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# Comparison of Subjective with Objective Measure of Amplitude of Accommodation with Age Matched Hofstteter's Normative Data

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## Abstract

**Aim:** To analyze the comparison of subjective with objective measure of amplitude of accommodation with age matched hofstetter's formula.

**Purpose:** Dynamic retinoscopy is an objective technique for assessing maximum accommodative responsivity. The present study examined the reliability of this procedure when measuring the amplitude of accommodation.

**Methods:** The amplitude of accommodation was measured in 57 subjects between 17 and 22 years of age using Dynamic Retinoscopy and a subjective method, Modified Pull Away. The repeatability between the methods were determined using the mean difference.

**Results:** Dynamic Retinoscopy showed the lowest mean value of Amplitude of Accommodation (average=7.71 D) whereas the mean value for Modified Pull Away was 9.80 D. Average for Dynamic Retinoscopy-Modified Pull Away was 2.10 D.

**Conclusion:** The Dynamic Retinoscopy technique provides a more veridical measurement of the Amplitude of Accommodation because it avoids the over-estimation resulting from the depth-of-field. Moreover, the Dynamic Retinoscopy technique exhibited higher reproducibility when compared with subjective methods.

## Keywords

Amplitude of accommodation; Dynamic retinoscopy; Modified push-down; Near work; Repeatability

## Introduction

Accommodation is defined as the process by which the crystalline lens varies its focal length in response to changes in the vergence of incident light [1]. Our eyes have been provided with a unique mechanism by which we can even focus the diverging rays coming from a near object on the retina in a bid to see clearly by the mechanism of accommodation. There is no disagreement that a change in the shape of the lens-an increase or decrease in curvature and thickness of its central parts that produces an increase or decrease in the dioptric power of the eye-is the basic mechanism underlying accommodation.

The nearest point at which small objects can be seen clearly is called near point of accommodation and the distant point is called far point of accommodation. The difference between the dioptric power needed to focus at near point and to focus at far point is called amplitude of accommodation. When an object is accurately focused monocularly, often the objects somewhat near and somewhat farther away are also seen clearly without any change in accommodation. This range of distance from the eye in which an object appears clear without change of accommodation is termed as depth-of-field. Depth-of-field reduces the necessity for precise accommodation [2].

Accommodation is measured in ''Diopters '' (D), that is, in terms of the reciprocal of the fixation distance [3].

The normal values for the Amplitude of Accommodation (AA), i.e., maximum accommodative ability as a function of age were determined by Donders towards the end of the 19th century and by Duane in the early 20th century [4,5]. In both cases the subjective push-up method was used to measure this parameter. However, several studies have shown that the amplitude findings cited in these classic papers probably overestimated the true result as the authors failed to consider the depth-of-field of the eye, i.e., the dioptric range of object distances over which visual acuity does not deteriorate [6-8]. In addition, subjective measurement techniques imply that some amplitude (approx. 1 D) persists beyond 60 years of age, whereas objective findings (which are not biased by the depth-of-field) verify that the Amplitude of Accommodation reaches zero around 55 years of age [9].

A Modified Push-Down (MPD) method has been proposed as an alternative technique to assess the Amplitude of Accommodation with the purpose of minimizing factors that might alter the accommodative response during the more common pushup procedure [10]. To minimize the change in image size, the Amplitude of Accommodation can be measured through a -4.00 D lens, thereby reducing the angular subtense to approximately half its original value. The negative lens also moves the near point away from the observer, thus reducing the effects of proximal accommodation. The maximum accommodative response can be assessed using an autorefractor or retinoscope. Using these devices, the expected Amplitude of Accommodation is lower than the values cited in both Donders and Duane's tables, and these differences may be as high as 1.50 D–2.00 D [9-11].

Dynamic retinoscopy provides a straight forward method of determining the accommodative response objectively using a relatively inexpensive and widely available instrument.

Hokoda , et al. [12] compared the Amplitude of the Accommodation measured with an objective retinoscopy technique (termed heterodynamic retinoscopy) with subjectively determined Minus lens

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(ML) and push-up values in seven amblyopes and five control subjects. For the heterodynamic retinoscopy procedure, subjects held a reduced Snellen chart and advanced it toward them until the letters first became blurry. With the target at the subjective near point of accommodation, the examiner performed retinoscopy, adjusting the working distance until a neutral reflex was observed.

The authors found that in the normal control subjects, the mean objective Amplitude of Accommodation was lower than the values obtained with either the push-up (mean difference=2.4 D) or Minus Lens (mean difference=0.77 D) procedures. In the amblyopic eyes, the results were more variable, with the difference between the mean objective finding and the subjective push-up and Minus Lens procedures being 5.00 D (Push Up being higher) and 0.46 D (Dynamic Retinoscopy findings being higher), respectively.

Rutstein, et al. [13] also used Dynamic Retinoscopy to measure accommodation in 54 subjects between 6 and 35 years of age, and compared the results with the push-up technique. For subjects under 12 years of age (N=29), the mean finding using Dynamic Retinoscopy was 1.73 D higher than the push-up value, while for subjects over 12 years of age (N=28), the mean Dynamic Retinoscopy result was 3.74 D higher than the push-up value. This observation of a higher value for Amplitude of Accommodation measured with retinoscopy, when compared with the subjective finding is unexpected. In this investigation, the near point of accommodation was taken as the point when the retinoscopy reflex became narrow, its colour dimmed and its speed became slow, rather than determining a neutral reflex. The use of this endpoint criterion, rather than the more commonly adopted neutral reflex, may be responsible for the observed higher findings.

Win-Hall, et al. [14] used both; the Grand Seiko WR 5100 K open-field, infra-red autorefractor and Hartinger coincidence optometer to measure the Amplitude of Accommodation objectively (with accommodation being stimulated with minus lenses) and compared the results with a subjective pushup procedure. They observed that both the mean and range of values obtained using the push-up procedure was greater than those found with either of the objective techniques. However, we are not aware of an investigation which assessed the repeatability (several measures obtained by one observer on the same subject under similar conditions) and reproducibility (comparing measurements obtained by multiple examiners) of objectively obtained measurements of Amplitude of Accommodation determined using Dynamic Retinoscopy. Accordingly, the aim of the present investigation was to examine the reliability (both within and across sessions) of the Dynamic Retinoscopy technique for measuring the Amplitude of Accommodation and compare the values with those obtained using subjective procedures.

## Methodology

The measurements of the Amplitude of Accommodation were obtained from 57 subjects, all of whom were optometry students from Sankara Eye Hospital in Pammal. All had visual acuity of 6/9 or better (at both distance and near) when measured using a Snellen Chart. Subjects wore a full refractive correction and had no ocular pathology.

### Exclusion criteria

- Refractive error> ± 2.00 D
- Accommodative dysfunction
- Strabismus
- Aphakia
- Amblyopia

### Inclusion criteria

- Refractive error upto 2.00 D
- Emmetropia
- Myopia
- Hyperopia
- Astigmatism
- Age group between(16-22) year

The data were obtained and recorded by optometry students of 3rd year. From the data the minimum correlation coefficient of 1.94 D with a standard deviation of 1.15 D and an error type of two methods were 2.10 D, a required sample size of 57 subjects was calculated.

Before recording Amplitude of Accommodation measurements, the refractive error of each subject was determined using static retinoscopy and subjective refraction (Jackson crossed cylinder). The measured refractive correction was worn for all trials. Amplitude of Accommodation was assessed using one subjective and one objective method as described below.

### Modified pull away

The distance refractive correction was placed in a trial frame, together with an additional -4.00 DS [15] with one eye occluded. The target comprised of high contrast letters with N8 size, printed on a dynamic retinoscopy card. Using the method described by Chen AH, et al. [16], the target was initially positioned close to the trial frame and subjects were asked to push the card away from them slowly (at approx. 4 cms) and to stop as soon as they could observe the letters clearly and sharply. The Modified Pull Away amplitude was calculated as the reciprocal of the distance from the target to the plane of the trial lens (measured in metres) when the letters first appeared absolutely clear, +4.00 D (to compensate for the additional -4.00 lens).

The procedure was repeated three times on each subject, with a 1 min interval allowed between each measurement. Each measurement took approximately 30s to complete.

### Dynamic retinoscopy

A variation of the heterodynamic retinoscope method described by Pascal [12] was used. Using a similar procedure to the Modified Pull Away technique described above, subjects were asked to keep the letters clear and sharp. The fixation target was placed close to the trial frame and then the subject pushed the card away until the letters became absolutely clear. With the target at this location, the examiner positioned the retinoscope at a working distance approximately twice the distance between the fixation card to the subject (Figure 1).

The retinoscopy reflex was observed and if an 'against' movement was seen (the expected response), the observer moved closer to the eye until a neutral reflex was found. Once this was achieved, the distance between the spectacle plane and the retinoscope was measured with a metre rule. The objective Amplitude of Accommodation was taken as the reciprocal of this distance in metres, +4.00 D (corresponding to the additional -4.00 lens added to the distance correction). The procedure was repeated three times on each subject, with a 1 min interval allowed between each measurement. Each measurement took approximately 40 s to complete (Figure 2).

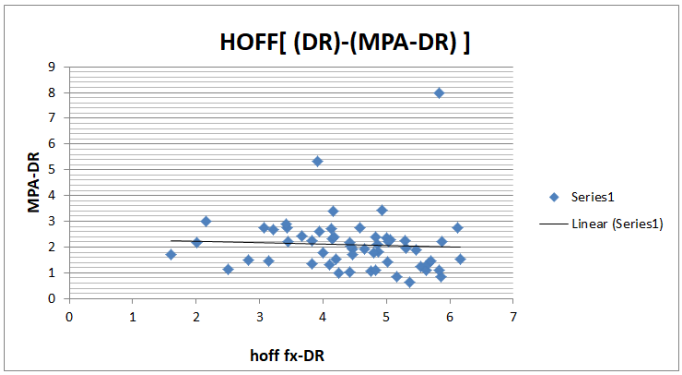


**Figure 1:** Positive analysis of DR vs MPA.

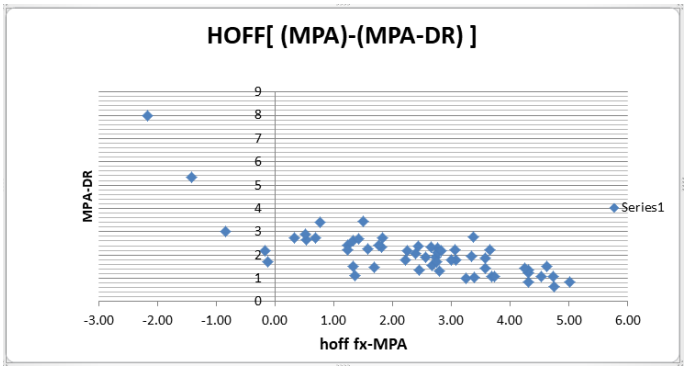


**Figure 2:** Negative analysis of MPA vs DR.

## Hypothesis

**Null hypothesis:** The mean value obtained from modified pull away method tends to be more correlative with hofstetter's normative data.

**Alternate hypothesis:** The mean value obtained from the dynamic retinoscopy method tends to be less correlative with hofstetter's normative data compared with modified pull away method.

## Results

From the above analysis, by comparing the mean values [(Modified Pull Away -9.80 D) (Dynamic Retinoscopy-7.70 D)] and standard deviation values [(Modified Pull Away -1.50) (Dynamic Retinoscopy-0.99)] from the two methods, modified pull away and dynamic retinoscopy, it is understood that the subjective method overestimates the Amplitude of Accommodation when compared with objective method.

## Discussion

In our study, we had selected 57 subject among them, 10 were males and 47 were females; 22 myopes, 2 hyperopes and 33 were emmetropes. In Modified Pull Away, the mean value is 9.80; median is 9.77; standard deviation is 1.50. In Dynamic Retinoscopy, the mean value is 7.70; median is 7.69; standard deviation is 0.99. According to our research, Modified Pull Away gave the closer value than Dynamic Retinoscopy while compared with hofstetter's formula.

In the previous study, they concluded that Dynamic Retinoscopy showed the lowest mean Amplitude of Accommodation of the three techniques. The differences between the objective (Dynamic Retinoscopy) and subjective methods (Modified Pull Away and Minus Lens) can be explained by the lag of accommodation. Subjective assessment measures the closest distance at which the patient can see clearly. This will exceed the near point of accommodation by approximately half the total depth-of-field of the eye. Objective procedures evaluate the actual increase in refractive power of the eye. The lag of accommodation increases with the accommodative stimulus, probably due to pupillary miosis which increases the depth-of-focus.

## Conclusion

The Dynamic Retinoscopy technique avoids the overestimation of the AA resulting from the depth-of-focus that occurs during subjective assessment. The higher reproducibility found with the Dynamic Retinoscopy technique, when compared with subjective methods may provide a useful tool for monitoring accommodative therapy.

Both the subjective and objective method underestimates the mean values of hofstetter's normative data. We compared the values of Modified Pull Away and Dynamic Retinoscopy which had a comparable difference in their mean values.

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