from 41–51 years-of-age. However, this apparent decrease was only obvious after 45 years-of-age, with it declining precipitously thereafter. The present results using a relatively large number of subjects clearly demonstrated that the slope remained relatively constant and exhibited little systematic age-related variation over the age range (e.g. 20–45 years). Thus, in the present experiment, at least over the ages of 20–45 years during which the vast majority of the accommodative loss occurs and which approaches absolute presbyopia ( ~ 52 years-of-age), relative slope constancy was found. This is consistent with, and expands upon, the results of Ramsdale and Charman [9].

### *4.5. Accommodative controller gain*

The determination of ACG as a formal parameter of accommodation began only relatively recently with introduction of the static model of Hung and Semmlow [20] and therefore only few studies having provided normative data on this parameter [20,75,26]. However, none of these earlier reports investigated the possible

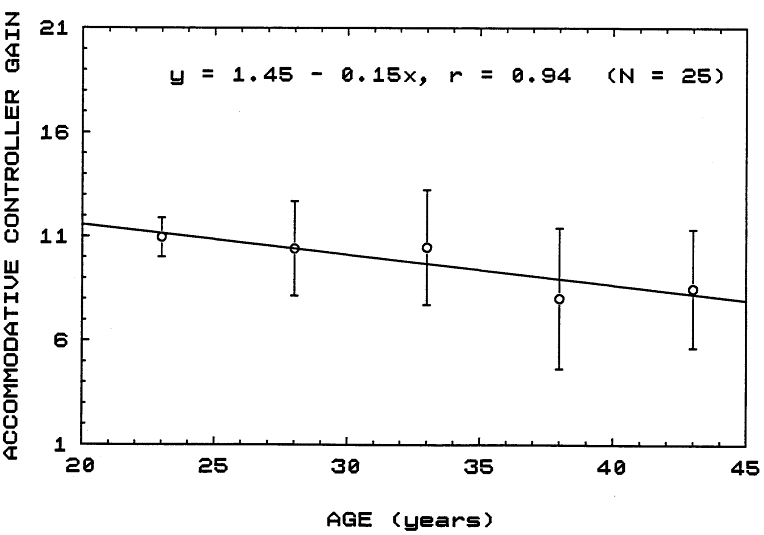

Fig. 7. Calculated ramp-derived optimal accommodative controller gain as a function of mean subgroup age; the oldest subgroup showed lack of response. Plotted is the mean ± 1 S.E.M. Linear regression equation and correlation coefficient are given.

effect of age. The ACG range and variability for our sample population group was 1.50–20.56 with a mean of approximately ten, and this is remarkably similar to that found in the above literature for normal young adults (1.7–21.0 with a mean ranging from eight to 11). The ACG values in the present study revealed a lack of dependence on age. It should be emphasized, however, that all measurements considered were the maximum average for each subject, since the equation values were only derived from the manifest midlinear response region and when accommodation was changing appropriately 300 ms or longer. And, obtaining three or more discrete sample points in this manner reasonably well assured lack of intrusion into the adjacent non-linear response regions, as might occur with older subjects in which the true linear region progressively decreases with age. Thus, we believe the gain function for accommodation is better derived from the ACG equation, at least in older subjects. These results imply normalcy of the internal neural gain and its controller, as well as the gross biomechanical aspects of accommodation over the approximately linear range tested. Again, the results are in support of the Hess–Gullstrand theory, and, as predicted, consistent with the slope results.

In conclusion, the results of the present investigation provide a comprehensive and quantitative overview of the changes in steady-state accommodation with increased age. Correlated changes in biomechanics and sensory aspects of vision were considered. The age-independent parameters pointed to retention and normalcy of neurologic control.

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