

The Effect of Test Sequence on Measurement of Positive and Negative Fusional Vergence

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ABSTRACT

Introduction: When performing fusional vergence testing the most commonly accepted clinical technique is to first measure negative fusional vergence (NFV) followed by a measurement of positive fusional vergence (PFV). The reasoning behind this is the supposition that if one tested convergence first, significant vergence adaptation would take place thus significantly altering the divergence fusion measurement. The purpose of this study was to accurately measure the vergence adaptation in both directions in order to determine if order of testing affects the results.

Methods: Thirty students between the ages of 18 and 30 were tested using a step vergence method. The subjects were randomly divided into two groups of fifteen. In Group A the NFV was measured first followed by PFV. One hour later the order of the measurements was reversed. Group B followed a similar regimen in reverse order, with PFV measured before NFV followed one hour later by the reversal.

Results: The NFV results measured after the PFV were significantly lower on average than those measured before PFV both in the recovery point ($p=0.01$) and the break point ($p=0.002$). The PFV

results were not significantly different both on the recovery ($p=0.13$) and the break ($p=0.09$) points when measured first or second.

Conclusions: The measurement of positive fusional vergence prior to negative fusional vergence significantly alters the results of negative fusional vergence. Therefore, if it is desirable to avoid this influence, the NFV measurement should precede the PFV.

Keywords: convergent fusion, divergent fusion, vergence adaptation, convergence, divergence, NFV, negative fusional vergence, PFV, positive fusional vergence

Introduction

Fusional vergence testing is used clinically to directly measure the amount of positive (convergence, PFV) and negative (divergence, NFV) fusional vergence ability.¹ Through the addition of gradually increasing prism power, the test measures the amount of reserve fusional strength the subject can call upon in order to maintain fusion. The increased prism demand creates retinal disparities which stimulate vergence movements in order to eliminate these disparities and allow single binocular vision. Base in (BI) prism creates a spatial change causing the apparent image of the target to recede thereby creating a demand to diverge while base out (BO) prism causes the opposite effect.²

In general during testing, the subject is asked to report when they begin to see a blurred (blur point), double (break point) and then later, one single image (recovery point). The blur point is interpreted as the limit of fusional vergence which is also the beginning of vergence dependent on accommodative changes.³ Table 1 indicates the norms for fusional vergence testing in adults as reported by Scheiman and Wick.

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Table 1: Norms for Step Vergence Testing in Adults

Test		Expected Findings	SD
Near BO	break	19	± 9
	recovery	14	±7
Near BI	break	13	±6
	recovery	10	±5

While superficially it would seem that convergence and divergence are simply opposite vergence movements of the same basic process, this has not proven to be the case. Their physiological and neurological characteristics are different and the effects of each process on the other have also been seen to be different.⁴ In the presence of a strong stimulus for convergence, the convergence response does not cease immediately with the absence of the demand but continues afterwards.⁵ As a result of this response, the divergent amplitude measured after performing convergence is expected to be lower than its “true” value due to this aftereffect. This aftereffect is thought to be much more prominent and longer lasting after convergence than after any similar vergence movement whether horizontal or vertical. One method of avoiding this influence is to test vertical vergence in between the two horizontal measurements.⁴

When prisms are placed before the eyes, there is a resulting change in the tonic state of the extraocular muscles, an increase in the amount of fixation disparity, and an increase in the fusional amplitude. These effects continue as long as the motor fusion response lasts. The cessation of this act either by occluding one eye, a breakdown in the fusion ability or by removing the prisms results in a gradual return to the previous (pre-prism) status. This gradual (rather than immediate) return to the previous fusional status is called prism adaptation.²

Prism adaptation has significant clinical importance in maintaining binocular fusion in cases of anisometropia and significant phorias.⁴ Vergence adaptation can explain the differences frequently found when measuring a deviation with the alternate cover test as opposed to the unilateral (cover/uncover) cover test, the difference between the stimulus and the response in AC/A measurements, the alteration in the phoria finding after successful vision therapy and the characteristic of some patients to constantly

require increasing amounts of prism power to reduce their symptoms.⁴ The amount and character of such vergence adaptation is amenable to optometric vision therapy.⁶

With the notable exception of the Optometric Extension Program method, it is currently common clinical practice that when measuring horizontal fusional reserves that the NFV measurement is performed before the PFV.⁷ The basis for this is the previously mentioned assumption that vergence adaptation due to BI can momentarily alter the BO finding but this change will not be significant. As previously stated the reverse is said to produce a significant change although there does not appear to be a study that directly measured the amount of this change.⁸ The current study compares the amount of divergent fusion measured before and after convergent fusion testing at a fixed interval. In addition we have measured the reverse phenomenon and compared the two results to see which is statistically significant.

Methods

Thirty subjects (26 females, 4 males) aged 18-30 (avg. = 24.5) were evaluated and near visual acuity of at least Jaeger 1 in both eyes. Each subject was administered a standard battery of tests in order to determine their acceptability into the subject pool. These tests consisted of the cover test, Modified Thorington test at near, and Randot Stereopsis test. Those included in the study had a phoria at near between orthophoria and 6 prism diopters of exophoria along with stereoacuity of 20 seconds of arc. The fusion testing method that was chosen was the step vergence method utilizing a prism bar and a target of a single line of 20/30 (6/9) letters placed at a distance of 40cm from the subject.³ Each subject was asked to respond as to when the blur point, break point and recovery point occurred.

The thirty subjects were randomly divided into two groups of fifteen, Group A and Group B. Each subject in Group A was tested twice, once at a specific time in the afternoon at which time the BI measurement preceded the BO and then one hour later with the BO testing preceding the BI. Group B underwent the same process however the testing order was reversed.

Results

Our analysis was limited to the break and recovery points as we were interested in the effects on

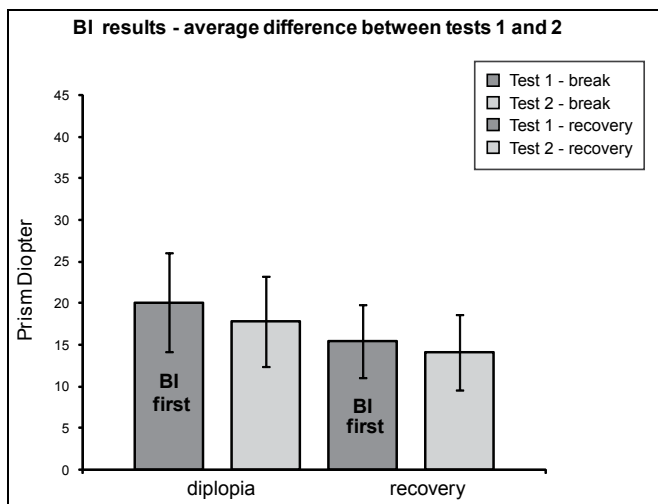


Figure 1: This graph shows the averaged results of the base in testing as measured in prism diopters. The graph depicts these measurements when performed before or after the BO testing. One can see that on average the results were higher when tested before BO testing was performed.

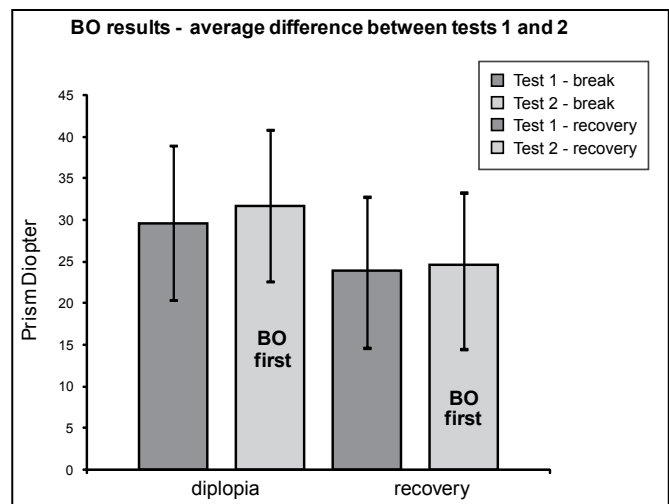


Figure 2: This displays the average results of the BO testing – the difference between the two tests on diplopia and recovery. The values are in prism diopters with test indicating BI tested first and test 2 indicating BI tested last.

total convergence (fusional plus accommodative) and not only fusional vergence. The statistical evaluation consisted of the student's t test. The results of the BI testing are shown in Figure 1. The average value of the break point in the first test, where BI was tested first, was 20.10 (± 5.92) whereas when BO was tested first this value was 14.13 (± 4.52). This difference was significant ($p=0.002$). The average value of the recovery point when BI was tested first was 15.47 (± 4.38) whereas when BO testing was performed first, the average value was 14.13 (± 4.52). The difference between these values was statistically significant. ($P=0.01$)

The BO results both break and recovery points, are shown in Figure 2. The average BO break point, when BI was tested first, was 29.53 (± 9.64) whereas when the order of testing was reversed this value was 31.30 (± 9.33). The average BO recovery point in the first test was 23.73 (± 9.30) whereas in the second test it was 24.87 (± 9.30) which was not statistically significant ($p=0.13$). The difference in the break points was similarly not considered significant ($p=0.09$).

Discussion

One might question why this study used the step vergence method for testing fusional reserves rather than widely used smooth (in phoropter) method. This method was chosen since it was thought to be more natural (not in phoropter testing) and enables one to view the subject's eyes thereby allowing confirmation of the subjective response with an observation of the objective response.³ It was previously stated that the

most accepted method of testing fusional reserves is to test BI before BO with the one exception of the Optometric Extension Program (OEP) method.⁹ The reasoning behind testing the divergent fusion first is to eliminate the supposed contaminating influence of vergence adaptation. One might easily conclude that this would indicate a flaw in the OEP method. The results of this study neither substantiate nor negate such a conclusion. The important point to consider is whether one wants to eliminate the effect of vergence adaptation or measure its influence. Either choice may be equally valid as long as the examiner is aware of what he is testing and that the analysis of the data takes this into consideration. The OEP analytical method takes this into account and is thus usually considered as valid as methods such as Graphical Analysis where the NFV test usually precedes the PFV.

Conclusions

As can be seen, the change in break and recovery measurements when testing BI after BO is statistically significant whereas the reverse did not hold. Therefore, the previously stated supposition that the vergence adaptation effect is not symmetric is shown to be untrue. It is worthwhile mentioning that there were significant differences in the range of fusion among the subjects who were tested even though all were considered normal. This is in agreement with currently accepted information which states that standard deviation of fusion ranges in normal individuals is quite high.⁴


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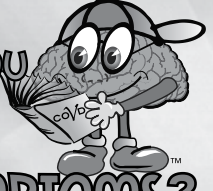
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