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A Presumed Reflex by which Upward Gaze Induces Relaxation of Accommodation, a Way to Overcome Instrument Myopia

E. Z. BLUMENTHAL

15 Erez Street, Omer, 84965, Israel

Abstract — This hypothesized reflex relates the vertical direction of gaze to the amount of tension exerted by the ciliary muscle. Based on simple observations the following is assumed. When looking downwards a tendency for closer focusing (near searching) exists even without a specific visual stimulus, whereas looking up favors a more relaxed state of the accommodative mechanism. This reflex is much weaker than accommodation induced by visual stimuli but may have potential practical implications with regards to automated objective ocular refraction devices. When using such instruments it is crucial to eliminate entirely all accommodation. The inability to achieve such relaxation has prevented automated devices from completely replacing all manual and subjective techniques in ophthalmology practice. If the reflex is empirically proven to exist, then by performing objective examinations while the patient's gaze is directed up, more precise measurements may be achieved. An additional benefit can be derived from comparing upward versus forward gaze measurements. Even a small difference can imply that accommodation has been triggered, so that ultimately this screening method enables identification of the accommodators sub-group and reciprocally approving the accuracy of the non-accommodators sub-group results.

Introduction

Techniques for measuring the refractive error of the human eye have been revolutionized since the first attempts to arrive at the optimal eye-glasses prescription using loose lenses placed in a trial-frame. Today, devices employing the latest technology of optics and electronics can provide prescriptions of both spherical and cylindrical values within a few seconds. These devices are automated and therefore independent of any operator experience or skill. Moreover, they are objective and therefore unbiased by patient responses, cooperation, intelligence or indecisiveness related to the nature of any subjective observation. The huge time saving and ease of operation should have made these techniques a part of every optometrist's and ophthalmologist's routine.

Contrary to expectations, the automated objective devices have largely failed to replace the classical exhaustive subjective examinations. Even in the most

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hi-tech clinics the phoropter and loose lens tray have not been discarded. The main reason for the unfavorable approach toward automated refractors is an error that invalidates a substantial percentage of all examination results, especially of younger aged patients. This error relates to instrument myopia, dead space myopia, or apparatus accommodation (1). These phenomena imply involuntary contraction of the ciliary smooth muscle and therefore a considerable change in the refractive power of the eye. This error totally invalidates the results obtained from a sub-group of examined patients. Practical problems arise both from the artifact itself and even more important, the inability to identify this problematic sub-group.

Various factors have been attached to these accommodative phenomena, such as fatigue, level of attention, illumination, image detail, various ill-defined psychological factors and the lack of a fixation target placed at optical infinity (1).

The reflex

The following hypothesized reflex may have some influence on relaxation of accommodation and consequently lead to more accurate results obtained by automated objective devices. A further important benefit is identifying this problematic sub-group of undesired accommodators. This reflex may have its origin either as congenital or acquired (through conditioning).

An upward gaze, relaxation of accommodation reflex implies a connection between the vertical axis of gaze at any moment and the tension exerted by the circular ciliary muscle of the eye. This tension directly influences the shape of the lens, and ultimately the total spherical refractive power of the eye. More specifically, this reflex causes upward gaze to induce a relaxed state of the ciliary muscle, whereas downward gaze leads to constriction of the muscle, loosening of the zonules and ultimately bringing closer the far point of the eye.

By upward gaze, two different movements are possible: either neck extension or an upward rotation of the eye (of the visual axis) within the orbit, accomplished through extra ocular movements (EOM). Intuitively I believe that EOM are more significant to the reflex as the following observations may suggest. (Upward gaze maneuvers should not be confused with lying on the back (supine) which is basically a straight forward gaze).

Observations

The hypothesis is based on the following observations:

1. Looking down (downward gaze) is used in everyday life for focusing on near-by objects such as finger manipulation, printed matter or the floor. Notice that reading is always done in a downward gaze. This can result from the existence of the reflex or vice versa: could be the primary conditioning for the reflex formation.
2. Upward gaze is mainly used for focusing on far away objects as scenery and the sky, it should be remembered that from an optical point of view infinity starts from as close as 6 m away.
3. Convergence is compounded by obligatory accommodation in the well-known accommodation-convergence reflex. People prefer to converge while looking down and it is very rare in everyday life that we converge while looking up. One exception is the unique and new habit, for humans, of spending hours in front of the monitor of a computer set in a forward gaze. This might explain some of the eye strain encountered. (There may be an advantage in placing computer screens at key board height, in a book like position, which would also relieve some of the shoulder-neck strain).
4. Both discomfort and strain are felt when trying to converge and focus on a near-by object high up, (this can be appreciated by trying to focus the fingerprints of your forefinger when placed just above your forehead).
5. Presbyopic aids are traditionally placed in the lower part of the frame, giving only down gaze reading ability.

Conclusions

The above observations have raised the hypothesis that if one were to place the automated refraction devices so that the examinee has to elevate his gaze, a possible relaxation of the ciliary muscle would emerge. In order to achieve this result only slight furniture adjustments will be needed, for example, an adjustable head rest and an adjustable stand for the device with both height and tilt possibilities.

Although automated refractive devices are monocular, with occlusion of the non-fixating eye, the reflex probably still exists in this setting. Let me point out that if only a partial relaxation is achieved, the difference between the results of forward versus upward gaze hints to the possibility that the examinee belongs to the problematic sub-group. This discrepancy implies that he should be referred to a more time consuming (but accurate) subjective examination. Although mainly concerned with automated objective

refracting devices, the reflex mentioned above has relevance to any refraction method whatsoever.

To empirically study whether the reflex exists the following is suggested. Each person from a large sample will be given the following four refraction tests:

A. subjective refraction;
B. cycloplegic refraction;
C. the usual forward gaze automated objective refraction;
D. upward gaze automated objective refraction.

Attention should be given to A–C differences vs. A–D differences. When A is significantly different (more negative) than B, we can assume unwanted accommodation in the subjective test (A) and thereafter substituting B for A would seem more appropriate.

One possible procedure for a routine office refraction test includes:

I. an upward gaze automated objective refraction reading;
II. a forward gaze reading to supplement I;
III. any discrepancy between I and II calls for a more extensive workup.

It must be stressed that the cylindrical component (both axis and power) should not change in a clinically significant manner even when ciliary contraction is present (as long as the principle meridians of the eye are measured simultaneously). Therefore we can rely on the cylindrical results obtained by automated objective devices when questioning the spherical measurement, which has been the issue of this paper.

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