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A Test for Progressive Myopia and the Role of Latent Accommodation in its Development

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Abstract

Purpose: To determine whether those myopes who respond like hyperopes when tested with a multivergence hologram are progressive myopes and to investigate the role of latent accommodation in the development of progressive myopia.

Methods: Recently, we introduced a specially designed hologram to test the vision of spectacle corrected subjects. A subject viewing through this hologram would see the real and virtual images of different test letters at various distances. We observed that some of the *myopes responded like hyperopes* in that test. The current study is designed to see if these myopes were *progressive myopes*. Using data on the spectacle correction measured initially and in later years for the myopes who participated in our studies with the hologram, we calculate the progression rate of myopia. Using progression rate, subjects are classified into progressive and non-progressive myopes. We analyse the data obtained for these subjects in the test with the hologram and propose a test for progressive myopia. We also investigate the role of latent accommodation in the measurement of low ametropia and the development of progressive myopia.

Results: We found that the myopes who respond like hyperopes in the test with the hologram are progressive myopes! Based on this result we propose a test for progressive myopia. Our initial results show that the test has a sensitivity of 54% and a specificity of 100%. Our studies indicate that progressive myopes have some latent accommodation like hyperopes and progressive myopia may be a consequence of incorrect diagnosis/correction of low hyperopia/myopia brought about by the play of latent accommodation.

Conclusions: A vision test with a multivergence hologram can screen progressive myopia. Correct diagnosis of low ametropia using the hologram could prevent myopia progression.

Keywords

Progressive myopia, Myopia, Hyperopia, Emmetropia, Multivergence hologram, Latent accommodation

Introduction

The multivergence hologram is a phase hologram that resembles a transparent glass plate in appearance and contains a holographic record of real and virtual images of various test characters located at different distances from the eye [1]. When this hologram is suitably illuminated with light from a low power He-Ne laser, a subject viewing through the hologram would see test characters of fixed angular size at various distances. In the hologram that we used for the current study, the real images seen through the hologram are located from 1 m in front of the eye to infinity in front of the eye. The range of the virtual images seen through the hologram extends from about 15 cm behind the eye to infinity behind the eye. A *spectacle corrected* subject viewing through this hologram should see the real images of the test characters clearly by exercising their accommodation. The test characters corresponding to the virtual images recorded in the hologram should appear blurred to the subject as a subject cannot exercise negative accommodation. The maximum amount of positive blur in a test character exceeding which the character is not recognized by the subject is defined in our study as the limiting blur of the subject. We measured the limiting blur for various spectacle corrected subjects in an earlier study and found that the limiting blur for hyperopes was about 0.9 D greater than that for myopes [1,2]. This difference was statistically significant. The mean limiting blur for myopes was close to +1 D and for hyperopes it was close to +2.0 D. The mean limiting blur for emmetropes on the other hand was around +1.4 D, a value that lies in between the mean for hyperopes and the mean for myopes. We also observed in our earlier study that some emmetropes responded like myopes and some emmetropes responded like hyperopes. This led us to wonder if the test with the hologram could serve as an indication of the development of myopia/hyperopia. Further, while the mean limiting blur for myopes was around +1 D, it was striking that some of the *myopes responded like hyperopes* with a limiting blur close to +2 D. We therefore wondered if these myopic eyes were also responding like hyperopic eyes in their eye growth. *These myopes may then be progressive myopes*! So we looked at the spectacle correction and the progression rate of myopia in the later years, where it was available, for the myopes who participated in our previous studies with the hologram. We found that the mean limiting blur of progressive myopes was significantly greater than the mean limiting blur of non-progressive myopes by about 0.8D. *None of the non-progressive myopes responded like hyperopes*. This finding suggested that our special hologram could be used to test for progressive myopia. In this paper, we present the test for progressive myopia and the initial results obtained.

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Further, investigation of the results obtained with the multivergence hologram also suggested that progressive myopes have some latent accommodation like hyperopes. In this paper, we discuss the role of latent accommodation in the measurement and correction of ametropia using a phoroptor in the clinic and its possible consequence on the development of progressive myopia. We also present results which show that the hologram could be used to confirm whether a low ametrope measured using a phoroptor in the clinic is a myope or a hyperope. We also found that the hologram is able to classify all subjects into two distinct categories: one with latent accommodation and the other without any latent accommodation. We present the details of these investigations and our findings.

To begin with we briefly outline how the multivergence hologram is recorded and used to test the subject. More details can be obtained from our earlier publications [3,4].

Materials and Methods

The multivergence hologram

The 3-D target that was used to record the multivergence hologram is shown in Figure 1. High contrast upside down mirror images of printed test letters are glued to the end faces of an array of wooden rods. The rods are placed at designed distances from a +20 D lens such that the vergences of the rays leaving the lens from these various test letters are in the range of -6.5 D to +1.0 D in steps of 0.5 D. The character V of the target is designed to be located at the focal plane of the lens. It is therefore imaged at infinity and the vergence of the image rays leaving the lens for this letter is 0 D. The height of each of the letters is designed to subtend an angle of 50' at the lens. The target is illuminated with a diverging beam of laser light derived from a He-Ne laser. The image forming wave fronts emerging from the lens are recorded in a hologram by interference with a plane reference wave derived from the same laser.

The measurement of limiting blur with the hologram

To measure the limiting blur of the subject with the hologram monocularly, the subject is positioned behind the hologram in such a way that his eye is at the same location as the +20 D lens was in the recording geometry. The hologram is illuminated from behind by a plane reference wave that is travelling in the reverse direction to the reference wave that was used while recording the hologram as shown in Figure 2. When the hologram is thus illuminated, the phase conjugate of the recorded waves are recreated in which the image forming rays reversed in direction of propagation emerge from the hologram. The vergence of the rays reaching the eye from the images of the test letters recorded in the hologram would therefore be in the range of +6.5 D to -1.0 D. The plane wave shown in the sketch represents the light coming from the image of the character V formed at infinity. The diverging wave corresponds to the light coming from the real image of a test letter in front of the subject's eye and the converging wave corresponds to the light that is travelling towards the virtual image of a test letter. The test letters corresponding to the converging waves at the eye would appear blurred to the subject. The subject is asked to call out the letters that he can recognize. The vergence corresponding to the letter with the most positive blur that is recognized by the subject, gives a measure of the limiting blur for the subject.

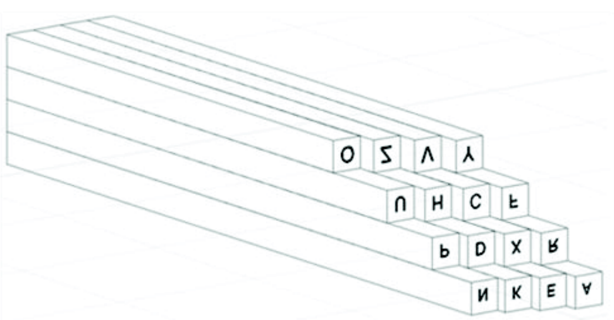

Figure 1: A sketch of the 3-D target that was used to record the hologram

Subjects

The spectacle correction in the later years for 25 myopes who participated in our earlier studies on the measurement of the limiting blur with the multivergence hologram was obtained from clinical records. Ethics approval was obtained from the Human Research Ethics Committee, UNSW Australia. The mean sphere of the spectacle correction (MS) for the myopes was in the range of −0.375 D to −5.5 D. The astigmatism of the subjects included in the study was ≤ 0.5 D. The spectacle correction recorded for the subjects was determined by subjective refraction in the clinic using a phoroptor. The maximum plus lens for best visual acuity was the criterion for the subjective end point. The best corrected visual acuity was 6/7.5 or greater and the subjects had no significant pathology. Using the data obtained from the records, the rate of progression of myopia was calculated for these subjects and the subjects whose progression rate was greater than or equal to −0.20 D per year were classified as progressive myopes and the others as non-progressive myopes.

Results

The test for progressive myopia

The initial mean sphere (MS), age, time elapsed before the next refraction, mean sphere after the time elapsed, the limiting blur that was obtained with the hologram in their first visit and the progression rate of myopia are given in Table 1 for non-progressive myopes and in Table 2 for progressive myopes. The data obtained on the emmetropic subjects are given in Table 3. The pupil size when it was recorded is also included. The measurements were made in a dimly lit room and the pupil size was measured on the fellow eye using the digital pupillometer from NeurOptics (Model 59001).

The limiting blur is plotted against the mean sphere for the non-progressive myopes in Figure 3a and for the progressive myopes in Figure 3b. The mean limiting blur for non-progressive myopes was 0.55 D with a standard deviation of 0.33 D. The mean limiting blur for progressive myopes was 1.32 D with a standard deviation of 0.75 D. Thus the mean limiting blur for the progressive myopes was 0.77 D greater than that for the non-progressive myopes and this difference was statistically significant in a one-tailed t-test with a p value of 0.0018 obtained for unequal variances.

The view obtained through the hologram is simulated for non-progressive myopes in Figure 4a and for progressive myopes in Figure 4b respectively.

The upper limit for the limiting blur of non-progressive myopes at the 95% confidence level is 1.21 D. To test for progressive myopia, if we use the criterion that any subject with a limiting blur greater than 1.21 D is a progressive myope, we see from Table 2 that 7 out of the 13 progressive myopes pass the test satisfying this criterion and would be counted as true positives giving 54% sensitivity for the test. From Table 1 we see that none of the non-progressive myopes satisfy this criterion and would fail the test as true negatives giving 100% specificity for the test.

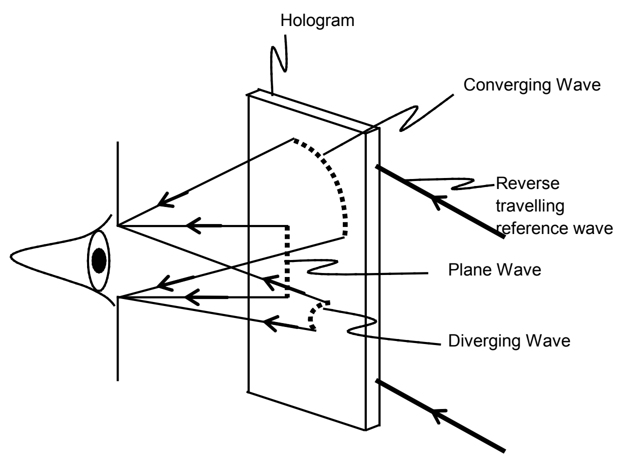

Figure 2: Using the hologram to test vision [2]

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Table 1: Data on the mean sphere measured initially and with a time lapse for non-progressive myopes who participated in the study with the hologram

S No	Initial Age (Years)	Initial Mean Sphere (D)	Time elapsed (Years)	Mean Sphere after time elapsed (D)	Progression rate (D per year)	Limiting Blur (D)	Pupil Size (mm)
1	38	-0.375	1.92	-0.50	-0.07	0.07	6.1
2	33	-0.375	4.06	-0.75	-0.09	0.59	-
3	35	-0.5	1.74	-0.50	0	0.96	4.1
4	19	-0.5	4.34	-1.25	-0.17	0.46	-
5	8	-0.75	2.67	-1.125	-0.14	0.46	6
6	18	-1.375	2.58	-1.50	-0.05	1.01	-
7	11	-2.75	3.71	-3.25	-0.13	0.46	7.3
8	17	-3.125	1.1	-3.125	0	1.01	7
9	28	-3.375	1	-3.375	0	0.59	5
10	17	-4.375	2.95	-4.375	0	0.59	-
11	25	-5.25	2.08	-5.5	-0.12	-0.06	6.9
12	25	-5.5	2.08	-5.625	-0.06	0.46	6.7
Mean:	**22.8**	**-2.35**	**2.57**	**-2.76**	**-0.07**	**0.55**	**6.1**
Std Dev:	**9.5**	**1.96**	**1.12**	**1.86**	**0.06**	**0.33**	**1.1**

Table 2: Data on the mean sphere measured initially and with a time lapse for progressive myopes who participated in the study with the hologram

S No	Initial Age (Years)	Initial Mean Sphere (D)	Time elapsed (Years)	Mean Sphere after time elapsed (D)	Progression rate of Myopia (D per year)	Limiting Blur (D)	Pupil Size (mm)
1	8	-0.375	2.95	-3.25	-0.98	0.59	6.7
2	10	-0.75	3.2	-1.625	-0.27	0.46	6.5
3	14	-1	1.2	-1.75	-0.62	1.38	-
4	11	-1.125	3.75	-3.00	-0.5	0.59	8.3
5	9	-1.25	3.4	-4.00	-0.81	0.46	7.4
6	13	-1.375	4.07	-4.00	-0.64	1.26	6.7
7	18	-1.375	4.11	-2.5	-0.27	0.59	7.2
8	13	-1.5	3.73	-2.25	-0.2	1.95	7.2
9	15	-1.625	3.92	-5.00	-0.86	2.44	5
10	16	-2.375	0.97	-2.75	-0.39	2.08	7.4
11	11	-3	0.93	-3.5	-0.54	1.13	6.5
12	23	-3.75	3.85	-4.75	-0.26	1.95	5.8
13	15	-4	3.3	-5.5	-0.45	2.32	6.5
Mean:	**13.5**	**-1.81**	**3.03**	**-3.38**	**-0.52**	**1.32**	**6.8**
Std Dev:	**4.1**	**1.13**	**1.19**	**1.23**	**0.25**	**0.75**	**0.8**

Table 3: Data on the mean sphere measured initially and with a time lapse for emmetropes who participated in the study with the hologram

S No	Age (Years)	Initial Mean Sphere (D)	Time elapsed (Years)	Mean Sphere after time elapsed (D)	Progression rate (D per year)	Limiting Blur (D)	Pupil Size (mm)
1	13	0	4.25	-0.125	-0.03	0.46	6.7
2	38	-0.25	2	-0.375	-0.07	0.88	5.8
3	17	-0.25	3.36	-0.50	-0.07	0.88	6.5
4	37	0.25	3.67	0.375	0.03	0.63	-
5	48	-0.125	3.17	0.125	0.08	1.01	-
6	23	-0.25	3.08	-0.25	0.00	0.88	4
7	24	0.25	4.97	-0.375	-0.13	0.46	-
8	28	0	1.4	0	0.00	0.88	-
9	30	0	3.08	0	0.00	1.95	4.5
10	11	0	4.17	-1.875	-0.45	1.95	5
11	50	0.25	1.08	0.50	0.23	2.07	-
Mean:	**29**	**-0.01**	**3.11**	**-0.23**	**-0.04**	**1.1**	**5.4**
Std.Dev:	**13.2**	**0.2**	**1.21**	**0.63**	**0.17**	**0.6**	**1.1**

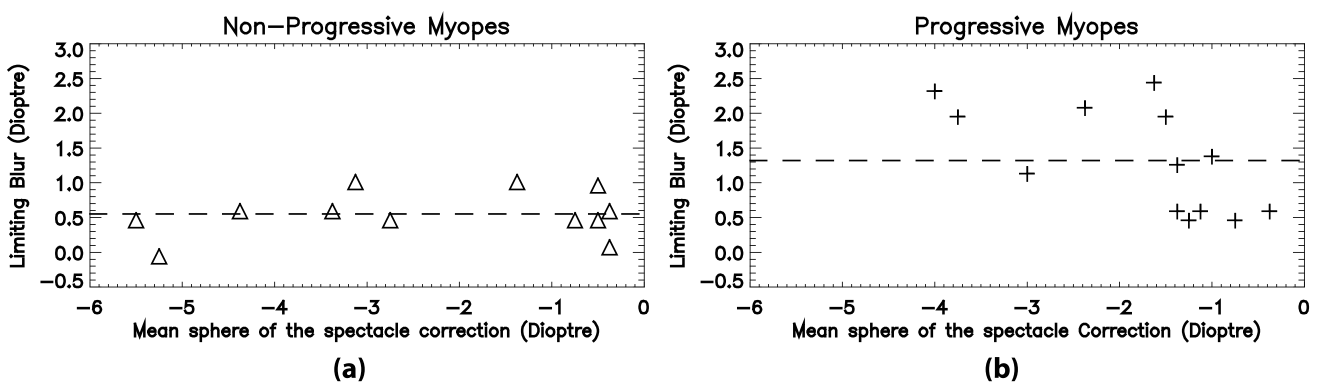


Figure 3: a) Plot of the limiting blur vs the mean sphere of the spectacle correction for non-progressive myopes. The dashed line indicates the mean limiting blur b) Plot of the limiting blur vs the mean sphere of the spectacle correction for progressive myopes. The dashed line indicates the mean limiting blur.

Table 4: Data obtained with the hologram for Myopes

Serial Number	Age (years)	Mean Sphere of the spectacle correction (Dioptre)	Number with most positive vergence recognized	Limiting Blur through the Hologram (Dioptre)
1	25	-7.625	2	1.005
2	11	-3.25	4	1.95
3	19	-3.25	3	1.38
4	11	-2.875	1	0.585
5	31	-2.375	1	0.585
6	20	-2.25	2	0.88
7	11	-1.5	3	1.38
8	17	-1.375	1	0.585
9	18	-1.375	2	1.005
10	29	-1.25	2	0.88
11	35	-1.25	4	1.95
12	32	-1.125	3	1.505
13	14	-1	3	1.38
14	21	-1	2	0.88
15	46	-0.75	4	1.95
16	19	-0.5	1	0.46
17	42	-0.5	2	0.88
18	33	-0.375	1	0.585
19	35	-0.375	2	0.88

Mean: 1.09 D

Std Dev: 0.488 D

Reproduced from [1], Table-2, P1177

Table 5: Data obtained with the hologram for Hyperopes

Serial Number	Age (years)	Mean Sphere of the spectacle correction (Dioptre)	Number with most positive vergence recognized	Limiting Blur through the Hologram (Dioptre)
1	12	0.375	4	2.075
2	51	0.375	5	2.445
3	10	0.5	4	1.95
4	13	0.5	5	2.32
5	43	0.5	2	0.88
6	57	0.5	4	1.95
7	51	0.625	4	2.075
8	45	0.75	4	1.95
9	40	1	4	1.95
10	58	1.125	2	1.005
11	38	1.25	5	2.32
12	15	1.5	2	0.88
13	51	1.75	4	1.95
14	51	1.75	5	2.32
15	50	2.125	4	2.075
16	52	2.25	5	2.32
17	55	2.25	5	2.32
18	55	2.25	5	2.32
19	28	4.25	5	2.32

Mean: 1.97 D

Std Dev: 0.50 D

Reproduced from [1], Table-3, P1177

Table 6: Data obtained with the hologram for Emmetropes

Serial Number	Age (years)	Mean Sphere of the spectacle correction (Dioptre)	Number with most positive vergence recognized	Limiting Blur through the Hologram (Dioptre)
1	46	-0.25	4	1.95
2	49	-0.25	4	1.95
3	9	0	1	0.46
4	13	0	2	0.88
5	26	0	2	0.88
6	28	0	2	0.88
7	33	0	4	1.95
8	9	0	1	0.46
9	15	0	4	1.95
10	17	0	2	0.88
11	11	0.25	5	2.32
12	13	0.25	4	1.95
13	25	0.25	1	0.46
14	52	0.25	4	1.95
15	53	0.25	4	1.95
16	56	0.25	3	1.38
17	16	0.25	1	0.46
18	15	0.25	4	1.95

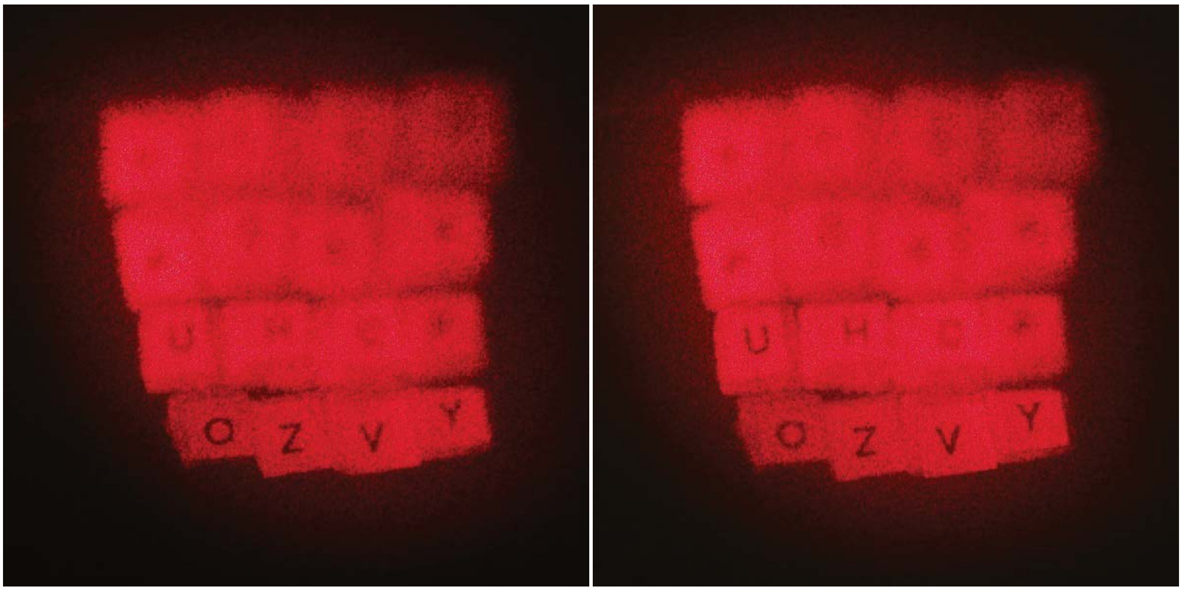
Mean: 1.37 D

Std Dev: 0.68 D

Reproduced from [1], Table-4, P1178

Discussions

Our earlier studies with the multivergence hologram had indicated that for hyperopes viewing a multivergence target or a test chart at infinity in a hologram the latent accommodation is not in play [2,4]. In the current study as we have found the progressive myopes to respond like hyperopes in viewing through the hologram we wonder if progressive myopes are indeed hyperopes who have been initially misdiagnosed as myopes due to their latent accommodation.



(a) (b)

Figure 4: Simulation of the view through the hologram for **a)** non-progressive myopes **b)** progressive myopes.

Accommodation during refraction and the phoropter

In the past, Reese and Fry [5] had found that in the refraction process using the phoroptor in the clinic it is *ostensibly* assumed that subjects relax their accommodation through the fogging lenses. They found that positive lenses used for fogging need not necessarily relax a subject's accommodation. It follows then that this could result in an emmetropic or a low hyperopic subject being measured as a low myope, or, a more myopic error being measured for a low myope. Further, the coefficient of repeatability for subjective refraction performed by two different examiners on 86 subjects has been reported to be about 0.76 D in the literature [6]. So we believe that the refractive error measured using a phoroptor could be in error especially in the diagnosis of low ametropes.

Hologram for the classification of low ametropes

In our earlier study with the multivergence hologram [1], when we found that the mean limiting blur of hyperopes was greater than that of myopes by about 0.9 D, the p value for the mean difference was found to be 0.0000015 in a one-tailed t-test. Data from this earlier study is reproduced in Tables 4-6. Subjects with refractive error of ± 0.25 D obtained using the phoropter were classified as emmetropes in that study. However, if these low ametropes are classified into myopes and hyperopes (i.e. the −0.25 D emmetropes included with the myopes and the +0.25 D emmetropes included with the hyperopes) the p value for the mean difference falls to 0.00007 and the mean difference falls to 0.67 D. If instead, *the limiting blur obtained with the hologram is used to classify* the emmetropic subjects into myopes and hyperopes (i. e., the emmetropes whose limiting blur is less than 1.21 D as myopes and the emmetropes whose limiting blur is greater than 1.21 D as hyperopes), the p value improves to 0.000000023 and the mean difference remains close to 0.9 D and is equal to 0.93 D. This suggests that the hologram may offer an improved way of identifying a *low ametrope* as a myope or a hyperope.

Latent accommodation and measured refractive error

Let us consider the following examples:

- A +2 D hyperopic subject accommodating by +1 D when measured with the phoroptor. This would result in a +1 D lens being prescribed for the +2 D hyperope which implies +1 D of under correction.
- A +0.5 D hyperopic subject accommodating by +1 D when measured with the phoroptor. This would result in a −0.5 D lens being prescribed for the +0.5 D hyperope which implies +1 D of under correction.

In the former case, a less positive lens is given to a hyperopic subject. When this subject lets go of his +1 D of accommodation he will be left with +1 D of hyperopia. The image of a distant object will then be formed behind the retina, but the error will be only half as much as when he went for correction. This is not disastrous.

In the latter case, a negative lens is given to a hyperopic subject. When this subject lets go of his +1 D of accommodation he will be left with +1 D of hyperopia due to the – 0.5 D lens correction that is given to him. This leaves him with twice the error he had initially, giving a feedback signal that is twice as strong for eye growth. Being hyperopic, their eyes are inclined to grow longer. May be the latter hyperopic subject becomes a progressive myope?

The unknowns when refractive error is measured with a phoroptor are the latent accommodation, and the accommodation response of individual subjects to fogging lenses. A low hyperope stands a greater chance of receiving a *negative* correction due to his/her latent accommodation. Giving a negative correction to a hyperopic subject would enhance the hyperopic defocus, and hyperopic defocus is known to encourage eye growth [7]. Providing a negative lens would upset the feedback loop in a hyperope and could eventually lead to a loss of control over the mechanism [8,9] that triggers eye growth. It thus seems possible that progressive myopia could result from hyperopes being driven to myopia! Negative and positive lenses over the eyes have been shown to affect eye growth [10]. The probability of the above error taking place is quite high considering that most children under 10 years of age are hyperopic and that the eye can grow up to the age of thirteen [11]. The fear of the child becoming a progressive myope and the parents' concern for the child in this regard could promote more children to go for correction when it may not be needed [12,13]. Although emmetropization occurs in early development, changes in eye growth could occur in young adults as well [14].

The multivergence hologram could be used to test subjects of all age groups to check if they have vision like hyperopes or vision

Table 7: Correlation of Age, Pupil size, and Refractive error with the limiting blur for progressive and non-progressive myopes

	Pearson Correlation Coeff. *r*, *p* value of *r*	
	Progressive Myopes	**Non Progressive Myopes**
Age and limiting blur	0.57, 0.02	-0.16, 0.62
Pupil size and limiting blur	-0.52, 0.04	-0.37, 0.18
Refractive error and limiting blur	-0.63, 0.01	0.23, 0.47

like myopes. The authors believe that environmental factors would become a minor issue in myopia progression if low ametropia is identified correctly. The brain has remarkable ability to cope with a wide range of lighting for example. On the other hand the brain could be easily confused if incorrect prescription however small is prescribed especially to growing children [9,10]. This view is supported by the fact that the literature is divided when it comes to environmental influences [13], but there is strong evidence on the progression of myopia and eye growth with incorrect lenses given to the eyes in the animal models [15].

Discussion on the results obtained with emmetropes

The refractive error data obtained on the emmetropic subjects pursued in later years is shown in Table 3. The first 8 subjects responded with low limiting blur, and their refractive error is stable confirming the high specificity of the test. The last three subjects responded with *high limiting blur*. One is a young subject (11 year old) who was measured with 0 D refractive error in his first visit and who is developing into a progressive myope. The 50 year old subject is a +0.25 D hyperope with a positive progression rate, indicating the emergence of latent hyperopia. The 30 year old emmetrope could be a latent hyperope based on his response to the hologram and could possibly need reading glasses earlier than normal as it happened for one of the authors. It is possible that the 11 year old subject was a latent hyperope who was diagnosed as a 0 D emmetrope in his first visit when he was also tested with the hologram. This subject was measured as having −1.875 D of myopia four years later. We don't know when this subject was first prescribed a negative lens. Rendering a small negative lens correction to this subject between the two visits may possibly have induced progressive myopia.

Latent accommodation and progressive myopia

If a hyperope is diagnosed as a myope incorrectly and prescribed a negative lens then he will need to accommodate more in doing near tasks. He would also become more weary while doing near tasks with the result that the sharp image would frequently be formed behind the retina signalling the brain for eye growth, leading to progressive myopia. Our earlier study indicated that the latent accommodation is responsible for the large limiting blur of hyperopes. As some progressive myopes show large limiting blur like that of hyperopes, it appears that progressive myopes *do* have latent accommodation similar to hyperopes. One could then expect some correlation of age, pupil size, and refractive error with the limiting blur for the progressive myopes as accommodation is correlated to these factors. A significant medium correlation was obtained for progressive myopes which was not observed for non-progressive myopes (Table 7).

The fact that atropine which arrests the accommodative ability of a subject temporarily serves as a deterrent in the development of progressive myopia [16] lends support to the idea that progressive myopes have some latent accommodation similar to hyperopes.

Classification of subjects based on limiting blur

It appears that the hologram is able to differentiate between subjects who have some latent accommodation and subjects who have no latent accommodation based on their limiting blur, irrespective of their refractive status. If we consider the data on the limiting blur that we obtained for various subjects in our earlier study (reproduced in Tables 4-6), and classify *all* the subjects based on the limiting blur into two groups, one having a high limiting blur (>1.21 D), and the other having a low limiting blur (<1.21 D), 33 subjects are found to have a high limiting blur, and 23 subjects are found to have a low limiting blur. The mean value of the high limiting blur is 1.98 D with a standard deviation of 0.3 D. The mean value of the low limiting blur is 0.75 D with a standard deviation of 0.2 D. The mean difference between the high limiting blur and the low limiting blur is 1.23 D with a p value of zero (3.7×10^{-25}). This difference perhaps gives a measure of the mean level of the latent accommodation when it is present, for subjects who show hyperope like vision when tested with the hologram. These results also suggest that any given subject has a vision characterised by low limiting blur (no latent accommodation) or characterised by high limiting blur (indicative of latent accommodation).

Progressive myopia and overcorrected myopes

We have used progression rate to define progressive and non-progressive myopia in this study. As some of the myopes classified as progressive myopes by this definition did not show hyperopic level of limiting blur in the test with the hologram, it may be that these myopes were overcorrected *myopes* who were rendered artificially hyperopic. These myopes would then experience hyperopic defocus which could eventually trigger progressive myopia. It is also possible that these myopes are in the process of developing some latent accommodation due to the constant accommodation resulting from overcorrection. This might show up as high limiting blur in the test with the hologram when their refractive error goes beyond −1.5 D, a value close in magnitude to the suspected mean level of latent accommodation of 1.23 D that was obtained in the previous section. Looking more closely at Table 2 or Figure 3b we see that all the progressive myopes whose myopia was greater than −1.5 D responded with a high level of limiting blur. Therefore it is possible that −1.5 D is close to the turning point for the progression of myopia for the overcorrected myopes. Alternatively, even though these subjects show high progression rate, their refractive error in the later years may stabilise and they may turn out to be non-progressive myopes. A retest with the hologram when the second refraction was carried out would have helped resolve this further, but is currently beyond the scope of this study. These observations and findings can be confirmed with further research.

Conclusions

Currently, there is no test which can predict which subject diagnosed as a myope would become a progressive myope. The multivergence hologram can be used to test for progressive myopia. Initial results indicate a sensitivity of 54% and a specificity of 100% for the test.

Our results suggest that progressive myopes have some latent accommodation like hyperopes and that progressive myopia could result from incorrect diagnosis of hyperopia as myopia brought about by the play of latent accommodation. Progressive myopia could also result from overcorrection of low myopes. Hence progressive myopia may be preventable by correct diagnosis of low hyperopia/myopia. Our studies also show that the hologram can help diagnose low ametropia correctly. Based on our findings we suggest that if a subject, diagnosed in the clinic using the phoroptor as a low myope (−0.25 D to −1.00 D) responds as a true positive in the test with the hologram, then no corrective lenses be prescribed to the subject. Alternative preventive measures may include cycloplegic refraction and closer follow ups. For higher myopes, we suggest under correction when they respond as true positives. Under correction has been shown to slow down the progression of myopia [17,18]. However the literature is divided on the role of under correction in slowing down myopia progression [19]. It is possible that the role of under correction in slowing down progressive myopia may prove to be significant if it is tried only on those classified as progressive myopes by the test with the hologram.

It is interesting that the hologram is able to divide all the subjects significantly into two distinct groups, irrespective of their refractive error: one having high limiting blur (indicative of subjects having latent accommodation) and the other having low limiting blur (indicative of subjects having no latent accommodation). Further research with the multivergence hologram would prove to be very useful in gaining an understanding of the nature of latent accommodation.

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