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Measurement accuracy in accommodative response by the Nott method

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ABSTRACT

The measurement of accommodative response is usually performed by means of the Nott method. The accommodative response values were obtained as described in the bibliography and considering that the neutralizing lens shapes the target image. The values in accommodative response differ according to the calculation method utilized.

The accommodation and convergence values when the target is placed 40 cm away from the glasses are not the same in emmetropic and ametropic subjects. At the position of the effective binocular object, the initial values are indeed the same for both types of subjects. Comparing with experimental measurements using the Monocular Estimate Method (Mem), it was obtained the same values given the effect of the neutralizing lens.

Optimizing the Nott method would require placing the target at a position where the effective binocular object is 40 cm. Furthermore, the effect of the neutralizing lens should be considered in the calculation method.

Keywords

Accommodative response; accommodative stimulus; lag of accommodation; lead of accommodation; effective binocular object

INTRODUCTION

The dioptric value of accommodation depends on the distance at which the fixed object (accommodative stimulus) is located and on refraction (R). Nevertheless, it is well known that the accommodation implemented by the eye (accommodative response) does not exactly correspond to the value of the aforesaid stimulus[1,2].

One of the methods most commonly used to measure this difference objectively is the Nott method, based on dynamic retinoscopy[3,4]. The Nott method is utilized in Optometry to determine the accommodative response (in diopters) when looking at a fixation target placed at a distance of 40 cm[5]. Analyzing the application of this technique within the set of accommodative and binocular targets can help identify the existence or the absence of some type of binocular vision dysfunction[6,7]. Based on this evaluation, the optometrist has to decide the type of lenses to be prescribed or whether it is advisable to carry out visual therapy, for which the assessment of this measure must necessarily be correct. The method is applied presenting a target (T) in near vision at a distance of 40 cm, measured from the glasses or the phoropter. In these conditions, the accumulative stimulus is supposed to be 2.50D, and convergence, 2.50 MA (metre angle)[2]. When the eye is emmetropic and consequently lacks lenses, this could arguably be true if the 40 cm distance were measured from the eye to the target.

However, the fact that the origin of distances is at the glasses already causes a change in these values, even in emmetropic subjects, since the origin of distances should be the anterior principal plane of the eye[8]. Moreover, accommodation and convergence under these conditions in neutralized ametropic subjects is not the same either, due to the effect of the neutralizing lens[9,10].

The approximations are usually made in both experimental measurements and theoretical calculations for the final value. Some authors obtain the value of accommodative response using different methods, for instance in studies over the dynamic retinoscopy techniques[11-15], analyzing the accommodative response[16-19] and the influence of factors such as age and refractive errors in the accommodation[20] or presbyopia[21]. Nevertheless neither of this studies change the measurement protocol and the method of calculation. For this reason, it seems advisable to study whether the error made in these approximations has some bearing on the final test assessment.

Two important considerations need to be put forward at this stage. Firstly, the image shaping carried out by the lens provides a target image (T'), which is the accommodative stimulus for the eye. Secondly, a compensated ametropic subject does not converge on the target plane, since each lens shapes an image of the target and the projection of both gives rise to the so-called 'effective binocular object,' which lies on another convergence plane. The effective binocular object is defined as a hypothetical object that would require the same binocular rotations for fixation, with the eyes lacking lenses, than the real objects visualized through lenses[10].

The dioptric value of accommodative stimulus, as well as the distance at which the effective binocular object is located will depend on the power of the neutralizing lens (P_{NL}). Therefore, the initial accommodation and convergence conditions in which the target takes place are not the same in ametropic and emmetropic subjects[22,23].

Returning to the Nott method, there is an additional need to consider lack of accuracy in the mathematical calculation performed from the experimental measurement, so that the difference between accommodative stimulus and accommodative response can be obtained. In the Nott method (neutral point distance x_{NP}) the accommodative stimulus lies at the position where the target's image is obtained through the lens (T') and the accommodative response does not occur on the retinoscope plane, if not in the position where its image is located through the neutralizing lens ($x_{NP'}$)[10].

Our aim consists in evaluating the extent to which all these considerations affect the result of applying the Nott optometric technique. The same as in any other optometric examination test the results obtained are compared with a normality pattern, which makes it possible to assess the optometric case. In general, the norms utilized in the different accommodative and binocular tests tend to be determined from emmetropic population groups; hence our conviction about the importance of analyzing whether normality patterns can be used in ametropic subjects too without having to introduce modifications in the measurement and calculation methods or, instead, a specific protocol is needed for these populations.

METHODS

1- Initial accommodation and convergence conditions in the Nott measurement

As mentioned above, if the target is placed at the same distance for emmetropic and ametropic subjects, the dioptric value of the initial accommodative stimulus and convergence is not exactly the same in every subject.

Firstly, we verify the influence of the neutralizing lens on accommodation and convergence values when the target is placed 40 cm away from the glasses. A calculation was made both of the accommodative stimulus (A_N), and of convergence C in metre angles (MA), for different refraction values R, i.e. for different neutralizing lens power values. A 12 mm lens-eye distance was considered in both cases –measured from the image principal plane of the lens to the eye's vertex.

Accommodation at the position where the accommodative stimulus is located depends on eye refraction and on the position of the test intermediate image through the lens-eye optical system ($A_N = R^{Hoc} - X'^{Hoc}$), where H_{oc} indicates that the measurement is carried out from the object principal plane of the eye. The superscripts below reflect the origin of distances, when that origin is not the corneal vertex. The A_N value can be obtained through equation 1[8].

$$A_N = \frac{X^{Hoc}(1 + \delta_V^{Hoc} \cdot R^{Hoc})^2}{X^{Hoc}(\delta_V^{Hoc})^2 \cdot R^{Hoc} - 1} \qquad \text{eq (1)}$$

where X^{Hoc} is the inverse of the distance to the target measured from the anterior principal plane of the eye; and $\delta_V^{Hoc} = \overline{H_{oc}H'_L}$ (back vertex distance), is the distance from H_{oc} to the posterior principal plane H'_L of the neutralizing lens.

The position of the effective binocular object x_B was obtained in function of neutralizing lens power values with the aim of calculating the value of convergence with neutralizing lenses[10]:

$$x_B = x - x^G \cdot q^G \cdot P_{NL} \qquad \text{eq (2)}$$

where x_B is the position of the effective binocular object measured from the corneal vertex; x is the distance to the object (target) measured from the corneal vertex; x^G is the distance to the object measured from the neutralizing lens; and q^G, the distance from the neutralizing lens to the eyes' rotation center (q^G= 25.5 mm).

Convergence C (in MA) was calculated as the inverse in meters of the distance to the effective binocular object[10]:

$$C = \frac{1}{x_B} \qquad \text{eq (3)}$$

Secondly, the conclusion was reached that the accommodative stimulus –as well as convergence– had to be the same for ametropic and emmetropic subjects in order to optimize the procedure to measure accommodative response using the Nott method. For this purpose, the target must be placed at a distance where the effective binocular object is 40 cm away from the neutralizing lens. The convergence value will thus become independent of refraction, taking a value of 2.35 MA in all cases. The accommodative stimulus value (A_N) in such conditions should be 2.42D for all refractions, insofar as this is its value in emmetropic subjects when the target is placed 40 cm away from the neutralizing lens. As will be seen later on, it is not always possible to obtain exactly this value.

The value of x^G in equation 2 (distance to the target measured from the neutralizing lens) was found seeking to obtain the distance at which the target has to be placed for the different P_{NL} values. The distances obtained can serve as a reference to determine the accommodative stimulus for a variety of P_{NL} values using equation 1.

2- Calculation of the accommodative stimulus/ accommodative response

Both in literature and in usual clinical practice, this calculation is performed considering that, when the target is placed at 40 cm: a) the accommodative stimulus is 2.50D; and b) the accommodative response will correspond to the dioptric value of the distance at which the neutral point is observed with the retinoscope (NP), measured from the spectacle plane or phoropter. The lag (>0) or lead (<0) of accommodation, i.e. the difference between stimulus and response, is consequently calculated as[3,23,24]:

$$\text{Lag or Lead} = 2.50 - \frac{1}{\left|d^G_{NP}\right|} \qquad \text{eq (4)}$$

where d^G_{NP} is the distance from the spectacle plane (or phoropter) to the retinoscope when the latter is placed at the neutral point position.

Our proposal to carry out this calculation more accurately stems from considering that the accommodation performed at the position of the accommodative stimulus (T') for an ametropic subject is obtained from equation 1. Similarly, the accommodative response does not occur at the neutral point position (NP) but at the image of that position through the neutralizing lens (NP') (see Figure 1). Therefore, the Nott value should be calculated as the difference between the accommodation values corresponding to the NP' and T' positions.

The calculations specified below, for an ametropic subject, were carried out with the aim of quantifying the significance of the error made for this reason:

a) Achievement of the target image (T) and of the neutral point position in the retinoscope (NP) through the neutralizing lens, (T' and NP', see Figure 1), applying the Gauss equation.

b) Calculation of accommodative stimulus in T' ($A_{T'}$). Using the distance to T' measured from the anterior principal plane of the eye: $x_{T'}^{Hoc} = x_{T'}^{G} - 0.01359$ and taking into account that the lens-eye distance is 12 mm and the distance from the corneal vertex to the anterior principal plane is 1.59 mm (Le Grand's theoretical model):

$$A_{T'} = R - \frac{1}{x_{T'}^{Hoc}} \qquad \text{eq (5)}$$

c) Calculation of accommodative response ($A_{NP'}$). In this case, using the distance to NP' also measured from the anterior principal plane of the eye $x_{NP'}^{Hoc} = x_{NP'}^{G} - 0.01359$:

$$A_{NP'} = R - \frac{1}{x_{NP'}^{'Hoc}} \qquad \text{eq (6)}$$

d) Calculation of accommodative response (Nott value) that will be compared with equation 4, corresponding to the common calculation[3]:

$$Nott_N = A_{T'} - A_{NP'} = \frac{1}{x_{NP'}^{Hoc}} - \frac{1}{x_{T'}^{Hoc}} \qquad \text{eq (7)}$$

RESULTS

1- Initial accommodation and convergence conditions in the Nott measurement

Table 1 shows the results obtained for accommodation values –both in myopic and in hypermetropic subjects– at the position of the accommodative stimulus and the convergence when the target is placed in all observers at 40 cm measured from the glasses or phoropter. Therefore, those would be the initial conditions of the Nott method in each case (equations 1 and 3).

[Table 1 near here]

It can be observed that accommodation and convergence do not take the values 2.50D and 2.50 MA for emmetropic subjects. In the case of accommodation, since the distance is measured from the anterior principal plane of the eye in equation 1, the accommodative stimulus turns out to be 2.42D. As for convergence, being calculated as the inverse of the distance to the effective binocular object, measured from the eyes' rotation center, it takes a value of 2.35 MA.

Accommodation and convergence values vary for the different P_{NL} values calculated both in myopic and in hypermetropic subjects. Correlation exists between accommodation and convergence values for a single P_{NL} value, but these are not the same ones that an emmetropic subject would have. The starting conditions when the binocular optometric tests are performed placing the target 40 cm away from the glasses will consequently differ.

As refraction (or P_{NL}) increases, the accommodative stimulus value for myopic subjects decreases –whereas it increases for hypermetropic subjects. In relation to convergence, it decreases with higher P_{NL} in myopic subjects but does the opposite in hypermetropic ones. For P_{NL}= -10D, this decrease would amount to 0.54D and, for P_{NL}=+10D, the stimulus would be 3.22D –that is, a 0.8D difference.

To ensure that the initial conditions for the application of this technique are the same, our proposal consists in placing the target in a position where the effective binocular object is 40 cm away from the neutralizing lens. Table 2 reflects those distances together with the accommodative stimulus values (A_N) for each case. Convergence would always have a 2.35 MA value.

[Table 2 near here]

As can be checked in Table 2, if the target position is changed according to the P_{NL}, the accommodation and convergence values in all cases are practically the same to those of an emmetropic subject. Differences do not exceed 0.12D.

2- Calculation of the accommodative stimulus/accommodative response

Our attention will now focus on the error due to the calculation by means of which the final value of the Nott test is obtained from the experimental measurement.

Tables 3 and 4 list the values obtained using the approximate calculation $Nott_{approx}$ described in the bibliography (equation 4) and the values, which would be obtained considering the position of intermediate images $Nott_N$ (equation 7). Table 3 shows the results in emmetropic and myopic subjects, while Table 4 does so for hypermetropic subjects, for different neutral points $\left|d_{NP}^{G}\right|$, in absolute value and measured from the glasses.

[Tables 3 and 4 near here]

According to the bibliography, normal values are considered for Nott: +0.50D±0.25D[1-4]. These $Nott_{approx}$ values are highlighted with a double line in the tables. The results of calculations are presented approximated to 0.25D seeking to facilitate the comparison with normal values. As can be checked, most of the values obtained using these two methods do not coincide.

In the case of emmetropic and myopic subjects (Table 3), for $\left|d_{NL}^{G}\right|$ between 45 and 60 cm, all values lie within the norm for the test. Hence why, even though the obtained value is approximate, the interpretation of the test would be correct in these cases. However, there are other examples of $\left|d_{NL}^{G}\right|$ where the test assessment would differ depending on whether $Nott_{approx}$ or $Nott_N$ is considered. By way of example, for a P_{NL}= -2D if $\left|d_{NL}^{G}\right|$=65 cm, $Nott_{approx}$ would be outside the norm (1D), whereas $Nott_N$ would lie inside the norm (0.75D). The higher the P_{NL} value, the greater the differences found. For a P_{NL}= -10D, if the neutral point is located at 75 cm, the $Nott_{approx}$ value would be 1.25D (outside the norm) and that of $Nott_N$, 0.75D (inside the norm); which means a 0.5D difference.

There are also results which would be interpreted correctly for being inside the norm in both cases when it comes to hypermetropic subjects (Table 4). Once again, other values exist for which the interpretation changes according to the calculation method used, the differences increasing in parallel with P_{NL}. For instance, for $\left|d_{NP}^{G}\right|$= 60 cm, the $Nott_{approx}$ value is 0.75D (inside the norm);

instead, for P_{NL}=+4D, the $Nott_N$ value would be 1D, and for a P_{NL}=+13D, the lag would be 1.25D. Therefore, this would mean considering a measurement which lies clearly outside the norm as being inside it.

Both tables contain values where $Nott_{approx}$ and $Nott_N$ equally lie outside the norm, which is why the test would be interpreted in the same way in the two cases. Now then, quantifying the lag or lead of accommodation may result in errors when comparing it with the normal values, insofar as values exist for which differences reach up to 0.75D. That is why it could be considered that the test goes further from the normal values than it really is or just the opposite.

3- Experimental verification with the Mem method

In addition to the Nott method, the accommodative response value is usually obtained using the Mem method –also based on skiascopy. The difference between these two methods lies in the way to obtain the neutral point, since the observation distance is modified in Nott and lenses are used in Mem. The following experience was carried out for the purpose of comparing the values obtained in both methods.

The difference between accommodative stimulus and accommodative response was measured both with the Mem method and with the Nott method for a population of 38 subjects. All the subjects measured were aged between 20 and 22 and showed no type of binocular dysfunction. The refractive state of the group under study was: 3 emmetropic eyes; 4 hypermetropic ones (+0.25D) and 31 myopic with refractions ranging between -0.25 and -6.75D. The astigmatism value did not exceed 1D. The study adheres to the tenets of the Declaration of Helsinki for Research Involving Human Observers.

The average value of all the measures–with their standard deviation– was obtained for Mem as well as for Nott (see Table 5). In the Nott method, a calculation was made both for the values obtained using the approximate calculation ($Nott_{approx}$) (equation 4) and for the values obtained considering the position of the intermediate images ($Nott_N$) (equation 7). For astigmatic subjects, the $Nott_N$ value varies according to the refraction of the principal meridians; that is why the value taken corresponds to the average value of the principal meridians. These differences were never above 0.1D.

[Table 5 near here]

The Mem and $Nott_{approx}$ values differ in 0.19D, the value obtained for $Nott_{approx}$ being higher. When the calculation is performed considering the position of the intermediate image, the $Nottt_N$ value is closer to that of Mem, both of them being very similar according to the literature (+0.50D±0.25D). [2]

Although the variations in the values found for Mem, $Nott_{approx}$ and $Nott_N$ do not seem relevant, the individual differences can actually lead to a misinterpretation of the measurement, especially in the Nott method. For example, one of the subjects with refraction (-5.00) (-1.00) 180º, obtained Mem=+0.75D, Not_{approx}=+1.07D and $Nott_N$=+0.70D. If the Mem or the $Nott_N$ value is used to assess the measurement, the latter would be inside the norm, but the value would be outside the norm if the Not_{approx} value is used to perform the measurement.

DISCUSSION AND CONCLUSIONS

The measurement protocol to evaluate the lag of accommodation or the lead of accommodation value using the Nott method should take into account a number of considerations. Attention should be paid to the effect of the neutralizing lens on the eye, both in measurement taking and in the calculations performed to obtain the final value of the test, insofar as failing to do so may lead to an erroneous result interpretation.

Firstly, the target should be placed at a distance where the effective binocular object is 40 cm away from the neutralizing lens (equation 2). The initial conditions for convergence and accommodation would be the same for emmetropic and ametropic subject if one considers that the accommodative stimulus value (T ') is the target image through the neutralizing lens.

Secondly, the accommodative response would take place at the distance in which the retinoscope image lies (NP', through the neutralizing lens) when the neutral point is located.

The Nott value would then be obtained using equation (7), as the difference between accommodative stimulus (in T') and accommodative response (NP'), both of them measured from the eyes' principal planes.

The differences between the measure obtained without taking into account these considerations and the one obtained following our proposal can reach values of up to 0.5D in myopias and up to 0.75D for some of the hypermetropic refractions studied. For this reason, the diagnosis based on the Nott method would not be reliable in such cases, within the margins established for normal values.

In order to optimize the time of completion of the test, the optometrist can prepare, in advance, tables where you could get the value of $Nott_N$ from the values of the P_{NL} and the position of the neutral point. Table 6 is a sample design. The complete tables with all P_{NL} values are made in steps of 0.25D (available from the authors). For basic optometric graduation the values can be found in Tables 3 and 4, you can be used Table 2 in order to know the distance it is recommended to place the target.

[Table 6 near here]

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FIGURE LEGENDS

Figure 1. Nott Method. The target (T) is placed 40 cm away from the neutralizing lens (P_{NL}). The accommodative stimulus for the eye would be situated at the target image through the P_{LN} (T'). Even though the retinoscope in the neutral point position would be at the NP, the accommodative response occurs at the position where the retinoscope image is located (NP').

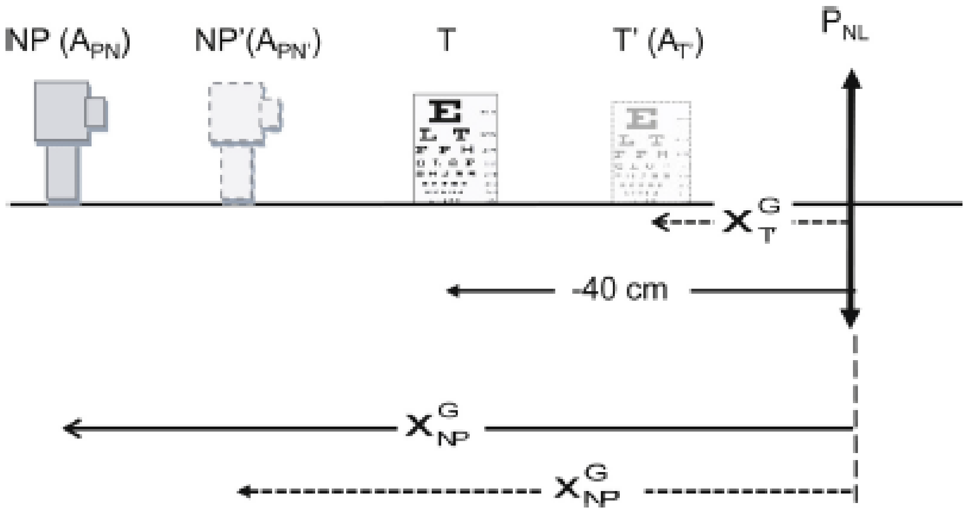

Table 1. Values of accommodative stimulus (A_N) and convergence (C) when the test is placed 40 cm away from the neutralizing lens in emmetropic, myopic and hypermetropic subjects for different neutralizing lens power values (P_{NL}).

	P_{NL} (D)										
	0	-2	-4	-6	-8	-10	-11	-12	13	-14	-15
A_N (D)	2.42	2.29	2.18	2.07	1.97	1.88	1.84	1.80	1.75	1.72	1.68
C (MA)	2.35	2.24	2.14	2.05	1.97	1.90	1.86	1.83	1.79	1.76	1.73

	P_{NL} (D)									
	+2	+4	+6	+8	+10	+11	+12	+13	+14	+15
A_N (D)	2.55	2.70	2.86	3.03	3.22	3.32	3.43	3.54	3.66	3.78
C (MA)	2.47	2.60	2.74	2.91	3.09	3.19	3.30	3.41	3.54	3.67

Table 2. Distance xG (cm) at which the target must be placed for the effective binocular object to be situated 40 cm away from the neutralizing lens, in emmetropic, myopic and hypermetropic subjects. x^G (cm) is measured from the neutralizing lens. Accommodative stimulus values (A_N) at such distances.

	P_{NL} (D)										
	0	-2	-4	-6	-8	-10	-11	-12	-13	-14	-15
x^G (cm)	40.0	38.1	36.3	34.7	33.2	31.9	31.2	30.6	30.0	29.5	28.9
A_N (D)	2.42	2.41	2.39	2.38	2.36	2.34	2.33	2.32	2.32	2.31	2.30

	P_{NL} (D)									
	+2	+4	+6	+8	+10	+11	+12	+13	+14	+15
x^G (cm)	42.1	44.5	47.2	50.3	53.7	55.6	57.6	59.8	62.2	64.8
A_N (D)	2.43	2.43	2.43	2.43	2.42	2.42	2.41	2.40	2.39	2.37

Table 3. $Nott_N$ values (in diopters) in myopic and emmetropic subjects considering the distance at which it accommodates for different P_{NL} values. The first two columns show the distances in absolute value at which the neutral point $\left|d_{NP}^{G}\right|$ and the $Nott_{approx}$ value would be obtained. The normal values according to $Nott_{approx}$ appear in bold and with a double line.

		P_{NL} (D)										
		0	-2	-4	-6	-8	-10	-11	-12	-13	-14	-15
$\left\|d_{NP}^{G}\right\|$ (cm)	$Nott_{aprox.}$ (D)	$Nott_N$ (D)										
15	-4.25	-3.75	-3.50	-3.25	-3.25	-3.00	-3.00	-2.75	-2.75	-2.75	-2.75	-2.50
20	-2.50	-2.25	-2.25	-2.00	-2.00	-1.75	-1.75	-1.75	-1.75	-1.75	-1.50	-1.50
25	-1.50	-1.50	-1.25	-1.25	-1.25	-1.25	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
30	-0.75	-0.75	-0.75	-0.75	-0.75	-0.75	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
35	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25	-0.25
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
50	0.50	0.50	0.50	0.50	0.50	0.50	0.25	0.25	0.25	0.25	0.25	0.25
55	0.75	0.75	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
60	0.75	0.75	0.75	0.75	0.75	0.75	0.50	0.50	0.50	0.50	0.50	0.50
65	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
70	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
75	1.25	1.00	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75	0.75	0.75
80	1.25	1.25	1.25	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.75	0.75
85	1.25	1.25	1.25	1.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
90	1.50	1.25	1.25	1.25	1.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00
95	1.50	1.50	1.25	1.25	1.25	1.25	1.00	1.00	1.00	1.00	1.00	1.00
100	1.50	1.50	1.25	1.25	1.25	1.25	1.00	1.00	1.00	1.00	1.00	1.00

Table 4. $Nott_N$ values (in diopters) in hypermetropic subjects considering the distance at which it accommodates for different P_{NL} values. The first two columns show the distances in absolute value at which the neutral point $\left|d_{NP}^{G}\right|$ and the $Nott_{approx}$ value would be obtained. The normal values according to $Nott_{approx}$ appear in bold and with a double line.

		P_{NL} (D)									
		+2	+4	+6	+8	+10	+11	+12	+13	+14	+15
$\left|d_{NP}^{G}\right|$ (cm)	$Nott_{aprox.}$ (D)	$Nott_N$ (D)									
15	-4.25	-4.00	-4.00	-4.25	-4.50	-4.75	-5.00	-5.25	-5.25	-5.50	-5.75
20	-2.50	-2.50	-2.50	-2.75	-2.75	-3.00	-3.00	-3.25	-3.25	-3.50	-3.50
25	-1.50	-1.50	-1.50	-1.50	-1.75	-1.75	-1.75	-2.00	-2.00	-2.00	-2.00
30	-0.75	-0.75	-0.75	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.25	-1.25
35	-0.25	-0.25	-0.25	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50
40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.50	0.50	0.50
50	0.50	0.50	0.50	0.50	0.50	0.50	0.75	0.75	0.75	0.75	0.75
55	0.75	0.75	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00
60	0.75	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.25	1.25	1.25
65	1.00	1.00	1.00	1.00	1.25	1.25	1.25	1.25	1.25	1.25	1.50
70	1.00	1.00	1.25	1.25	1.25	1.25	1.50	1.50	1.50	1.50	1.50
75	1.25	1.25	1.25	1.25	1.50	1.50	1.50	1.50	1.50	1.75	1.75
80	1.25	1.25	1.25	1.50	1.50	1.50	1.75	1.75	1.75	1.75	1.75
85	1.25	1.25	1.50	1.50	1.50	1.75	1.75	1.75	1.75	2.00	2.00
90	1.50	1.50	1.50	1.50	1.75	1.75	1.75	1.75	2.00	2.00	2.00
95	1.50	1.50	1.50	1.75	1.75	1.75	2.00	2.00	2.00	2.00	2.25
100	1.50	1.50	1.50	1.75	1.75	2.00	2.00	2.00	2.00	2.25	2.25

Table 5. Average values (in diopters) for Mem, Nott with the approximate calculation ($Nott_{approx}$), and Nott considering the position of the intermediate image ($Nott_N$).

	MEM	$Nott_{aprox}$	$Nott_N$
media	+0.58	+0.77	+0.56
sd	±0.30	±0.31	±0.31

Table 6. Example $Nott_N$ results for P_{NL}=8D and different distances of neutral point measured from the neutralizing lens ($|d^G_{NP}|$).

P_{NL} (D)	$\lvert d^G_{NP}\rvert$ (cm)		$Nott_N$ (D)
	from	to	
-8	25	26	-0.75
	26.1	28.5	-0.50
	28.6	31.4	-0.25
	31.5	35.1	0
	35.2	39.7	0.25
	39.8	45.6	0.5
	45.7	53.4	0.75
	53.5	64.5	1
	64.6	80	1.25