1040-5488/99/7609-0650/0 VOL. 76, NO. 9, PP. 650–655
OPTOMETRY AND VISION SCIENCE

ORIGINAL ARTICLE

Comparison Between MEM and Nott Dynamic Retinoscopy

M[A] DEL PILAR CACHO, OD, ÁNGEL GARCÍA- MUÑOZ, OD, JOSÉ R. GARCÍA-BERNABEU, OD, and ALBERTO LÓPEZ, OD

Departamento Interuniversitario de Óptica. Universidad de Alicante, Spain (MPC, AGM), and Private Practice, Spain (JGB, AL)

ABSTRACT: *Purpose.* The aim of this study was to compare MEM dynamic retinoscopy with the Nott method, to discover whether there were different results in the accommodative response and whether a relation exists between the two techniques. *Methods.* We performed MEM and Nott dynamic retinoscopy in 50 visually normal university students. Both methods were performed first on the basis of static retinoscopy and second with the result of the subjective refractive exam (binocular balancing). *Results.* A statistically significant difference existed between the methods. Nott retinoscopy assessed on basis of the subjective refractive exam was the method that obtained the lowest amounts of accommodative lag (+0.42 D), whereas MEM method performed through the static retinoscopy result showed the highest accommodative lag (+0.94 D). Furthermore, correlation analysis showed that a linear relation existed between both methods, so that the Nott value was about one-half the value of the MEM retinoscopy. *Conclusions.* MEM dynamic retinoscopy showed greater lag than Nott retinoscopy. (Optom Vis Sci 1999;76:650–655)

Key Words: accommodative response, accommodative lag, accommodative lead, dynamic retinoscopy, monocular estimate method, Nott retinoscopy.

Clinical evaluation of accommodation is an essential part of the study of different visual dysfunctions. The assessment of the accommodative response to a near target is an essential test, among others, to diagnose and develop treatment of some accommodative and binocular dysfunctions.[1] There are different subjective and objective clinical techniques to measure the accommodative response. Among the subjective techniques are the binocular cross-cylinder and the duochrome test, although their results are variable and not very reliable.[2, 3] The most notable objective clinical techniques are Monocular Estimate Method (MEM) retinoscopy, Nott retinoscopy, and Cross retinoscopy. The MEM dynamic retinoscopy[4] consists of estimation of the monocular accommodative response in binocular conditions, using the rapid interposition of spherical lenses. With the Nott method[5, 6] the retinoscope is moved closer or farther away until neutral motion is observed, while the fixation target is held at a constant nearpoint. In Cross retinoscopy[7] the patient binocularly fixes the target while the examiner adds spherical lenses over the spectacle correction until the neutrality can be observed.

There are several studies about these dynamic retinoscopy techniques. Rouse et al.[4] studied the validity of MEM dynamic retinoscopy, comparing the results of this technique with those obtained by a haploscope instrument, a phoroaccommodometer. They concluded that these two methods of determining accommodative response could be considered equivalent for accommodative stimulus levels up to 3.00 D, indicating that the results supported MEM as a useful clinical method for determining accommodative response. In a study with 10 subjects, Casser and Somers[3] stated that any method of dynamic retinoscopy (MEM, Cross, or Nott) could be interchangeable to assess accommodative lag or lead, as there were no statistically significant differences between them. However, they state that the Bell retinoscopy results were not comparable to those obtained in the other three dynamic retinoscopy techniques.

Rosenfield et al.[2] studied 24 visually normal subjects and measured their accommodative response with different techniques. They used an Infrared Autorefractor under binocular conditions to determine the accommodative response objectively. They also performed two dynamic retinoscopy procedures under binocular conditions, first using supplementary lenses, and second, Nott retinoscopy. They found that the two retinoscopy procedures showed the best agreement (±0.48 D). In addition, of the two dynamic retinoscopy methods used, better agreement with the autorefractor was observed with the Nott procedure (±0.65 D). The agreement between the autorefractor and the dynamic retinoscopy with lenses was ±0.91 D. They suggested that "any test which requires the introduction of supplementary lenses to evaluate the accommodative response may not produce valid results". Accordingly, they said "the Nott method of dynamic retinoscopy, which does not require the introduction of supplementary lenses, should be the method of choice for the clinical assessment of the accommodative response in young patients".

Based on the comments of Rosenfield et al. about Nott dynamic retinoscopy, we decided to compare MEM and Nott retinoscopy to discover if there were different results in the accommodative response and attempted to analyze what relation existed between the two. We chose these dynamic retinoscopy techniques because they are the most reliable in assessing accommodative response.[2] MEM retinoscopy requires the insertion of a lens for a very brief period of time, and with Nott retinoscopy supplementary lenses are not necessary. Moreover, we compared the two techniques to investigate if there were differences between the two tests using the static retinoscopy result or the subjective binocular test results, because although it is accepted that any method of dynamic retinoscopy should be conducted with subject's current distance spectacle correction in place (or the result of the subjective binocular exam at distance), certain authors advocate the use of dynamic retinoscopy over the static retinoscopy result.[8]

METHODS

Subjects for this study were 50 Optometry students, ranging in age from 15 to 35 with a mean of 23.96 ± 3.17 years. None of the subjects had systemic or ocular disease, was taking medications, or wore contact lenses. All subjects in the study demonstrated a corrected visual acuity of 20/20 or better. A complete optometric examination was conducted to rule out subjects with accommodative and binocular dysfunctions. The criteria used to diagnose these dysfunctions were those used in the integrative analysis approach by Scheiman and Wick.[9] The tests performed were: static retinoscopy, subjective refraction, cover test, monocular amplitude of accommodation with minus lenses, positive and negative relative accommodation, fusional vergences far and near, accommodative facility with ±2.00 D flipper lenses with suppression control, stereopsis, and dynamic retinoscopy. None of the subsequent subjects had accommodative and/or binocular dysfunctions.

MEM and Nott retinoscopy was performed first through the result of static retinoscopy, and second, through the subjective exam result of the patient. Static retinoscopy was done while the subject was instructed to watch the 20/400 letter E on the distant chart at 6 m. Subjective refraction was performed by means of a monocular fogging method with cross-cylinder, followed by binocular balancing to a standard endpoint of maximum plus for best visual acuity.

The accommodative lag or lead was first measured with Nott retinoscopy in order to remove the possible effects of plus or minus lenses in the accommodative response when performing the MEM retinoscopy. Both dynamic retinoscopy techniques were performed first through the result of the static retinoscopy and then through the result of the subjective refractive exam placed in a trial frame. The MEM technique was performed as follows: the patient was seated in normal room illumination; a commercially available nearpoint card with paragraph text as an accommodative stimulus was used (Bernell Corporation BC 11981, South Bend, IN); the card original dimensions were 4.5 × 5.5 in; the test was placed on the nearpoint rod at 40 cm (16 in) while the subject read aloud the 6/12 (20/40) sized text immediately adjacent to the aperture; MEM was done on the horizontal meridian of the right eye first and then the left; test distance was held constant by means of a calibrated string attached to the retinoscope; lenses were briefly introduced by the examiner (MPC) with a lens bar in 0.25 D steps until neutral was first observed (low neutral).

Nott dynamic retinoscopy was performed at the same near distance, ambient illumination, and with the same target used in MEM retinoscopy. Due to the problems for seeing against motion in Nott dynamic retinoscopy, the nearpoint card was reduced to 2.5 in (6.4 cm), wide enough to permit free movement of the retinoscope in the observation of retinoscopic reflex. The retinoscope was placed on the outside of the card while the subject was asked to fixate the words on the side of the card closest to the retinoscope. In this way the distance between the place where the patient fixated and the retinoscope position was equal to that used in MEM retinoscopy. Initially, the results of Nott dynamic retinoscopy were recorded as the distance in millimeters where the neutrality was observed. When all subjects of the study were examined, the final results of the Nott dynamic retinoscopy were expressed as the dioptric difference between the position of the target and that of the exit pupil of the retinoscope when the neutrality was first observed. This exit pupil position of the retinoscope was measured with a precision of ±1 mm.

The same examiner (MPC) performed both dynamic retinoscopy techniques. The use of a single examiner doing both methods on the same subject could have biased the MEM results because of the examiner's knowledge of the Nott findings. However, as the Nott results were initially recorded in millimeters, it was unlikely that the examiner was biased when assessing the MEM dynamic retinoscopy, in which the results were expressed in diopters.

RESULTS

Accommodative responses for each eye were recorded and the mean values for each eye of both dynamic retinoscopy techniques were compared statistically. Because the differences between both eyes were not statistically significant in any of the four conditions ($p > 0.05$) only the right eye (OD) data of the subjects is reported (Table 1).

An analysis of variance was performed designating the *methods* and the *ages* as the independent variables and the *dioptric results of dynamic retinoscopy* as the dependent variable. Four *methods* were considered: (1) MEM retinoscopy performed through the static

TABLE 1.
Difference between the subjects' right and left eye for both dynamic retinoscopy techniques

Through Static Retinoscopy		Through Subjective Refraction	
MEM	Nott	MEM	Nott
$p = 0.2671$ $t = 1.1160$	$p = 0.3869$ $t = 0.8689$	$p = 0.4844$ $t = 0.7018$	$p = 0.7987$ $t = 0.2556$

retinoscopy result, (2) MEM retinoscopy on basis of subjective refraction result, (3) Nott retinoscopy on basis of static retinoscopy result, and (4) Nott retinoscopy on basis of subjective refraction result.

Two age groups were studied: those between 15 and 25 years and those over 25 years but not over 35 years. This analysis revealed a highly significant difference between methods ($p = 0.0001$) but no significant difference between the age of subjects ($p = 0.3326$); there was no interaction between the two factors. Because no significant difference was found between the subject's ages the data were grouped by *methods* and the analysis of variance was performed again. The analysis revealed a significant difference between the four methods, $p < 0.0001$ (Table 2).

The mean dioptric values for each dynamic retinoscopy are illustrated in Table 3. The accommodative lag for the MEM technique referenced to static retinoscopy had a mean value of +0.94 D, and +0.74 D referenced to the subjective exam. For the Nott method, the mean value was +0.53 D referenced to the static retinoscopy and +0.42 D referenced to the subjective exam. Mean difference of spherical equivalent between static retinoscopy and subjective refraction was −0.16 D. The largest mean value of accommodative lag of the four groups was obtained by the MEM technique performed over the static retinoscopy result, whereas the Nott technique carried out over the subjective binocular exam result showed the lowest accommodative lag. A multiple range analysis for dioptric results of accommodative lag using the method of 95% Fisher's least significant difference was completed (Table 4). This analysis applies a multiple comparison procedure to determine which means are significantly different from others. An asterisk has been placed next to pairs, indicating that these pairs show a statistically significant difference at the 95% confidence level. This multiple analysis revealed a statistically significant difference between all groups except in one of them: Nott technique performed on basis of static retinoscopy result in contrast to Nott technique performed through the subjective exam result.

In order to establish whether relationships existed between the MEM and the Nott technique, a correlation analysis was carried out, using the values of both dynamic retinoscopy techniques on the basis of the static retinoscopy result (Fig. 1) and the subjective binocular exam result (Fig. 2). In the first case (comparing MEM and Nott using the static retinoscopy result) a linear regression line: $y = 0.507x + 0.052$ with a correlation coefficient $r = 0.88$ was obtained. The regression line between MEM and Nott performed on basis of the subjective refraction result was: $y = 0.537x + 0.020$ with a correlation coefficient $r = 0.94$, y was the Nott retinoscopy value and x was the MEM result. In both cases the regression line indicates that the Nott dioptric value can be calculated by dividing the result of the MEM retinoscopy by two. A direct comparison between MEM and Nott is shown in Table 5. These comparisons between both dynamic retinoscopy techniques were made for both bases used in measuring the accommodative response, static retinoscopy result and subjective refraction result. The 95% limits of agreement between the methods, calculated as 1.96 multiplied by the standard deviation of the differences, are also indicated.[10]

Furthermore, a comparison between the basis used (static retinoscopy result and subjective refraction result) for both dynamic retinoscopy techniques was studied. The results of those direct comparisons are illustrated in Table 6. The 95% limits of agreement between both bases was calculated as 1.96 multiplied by the standard deviation of the differences.

TABLE 2.
One-way ANOVA using method as the independent variable and the dioptric results of dynamic retinoscopy as dependent variables; Methods are: 1: MEM on basis of static retinoscopy; 2: MEM with subjective refraction; 3: Nott on basis of static retinoscopy; 4: Nott with subjective refraction

Source	Sum of Squares	D.F.	Mean Square	F-ratio	P-value
Main effects					
Methods	8.050	3	2.683	10.222	<0.0001
Residual	51.453	196	0.263	–	–

DISCUSSION

In our study the analysis of variance shows that the values of the dynamic retinoscopy are not the same when assessing the MEM method and the Nott dynamic retinoscopy. The differences between both dynamic retinoscopy techniques found in our study must be from the insertion of spherical lenses before the subject altering the accommodative response.

It has been proved that the best form to assess the accommodative response when performing dynamic retinoscopy using spherical lenses is the MEM method. Rouse et al.[4] evaluated the validity of MEM with four subjects by comparing the response obtained by MEM and by a haploscopic instrument. They reported a high correlation between both methods, thereby indicating that the MEM technique was indeed valid. We agree with the fact that the MEM retinoscopy may be a valid method to evaluate the accommodative response, but we believe that any test which requires the introduction of supplementary lenses to evaluate the accommodative response may not produce a valid result because the subject could adapt himself to the effect of inserting lenses. This is not the case with the Nott method, where the observer simply neutralizes the retinoscopic reflex by modifying the distance, so that the accommodative response is not altered. Furthermore, we have to consider that with the Nott retinoscopy we physically measure the point where the subject is accommodating. Our results show these differences between MEM and Nott retinoscopy. In Table 2, it can be observed that there are statistically significant differences between both dynamic retinoscopy techniques as well as assessing both retinoscopy techniques through the static retinoscopy result or through the subjective refractive result. Table 3 shows that with the MEM technique the mean value of the accommodative lag is more positive than that obtained with the Nott method. This indicates that the MEM method may overestimate the accommodative lag, probably because of the effect of the supplementary lenses. Moreover, the accommodative lag results in the Nott method are similar to the eye's depth of focus measured by Campbell.[11] He used a 3-mm fixed diameter for the pupil and a screen with 1000 mL of luminance, with a target consisting of black disks 10 arcmin in diameter, resulting a mean depth of focus ±0.43 D. However the depth of focus varies with the spatial frequency, size

TABLE 3.
Mean (and SD) values of accommodative lag (D) for each method; 95% Fisher's Least Significant Difference (LSD) intervals for the mean are also given

Method	N	Mean	SD	95% LSD Intervals
MEM through static retinoscopy	50	0.940	0.524	0.838 to 1.041
MEM through subjective exam	50	0.735	0.719	0.634 to 0.836
Nott through static retinoscopy	50	0.529	0.304	0.428 to 0.630
Nott through subjective exam	50	0.415	0.409	0.314 to 0.516

TABLE 4.
Multiple range analysis for accommodative lag by method with 95% percent of LSD; *denotes a significant statistically difference

Comparison	Mean Difference	95% LSD intervals
MEM through static retinoscopy vs. MEM through subjective exam	0.205	±0.202*
MEM through static retinoscopy vs. Nott through static retinoscopy	0.411	±0.202*
MEM through static retinoscopy vs. Nott through subjective exam	0.525	±0.202*
MEM through subjective exam vs. Nott through static retinoscopy	0.206	±0.202*
MEM through subjective exam vs. Nott through subjective exam	0.320	±0.202*
Nott through static retinoscopy vs. Nott through subjective exam	0.113	±0.202

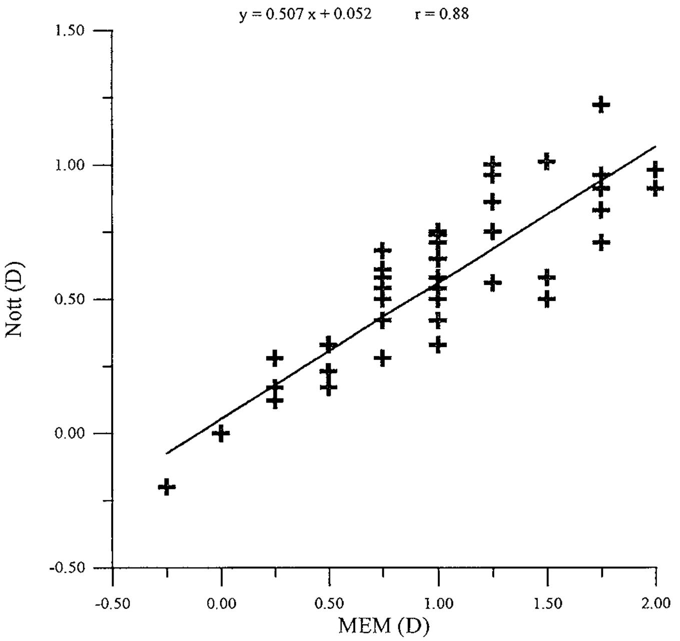

FIGURE 1.
Relation between MEM dynamic retinoscopy and Nott technique dioptric results, assessed on basis of the static retinoscopy result.

of pupil, chromatic aberration, spherical aberration, etc., so that the depth of focus can reach higher values.[12] Therefore, the depth of focus may not be the appropriate reference to determine which dynamic retinoscopy method is more valid. On the basis of these considerations and on our results, we consider Nott retinoscopy to be the method of choice for analyzing the accommodative lag, not because of its similarity with certain depth of focus values, but because it may be the method that least contaminates the accommodative response. Nott retinoscopy should be taken as the subject's near state accommodative reference, as this value is important in the diagnosis of accommodative and binocular dysfunctions. If the MEM test is performed and proves to be a determinant when diagnosing one type of dysfunction or another, it would then be necessary to know whether the subject really has this MEM value because he accepts positive or negative lenses or if the test is being contaminated by the effect of the supplementary lenses. Therefore in these cases, it would be interesting to assess the Nott method in an attempt to examine the accommodative response of each subject properly.

As for comparing the accommodative lag results when performing both dynamic retinoscopy techniques through the static retinoscopy result or through the subjective binocular exam result, differences can be observed. Table 3 indicates that by using the static retinoscopy as a basis for dynamic retinoscopy, the mean accommodative lag value is higher than if it is performed using the subjective binocular result as a benchmark. This finding is due to the mean difference of spherical equivalent between static retinoscopy and subjective exam of our study. Static retinoscopy was more negative than subjective refraction (mean difference = −0.16 D), so with our result, the assessment of any dynamic retinoscopy on the basis of static retinoscopy may be more positive than when it is performed through the subjective refraction result. However, in Table 4 it can be observed that a statistical difference does not exist between the Nott technique referenced to static retinoscopy or the subjective refraction, but statistical differences do exist between the MEM technique when referenced to both static retinoscopy and subjective refraction. Despite the conditions being similar for each dynamic retinoscopy (i.e., static retinoscopy and subjective refractive exam), the patient appeared to adapt him/herself in different ways. Because the lenses are the only different factor between the techniques, this suggests that in MEM dynamic retinoscopy, the use of supplementary lenses may have an effect on the accommodative response. The subject may be able to adapt to the lenses, a situation that does not occur for the Nott method. In any case, the use of the subjective refraction as a basis of the dynamic retinoscopy is the most representative situation of the work habitual conditions of any subject, so it would be the reference to assess any dynamic retinoscopy as it is the basis to measure any test of accommodative function. This finding agrees with the widely accepted notion of performing dynamic retinoscopy through the subjective

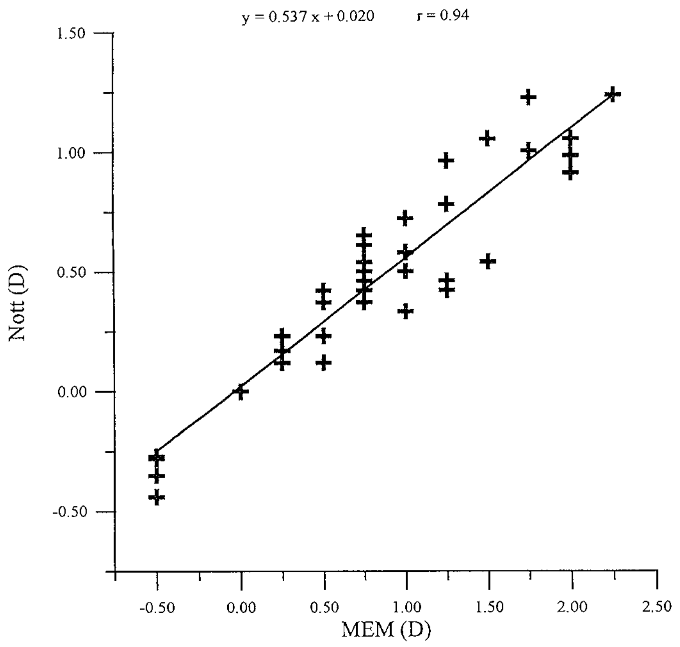

FIGURE 2.
Relation between MEM dynamic retinoscopy and Nott technique dioptric results, assessed on basis of the subjective refractive exam.

TABLE 5.
Comparison between techniques for assessing accommodative lag; the mean difference, standard deviation of the differences and the 95% limits of agreement between the two methods (calculated as 1.96 multiplied by the SD of the differences) are given in D

Comparison	Mean Difference	SD	95% Range of Agreement
MEM versus Nott (over subjective exam)	0.32	0.36	±0.71
MEM versus Nott (over static retinoscopy)	0.41	0.30	±0.59

exam result (or with the subject's distance refractive correction in place).

The values illustrated in Tables 5 and 6 corroborate the former. Table 5 shows that the best agreement exists for the MEM and Nott technique when the static retinoscopy result was used for performing dynamic retinoscopy, indicating that if the subjective exam results are used to assess dynamic retinoscopy, the differences between the mean value of both techniques will be larger. This finding suggests that when using the subjective exam result as a reference, the MEM and Nott methods are not interchangeable. In Table 6 it can be observed that the worst agreement between both bases used (static retinoscopy result and subjective refraction result) was for the MEM method and the best agreement was for the Nott method. This suggests that there will be more differences in assessing the MEM technique on basis of static retinoscopy or on basis of subjective exam than assessing the Nott method. These differences are likely due to the insertion of supplementary lenses in the MEM technique, as this is (the lenses) the only different factor with regard to the Nott technique. This fact indicates that the result of accommodative response would be influenced by supplementary lenses used in MEM technique. These results are different from those obtained by Casser and Somers,[3] who concluded that MEM, Nott, and Cross dynamic retinoscopy were interchangeable. We think that the difference between their report and our study results must be from the sample used, as they only studied 10 subjects; the rest of the conditions were similar to those used in our study, including the same card.

TABLE 6.
Comparison between the basis for assessing accommodative lag with MEM and Nott techniques; the mean difference, standard deviation of the differences and the 95% limits of agreement between the two methods (calculated as 1.96 multiplied by the SD of the differences) are given in D

Comparison	Mean Difference	SD	95% Range of Agreement
MEM over static retinoscopy vs. MEM over subjective exam	0.21	0.43	±0.85
Nott over static retinoscopy vs. Nott over subjective exam	0.11	0.22	±0.43

The calculation of the correlation between the two methods studied showed that both can be related by means of a linear regression line. The corresponding regression line calculated for both methods when using the static retinoscopy result as well as the subjective binocular result indicates that the accommodative lag value for the Nott method can be calculated by multiplying the MEM result by a factor of about 0.50, or by dividing it by 2. In this way we would have a simple formula for calculating the results of one method based on the results of the other method. We propose that this finding could have interesting implications for determining whether a suspicious MEM result is related to adapting to the inserted lenses. In these cases the Nott retinoscopy value should be about one-half that of the MEM, so that if the Nott result varies from this theory substantially, the MEM value was probably contaminated by the supplementary lenses. In any case, the sample used in this study is not large, and it would be prudent to confirm these results in larger and more heterogeneous samples, in which it would also be necessary to analyze subjects with accommodative and binocular dysfunctions.

CONCLUSIONS

The results of this study indicate that dynamic retinoscopy results are different when performed with the MEM method than when assessing Nott retinoscopy. MEM values showed greater accommodative lag than Nott dynamic retinoscopy.

Accommodative lag findings performed through the static retinoscopy result are more plus than when the test is carried out by measuring the accommodative response after having performed the subjective binocular exam.

The accommodative lag result assessed with the Nott method can be calculated by means of a linear regression equation, in which the accommodative lag value using the Nott method is calculated by dividing the accommodative lag result obtained with the MEM technique by 2.

ACKNOWLEDGMENTS

Received April 9, 1998; revision received November 9, 1998; final revision received February 16, 1999.

REFERENCES

1. Scheiman M, Wick B. Clinical Management of Binocular Vision: Heterophoric, Accommodative, and Eye Movement Disorders. Philadelphia: JB Lippincott Company 1994:19–26.
2. Rosenfield M, Portello JK, Blustein GH, Jang C. Comparison of clinical techniques to assess the near accommodative response. Optom Vis Sci 1996;73:382–8.
3. Locke LC, Somers W. A comparison study of dynamic retinoscopy techniques. Optom Vis Sci 1989;66:540–4.
4. Rouse MW, London R, Allen DC. An evaluation of the monocular estimate method of dynamic retinoscopy. Am J Optom Physiol Opt 1982;59:234–9.
5. Nott IS. Dynamic skiametry, accommodation and convergence. Am J Physiol Opt 1925;6:490–503.
6. Nott IS. Dynamic skiametry: Accommodative convergence and fusion convergence. Am J Physiol Opt 1926;7:366–74.
7. Borish IM. Dynamic skiametry. In: Borish IM, ed. Clinical Refraction, 3rd Ed. Chicago: Professional Press, 1975:697–713.
8. Grosvenor TP. Primary Care Optometry, 2nd Ed. Boston: Professional Press Books, 1989:251.
9. Scheiman M, Wick B. Clinical Management of Binocular Vision: Heterophoric, Accommodative, and Eye Movement Disorders. Philadelphia: JB Lippincott Company 1994:41–81.
10. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986;1: 307–10.
11. Campbell FW. The depth of field of the human eye. Optica Acta 1957;4:157–64.
12. Legge GE, Mullen KT, Woo GC, Campbell FW. Tolerance to visual defocus. J Opt Soc Am (A) 1987;4:851–63.

Mª Pilar Cacho Martínez
Departamento Interuniversitario de Óptica
Apartado 99. Universidad de Alicante.
030 80, Alicante, Spain