# IMPORTANCE OF PROXIMITY CUES ON THE DISTANCE ROCK ACCOMMODATIVE FACILITY TEST

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### Abstract

*The term used for the clinical assessment of dynamic properties of accommodation is accommodative facility. Accommodative facility is tested by alternating between two dioptric accommodative stimulus levels, and is measured in cycles per minute. This is achieved by changes in lens powers ("lens rock") or by changes in fixation distance ("distance rock"). Previous studies have reported greater facility rates on distance rock than on lens rock testing. Possible reasons for the difference could include difference in the change in dioptric accommodative stimulus required, time required for manipulation of lenses, difference in changes in fusional vergence, and proximity cues. An experiment was conducted to rule out factors other than proximity cues. Fifty university students, screened to eliminate visual system anomalies, were tested. Distance rock facility rates were higher than lens rock facility rates and rates on two control procedures, both monocularly and binocularly. We conclude that proximity cues are an important component of the accommodative stimulus on distance rock testing.*



### Key Words

*accommodation, binocular vision, convergence, optometric testing*


Accommodative facility testing is a method of assessing the latency and velocity of accommodative responses in the clinical setting. Accommodative facility assessment is beneficial in the diagnosis of accommodation and vergence disorders.[1-4] It is tested by alternating the dioptric accommodative stimulus between two levels, either by changing lens power or by changing target distance. The former is often called a lens rock test, and the latter is referred to as distance rock. While both are measures of accommodative facility, several test variables are different, including accommodation and convergence stimulus levels, task requirements, types of available stimulus information, etc. On lens rock testing, viewing is alternated between plus and minus lenses which are usually equal in absolute power.[3] The plus lenses are used to inhibit and the minus lenses to stimulate accommodation while maintaining fixation on the same plane. Accommodative facility can also be measured using a near-far alternate fixation technique (distance rock).[3,5] The distance rock test evaluates the ability to change fixation, and thus accommodation, alternately between a near and distant target.

Several differences in the visual tasks required on the two forms of accommodative facility testing can be identified. On the lens rock test, the dioptric accommodative stimulus is alternated between two levels, while the total convergence stimulus does not change. For the changes in accommodative vergence, which accompany the changes in accommodation, there must be a compensatory change in fusional vergence which is equal in amount but opposite in direction to the change in accommodative vergence. On the distance rock test, far viewing is associated with accommodative and vergence stimuli close to zero. The switch to near viewing requires increases in both accommodation and convergence. Fusional vergence would add to the accommodative convergence to give the full amount of convergence needed. Fusional vergence would be in the positive direction if the ACA ratio is low and in the negative direction if the ACA ratio is high.

Lens rock testing is usually done with a "flipper bar" which has the alternate sign lenses on either side of a handle. Lens rock testing thus requires manipulation of this flipper bar, while distance rock testing does not. On distance rock testing, not only are accommodation and vergence changed, but a vertical saccade is required for the shift in fixation between the near and far targets. For the lens rock testing, fixation is maintained on the same target.

The two forms of accommodative facility also vary in the types of stimulus cues available. Both optical and proximity cues are available on the distance rock test. It has been suggested that proximity cues affect the results of some clinical tests.[6,7] Optical cues are present on the lens rock, but the only proximity cues are those that might occur due to the magnification and minification effects of the plus and minus lenses.

## Previous Studies

Several studies have presented data for binocular lens rock with +2.00/-2.00 D flippers.[8-13] Means have generally been between 6 and 12 cycles per minute. Several variables, including test distance, size of test letters, and lens power affect lens rock test results.[14] Children in the first few years of school may have lower rates than older children and young adults.[13] There are strong practice effects on accommodative facility results.[15-17]

Haynes[5] reported distance rock facility rates for young adults using 20/25 letters. Mean rates varied from 20 to 26 cycles per minute, depending on the separations of the letters. For a sample of school children, mean distance rock facility rates varied with grade in school, from 14 cycles per minute for first graders to 26 cycles per minute for sixth graders.[5] These rates are higher than those reported for lens rock in other studies.

There appears to have been only one study which gave lens rock and distance rock data for the same population.[18] For 244 subjects between the ages of 7.9 and 15.9 years, the accommodative facility rates were determined with +2.00/-2.00 D flippers, and by alternating fixation between 4 m and reading distance. The mean rates were 8.9 cycles per minute for binocular lens rock and 20.9 cycles per minute for binocular distance rock.

## Purpose of the Study

Possible reasons for the higher facility rates on distance rock testing than on lens rock testing are: (1) different amounts of change in dioptric accommodative stimulus, (2) time required to flip the lenses, (3) difference in required change in fusional convergence on binocular testing, (4) absolute levels of accommodation and convergence required, and (5) lack of proximity cues to accommodation on the lens rock. We hypothesized that the difference was due, in part, to the lack of proximity cues on lens rock testing. Facility testing was performed under various conditions, eliminating the first four possible factors.

## Study Design and Procedures

One flipper set was designed to be performed in a "lens rock" fashion incorporating a +1.25/-1.25 D lens combination. The task was to alternately clear a 20/20 line on a reduced Snellen card at 40 cm. Although traditional lens rock tests are usually run utilizing the higher dioptric stimulus values of +2.00/-2.00 D, facility responses have been reported with lower dioptric lens powers.[9,14] The specific power of the lenses in this study result in equality of the total dioptric stimulus to accommodation between distance rock (2.50 D) and lens rock (2.50 D).

**Table 1. Stimulus Values for Flipper Tests**

| | Exposure #1 Accomm. Stimulus | Exposure #1 Conv. Stimulus | Exposure #2 Accomm. Stimulus | Exposure #2 Conv. Stimulus |
|---|---|---|---|---|
| Lens rock | 3.75 D | 15Δ | 1.25 D | 15Δ |
| Distance rock | 2.50 D | 15Δ | 0.00 D | 0Δ |
| Near control | 2.50 D | 15Δ | 0.00 D | 0Δ |
| Distance control | 2.50 D | 15Δ | 0.00 D | 0Δ |

**Table 2. Lens, prism, and fixation distance conditions used to achieve the stimulus levels given in Table 1.**

| | Exposure #1 Lens | Exposure #1 Prism | Exposure #1 Fixation Distance | Exposure #2 Lens | Exposure #2 Prism | Exposure #2 Fixation Distance |
|---|---|---|---|---|---|---|
| Lens rock | -1.25 D | 0 | 40 cm | +1.25 D | 0 | 40 cm |
| Distance rock | 0.00 D | 0 | 40 cm | 0.00 D | 0 | 6 m |
| Near control | 0.00 D | 0 | 40 cm | +2.50 D | 15D BI | 40 cm |
| Distance control | -2.50 D | 15Δ BO | 6 m | 0.00 D | 0 | 6 m |

The second flipper set was used to determine "distance rock" facility. It was composed of Plano lenses on both sides. Traditionally, distance rock tests do not employ lenses as an accommodative stimulus. However, a flipper was included in this instance to control for the variables induced by a lens stimulus and the time required to flip the lenses during the lens rock procedure not normally present during a distance rock. The distance rock flippers were flipped between clearing of the 20/20 line on a distance Snellen acuity chart and the 20/20 line on a reduced Snellen card at 40 cm. Thus, the change in stimulus to accommodation is 2.50 D, the same as for the above mentioned lens rock test.

The third flipper set was designed to be used as a "near control" for the other two. It was decided to duplicate the accommodation and convergence stimulus levels of the distance rock test to eliminate different absolute levels; 3.75 D and 15Δ for lens rock as compared to 2.50 D to 0.00D and 15Δ to 0Δ for distance rock (see Table 1). This was achieved at near by placing Plano lenses in one side of the flipper bar and combining +2.50 D with 15Δ BI on the opposite side while viewing the same plane of regard at 40 cm. The Plano lenses produce a 2.50 D stimulus to accommodation when a 20/20 Snellen line is viewed at 40 cm. The +2.50 power in the opposing side provides 0.00 D stimulus to accommodation at 40 cm, while the 15D BI makes the convergence demand to 40 cm equal to 0Δ. This combination imitates the accommodation and convergence stimuli of optical infinity.

The fourth flipper set was designed to be used as a "distance control" for the first two by imitating the accommodation and convergence stimulus levels of distance rock testing with fixation at distance. Plano lenses were placed in one side of the flipper. On the other side of the flipper we placed -2.50 D and 15Δ BO. Viewing a 20/20 line on a distant Snellen chart with these lenses provided the same accommodation and convergence stimuli as a near target. The flippers containing prism had the prism power split equally between the two eyes.

An outline of the dioptric and prism dioptric stimuli for each set of flippers is given in Table 1. A summary of the lens and prism powers and fixation distances

**Table 3.**
**Convergence changes, increase (+) or decrease (-) from Exposure #1 to Exposure #2, on binocular testing. For monocular testing, fusional convergence changes would be 0 in all cases.**

| | Accomm. Conv. | Fusional Conv. | Total Change |
|---|---|---|---|
| Lens rock | (-) | (+) | 0 |
| Distance rock | (-) | + or - depending on AC/A ratio | (-) |
| Near control | (-) | + or - depending on AC/A ratio | (-) |
| Distance control | (-) | + or - depending on AC/A ratio | (-) |

**Table 4.**
**Mean facility rates and standard deviations (SD) in cycles per minute.**

| | OD | | OS | | OU | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| Lens rock | 16.9 | 4.6 | 18.3 | 4.6 | 17.3 | 6.1 |
| Distance rock | 21.0 | 4.9 | 22.3 | 4.9 | 24.1 | 4.8 |
| Near control | 11.6 | 8.6 | 12.8 | 8.8 | 14.9 | 5.2 |
| Distance control | 13.6 | 5.7 | 15.3 | 5.1 | 15.9 | 5.3 |

**Table 5.**
**Number of subjects who answered yes on questionnaire.**

| | Eyestrain | Lost Place Along the Row of Letters | Diplopia | Most Difficult |
|---|---|---|---|---|
| Lens rock | 20 | 8 | 13 | 4 |
| Distance rock | 7 | 40 | 3 | 2 |
| Near control | 25 | 13 | 25 | 34 |
| Distance control | 26 | 11 | 23 | 10 |

used to achieve those stimulus levels is given in Table 2. On all four procedures a change in accommodative stimulus would be associated with a change in the optical cues. Only the distance rock had a change in fixation distance. Monocular testing eliminates fusional vergence as a factor. Changes in fusional convergence on binocular testing are summarized in Table 3. Although monocular testing did eliminate fusional vergence, on the flippers containing prism, an eye movement to compensate for the prism would have been necessary.

One examiner performed testing to determine subject eligibility and another performed the facility tests without knowing the findings obtained on the eligibility testing. Flipper tasks were performed, OD, OS, OU, in that order. The order of the individual flipper tests (lens rock, distance rock, near control, and distance control) was varied in a counterbalanced fashion in order to equalize the distribution of each test procedure in the test sequence.

The target used was a single row of Snellen 20/20 letters for both 6 m and 40 cm. After each task was performed, the letters were changed to limit learning or memorization by the subject. The targets were carefully aligned for distance and near, especially for the distance rock test so as to minimize any version eye movements. A specially made flipper set was used to align the lenses with the subjects' interpupillary distance. Standard room illumination was used for the distance target. In addition, the overhead lamp was set on a standard high illumination for the near target. The overall goal was to provide good contrast of targets for all tests.

Each task began with the stimulatory accommodative stimulus, i.e., the minus lens or the near target. When the letters were clear and single, the subject was to call out the first letter of the target. The lens was then flipped by the examiner and the subject was to call out the second letter of the target (or the first letter of the far target for distance rock). When it was clear and single, the lens was again flipped. Every two flips constituted one cycle (i.e., near-far-near was one cycle, minus-plus-minus was one cycle). Following the completion of the facility tests, subjects completed a questionnaire concerning the ease and comfort of the tests. Because the binocular vision requirements in the subject inclusion criteria (below) were fairly stringent, no attempt was made to monitor suppression during facility testing.[21]

## Subjects

Fifty university students, 21 to 36 years of age, were used as subjects. Forty-five of the 50 subjects were optometry students. Criteria for inclusion in the study were: (a) visual acuity at least 20/20, monocularly and binocularly, at distance and near, with correction, (b) a break of 7 cm or closer and a recovery of 11 cm or closer on nearpoint of convergence testing, (c) no tropia indicated by the cover test, (d) no microstrabismus shown on the 4Δ base-out test, (e) passing score on NSUCO saccade and pursuit testing,[19] (f) Donders push-up amplitude exceeding Hofstetter's minimum age expected value,[20] (g) stereoacuity of at least 40 seconds of arc at 16 inches, (h) magnitude of both the negative relative accommodation finding and the positive relative accommodation at least 1.75 D, and (i) no ocular disease.

## Results

A summary of means and standard deviations of the facility rates is given in Table 4. The distance rock rates were greater than the lens rock, near control, and distance control rates, OD, OS, and OU. The differences were all statistically significant at the 0.0000001 level. Facility rates were normally distributed on all four tests OD, OS, OU, with the exception of the distance control OD and OU, which were negatively skewed.

Table 5 shows the numbers of subjects who reported difficulty on the testing procedures. Most subjects reported losing their places along the row on the distance rock. Otherwise, it appeared to be the easiest procedure. Most subjects reported the near control to be the most difficult procedure.

## Discussion

Possible reasons for different performance on the distance rock and lens rock tests in previous studies were listed above in the section of this paper on the purpose of the study. This study was designed to rule out each of those factors except proximity cues. With those factors ruled out, the distance rock rates were higher than those for the other procedures. Therefore, we conclude that the proximity cues from the change in viewing distance on the test are an important part of the accommodative stimulus during that procedure.

Further evidence for the importance of proximity cues may come from the lower rates and the subject reports of greater difficulty on the near control and distance control procedures. There was no change in viewing distance on these procedures, but optical cues and proximity cues were conflicting on one side of the flippers on each procedure. On the near control, the +2.50 D lens and the 15Δ BI prism, along with the 40 cm viewing distance, represent zero accommodative and convergence stimuli, but the awareness of nearness of the fixation target at 40 cm would stimulate accommodation and convergence. On the distance control, the -2.50 D and 15 BO stimulated accommodation and convergence, but the 6 m viewing distance suggested accommodation and convergence should be at a minimal level. That conflict between optical and proximal cues may have been responsible for the lower performance on the near control and distance control procedures.

## Conclusion

Proximity cues are an important component of the accommodative stimulus on distance rock accommodative facility testing.

## References


1. Cooper J. Accommodative dysfunction: In: Amos JF, Ed. Diagnosis and management in vision care. Boston: Butterworth, 1987: 431-54.
2. Wick B, Hall P. Relation among accommodative facility, lag, and amplitude in elementary school children. Am J Optom Physiol Opt. 1987; 64(8): 593-98.
3. Daum KM. Accommodative facility. In: Eskridge JB, Amos JF, Bartlett JD, Eds. Clinical procedures in optometry. Philadelphia: Lippincott, 1991: 687-97.
4. Goss DA. Ocular accommodation, convergence, and fixation disparity: a manual of clinical analysis, 2nd ed. Boston: Butterworth-Heineman, 1995: 135-46.
5. Haynes HM. The distance rock test—a preliminary report. J Am Optom Assoc, 1979; 50(6): 707-13.
6. Hokoda SC, Ciuffreda KJ. Theoretical and clinical importance of proximal vergence and accommodation. In: Schor CM, Ciuffreda KJ, Eds. Vergence eye movements: basic and clinical aspects. Boston: Butterworth, 1983: 75-97.
7. Ciuffreda KJ. Accommodation and its anomalies. In: Charman WN, Ed. Visual optics and instrumentation, Vol. 1 of Vision and visual dysfunction. Boca Raton, FL: CRC Press, 1991: 231-79.
8. Burge BA. Suppression during binocular accommodative rock. Optom Monthly, 1979; 79(12): 867-72.
9. Garzia RP, Richman JE. Accommodative facility: a study of young adults. J Am Optom Assoc, 1982; 53(10): 821-25.
10. Zellers JA, Alpert TL, Rouse MW. A review of the literature and normative study of accommodative facility. J Am Optom Assoc, 1984; 55(1): 31-37.
11. Hennessey D, Iosue RA, Rouse M. Relation of symptoms to accommodative infacility of school-aged children. Am J Optom Physiol Opt, 1984; 61(3): 177-83.
12. Levine S, Ciuffreda KJ, Selenow K, Flax N. Clinical assessment of accommodative facility in symptomatic and asymptomatic individuals. J Am Optom Assoc, 1985; 56(4): 286-90.
13. Scheiman M, Herzberg H, Frantz K, Margolies M. Normative study of accommodative facility in elementary school children. Am J Optom Physiol Opt, 1988; 65(2): 127-34
14. Siderov J, Johnston AW. The importance of the test parameters in the clinical assessment of accommodative facility. Optom Vis Sci, 1990; 67(7): 551-57.
15. McKenzie KM, Kerr SR, Rouse MW, Deland PN. Study of accommodative facility testing reliability. Am J Optom Physiol Opt, 1987; 64(3): 186-94.
16. Rouse MW, DeLand P, Chous R, Determan TF. Monocular accommodative facility testing reliability. Am J Optom Physiol Opt, 1989; 66(2): 72-77.
17. Rouse MW, DeLand PN, Mozayani S, Smith JP. Binocular accommodative facility testing reliability. Optom Vis Sci, 1992; 69(4): 314-19.
18. Jackson TW, Goss DA. Variation and correlation of clinical tests of accommodative function in a sample of school-aged children. J Am Optom Assoc, 1991; 62(11): 857-66.
19. Maples WC, Ficklin TW. Interrater and test-retest reliability of pursuits and saccades. J Am Optom Assoc, 1988; 59(7): 549-52.
20. Hofstetter HW. A useful age-amplitude formula. Penn Optom, 1947; 7(1): 5-8.
21. Pica M, Redmond MS, Zost M. Polarized versus anaglyphic materials for suppression control in binocular accommodative facility testing. J Behav Optom, 1996;17(2): 43-45.



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Date accepted for publication:
March 12, 1996