THE SEVEN PRIMARY POSITIONS OF GAZE*†

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The existence of multiple primary positions of gaze and the need for investigating the changing binocular status in such multiple positions were reported many years ago. Moreover, changes now labelled as “A” and “V” phenomena were also suggested (Krimsky, 1948) long before they were mentioned as a novel discovery (Fig. 1).

**Fig. 1.—** The three primary positions: (1) Straight-up and straight-down (Krimsky, 1948). (2) Paralysis of left superior oblique. Right eye remains the fixing eye. In looking straight down the left eye shows 1° esotropia and 10° hypertropia. This is now referred to as the “V” phenomenon (Krimsky, 1948). (3) Paralysis of left inferior oblique. Right eye remains the fixing eye. In looking straight up the left eye shows 1° esotropia and 10° hypotropia. This is now referred to as the “A” phenomenon (Krimsky, 1948).

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Duane (1897) described the primary positions for near and distance, and noted that eyes often showed different deviations for near and distance. He distinguished between these two test ranges by referring to the near one as the "convergence range" and the 20-foot test distance as the "divergence range". He then divided deviations found at these separate ranges, other than convergence near-point disorders, as follows:

1. **Convergence Excess**—esotropia for near, and
   **Convergence Insufficiency**—exotropia for near;
2. **Divergence Excess**—exotropia for distance, and
   **Divergence Insufficiency**—esotropia for distance.

While Duane noted different deviations for two separate primary positions, his observations were limited to the horizontal plane of gaze. Deviation studies were also made with the eyes taking up six peripheral motor or cardinal positions in order to establish an anatomical or eye-muscle pattern. Because post-operative results were not always predictable and because post-operative straightening of the eyes might prove only transient, other reasons were sought to explain the deviations. These included neurogenic, psychogenic, refractive, and visual disorders. Using the Wheatstone type of stereoscope (Wheatstone, 1838, 1852) as exemplified by the synoptophore as well as a refined calibrated type of Brewster stereoscope (Krimsky, 1937, 1941a), eyes were studied not only to ascertain deviation, but also to determine normal or abnormal image responses, such as fusional amplitude, visual suppression, or retinal correspondence. In the Brewster type of stereoscope one can, by incorporating a tilting mechanism, study the eyes in the straight-up and the straight-down primary positions for near and distance and make controlled observations of the corneal light reflexes (Fig. 2).

![Brewster stereoscope](image)

**Fig. 2.**—Brewster stereoscope adjusted to selected ranges of accommodation, or to upward or downward gaze in the primary positions (author's model).

Tschermak (1903) also aimed at evaluating abnormal binocular responses in strabismus by investigating retinal correspondence. He sought to elicit so-called after-image responses by subjecting the eyes momentarily to a bright source of light; as this is a subjective test requiring a highly co-operative patient, this method did not gain wide use.

It already seemed obvious that the primary positions were becoming increasingly important in our evaluation of the binocular status of the eyes, as regards both
deviation and function. Scobee (1952) did not agree that there was a need to stress the primary positions:

"To include up and down directions of gaze as cardinal positions is erroneous, for these are not cardinal positions and no information of value is gained . . . the fallacy of attempting to study versions in any but the six cardinal directions of maximal motor efficiency is evident."

Because the positions of the corneal reflexes provided reliable landmarks in the study of deviation and image response both with the synoptophore and with the author's modified Brewster stereoscope (Krimsky, 1941a), a simpler objective method was sought, first by using an ordinary flashlight and then by again studying the corneal reflexes with the aid of a prism (Krimsky, 1943). It was found that a prism of correct strength could restore a displaced corneal reflex, as in strabismus, to the normal or central pupillary position and could thereby serve as an accurate measure of deviation. This was confirmed by supplementary cover (screen) testing. It was also shown that in cases of marked amblyopia accompanied by eccentric fixation, where the cover test fails to operate, the prism-reflex method will readily indicate the degree of strabismus, and that in smaller deviations, where the cover test fails to show noticeable eye movement, good responses could be obtained.

The value of the prism-reflex method (Krimsky, 1951) was enhanced by ascertaining objectively both functional and image responses as well as deviations both in normally straight eyes and in eyes showing manifest strabismus. In normally straight eyes it is possible to demonstrate the nature and amount of latent strabismus (heterophoria) as well as the fusional amplitude. In eyes showing manifest deviation one could determine objectively not only the amount of deviation but also the nature and amount of rudimentary fusional amplitude (if present), spontaneous diplopia (if present), visual suppression, and retinal correspondence. All this is mentioned because, in the investigation of the status of the eyes in the different primary positions of gaze, the eyes may respond normally in some positions and abnormally in others.

The flashlight and prism prove adequate in most cases, but in more marked deviation an arc-shaped apparatus gives more accurate results. The ordinary perimeter is unsuitable because the obstructive framework in the centre of the arc prevents proper inspection of the eyes and corneal reflexes, and the central pivot limits the examination to the horizontal position of gaze. If the ends of the arc are pivoted at the sides, as in the cardinal anglometer (Krimsky, 1941b), these drawbacks are overcome (Fig. 3). The eyes can be seen directly by the examiner and the corneal reflexes can be measured for the three primary positions for near and distance.

Fig. 3.—Cardinal anglometer for measuring convergent strabismus. In this case of right convergent strabismus, the left eye is made to look at the zero position of the arc, the right eye being directed towards the 44° position. The illuminated carriers enable the corneal reflexes to be centred in each eye, and thereby to serve as a measurement of the strabismus (author's model).
The Meaning of Primary Positions of the Eyes

The term "primary position" implies a mean or zero position, when looking straight ahead, as in driving an automobile. It also means looking straight up and straight down along this mean sagittal or antero-posterior plane. Because it includes three primary positions for near and distance as well as the convergence near-point, we must consider seven primary positions, each giving individual test responses (Krimsky, 1948).

In studying deviation and eye movements, one cannot dissociate the primary position of the eyes from the primary position of the head. The relation between head-turning and eye-turning in daily visual activities has not been sufficiently explored.

The Paraprimary Positions

It is not generally recognized that, in the absence of voluntary effort, the eyes normally remain at or near the primary positions. At different levels of gaze normal eye excursions do not usually exceed 5 or 10° from the mean sagittal or antero-posterior plane, lest the strain on the ocular muscles become painful. In looking up beyond this, the subject will instinctively tilt the head backwards to avoid muscle strain from hypercontraction of the superior rectus and inferior oblique muscles in addition to the occipito-frontalis muscle. Normal downward movements of the eyes, on the other hand, require no strain and may amount to more than 45° below the horizontal. These comfortable paraprimary positions form but a small part of the entire motor field which, according to Duane, extends to 50° to 60° inwards, outwards, or downwards, from the zero central position, and from 40° to 60° upwards. Tests on the cardinal angiometer showed extreme extraprimary eye movements as follows:

- Extreme upward gaze–15° v. 5–10° paraprimary.
- Extreme right or left–40° v. 5–10° paraprimary.
- Extreme downward gaze–60° v. 45° paraprimary.

From a practical or clinical standpoint we may ask what importance should be given to findings elicited in the more extreme regions of the motor field which are not normally required. A restful eye position is more easily tolerated when the concomitant head position is restful. It is uncommon to see heads that are militarily straight. There is frequently a slight head-tilt in persons whose eyes are straight, and this very slight inclination becomes part of the subject's normal appearance.

As stated above, the eyes turn easily to the right or left through a small paraprimary excursional range from the zero position. In abnormal states, such as Duane's syndrome (congenital fibrosis of the lateral rectus muscle), the eyes may appear perfectly straight in a limited primary sphere of gaze in which they often show normal binocular function and even a satisfactory near-point of convergence; but because the paraprimary motor field becomes much reduced, head-turning is exaggerated to compensate for the inability of the eyes to turn easily beyond certain limits.

The Cardinal or Extra-primary Positions

The importance of the primary and paraprimary motor fields for normal daily visual requirements having been recognized, one may ask how necessary is it to force the eyes into extreme positions to evaluate binocular function in the commonly-needed positions.

Measurements made in such extreme positions can never be meaningful or accurate if the examiner has to juggle a battery of prisms, hold the patient's head, operate a cover and a light, and face a tense patient or a screaming child. To simplify such study objectively, considerable information may be gained merely by observing and noting the positions of the corneal reflexes in selected positions of gaze, and by supplementing such studies by
prism-reflex measurements. More elaborate studies may be carried out with the cover test or the cardinal angrometer.

**Binocular Testing in the Primary Positions of Gaze**

(A) **Studying the Positions of the Corneal Reflexes using only a Flashlight**

With the flashlight alone one can ascertain whether the eyes are straight by observing the corneal reflex in the primary positions, looking straight up, straight down, and straight ahead, and noting any displacement of the corneal reflex.

*Testing for Near Vision* (Fig. 4A).—The examiner holds a flashlight firmly against his cheek directly beneath his fixing eye, and directs the light towards the bridge of the patient’s nose to illuminate both eyes equally. The patient is instructed to look at the flashlight, and the position of the corneal reflex is noted mentally in relation to the pupillary centre, first with each eye separately and then with both eyes uncovered. If the corneal reflexes are in the same place in the uniocular observations as when both eyes are observed together, it appears that the eyes are straight for that position of gaze.

![Fig. 4.—Method of observing corneal reflexes. (A) For near. (B) For distance (20 feet). The examiner faces the patient directly but lowers his head slightly to observe the light reflexes from a 75 watt test light.](image)

*Testing for Distance* (Fig. 4B).—The observer tells the patient to look at a 50 or 75 watt lamp at a distance of 20 ft., and examines the eyes first separately and then together. The examiner sits directly in front of the patient rather than to one side and lowers his head slightly so that the patient can see the lamp just above his (the examiner’s) head.

To determine how the eyes behave on looking straight up or straight down, the examiner either raises or lowers his head to make the patient look up or down at the lamp, or remains still while the patient bends the head backwards or forwards while looking at the lamp.

*Testing for Convergence Near-Point* (Krimsky, 1961).—A flashlight is brought gradually nearer to the patient’s eyes and the positions of the corneal reflexes are observed. As soon as the limit of convergence is reached, one eye turns out and the corneal reflex is displaced inwards from its normal position.
(B) Supplementary Testing with Flashlight and Prism

(1) Prism-Reflex Test in Manifest Strabismus.—Displacement of the corneal reflex in either eye indicates the presence of manifest strabismus. In convergent strabismus the corneal reflex is displaced outwards (temporally); a base-out prism of sufficient strength will restore the corneal reflex to the central pupillary position, and the strength of the prism will represent the degree of deviation, which is noted in terms of prism dioptres (Fig. 5). It is preferable to place the prism over the deviating eye to avoid errors which might otherwise be introduced through secondary deviation, as in cases of muscular paralysis.

![Fig. 5.—Prism-reflex test in manifest strabismus.](image)

(1) Right convergent strabismus. There is temporal displacement of the corneal reflex in the right eye, and subsequent restoration to the central position by using a 20-dioptre base-out prism. (2) Left divergent strabismus. There is medial displacement of the corneal reflex in the left eye, and subsequent restoration to the central position by using a 30-dioptre base-in prism.

(2) Prism-Reflex Test in Latent Strabismus.—Normally straight eyes show either orthophoria or heterophoria for near and/or for distance. This is measured by different methods, such as the cover test or the Maddox rod, or by placing a sufficiently strong base-down prism before either eye to “break” fusion and create double vision. By the prism-reflex method one can tell objectively whether one is dealing with orthophoria or heterophoria for any test distance by noting the changes in the relative positions of the corneal reflexes when the base-down prism is used.

In orthophoria the eyes remain straight; the patient sees two lights in true vertical alignment, and the examiner sees two corneal reflexes in true vertical alignment—a simple objective proof of true vertical diplopia.

In latent exophoria or esophoria, because the eye moves inwards or outwards as a result of the base-down prism, the corneal reflex will be displaced obliquely in the deviating eye (Fig. 6, opposite); the images are now seen by the patient in an oblique arrangement, and the relative positions of the corneal reflexes will demonstrate this to the examiner. To measure such a latent deviation objectively, the observer endeavours to bring the corneal reflexes into a true vertical relationship by adding a supplementary base-in or base-out prism. The strength of prism required represents the degree of exophoria or esophoria.
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Fig. 6.—Prism-reflex test in exophoria. (A) Before the base-down prism is applied, the eyes are straight and the corneal reflexes are centred in both pupils. (B) Effect of 20-dioptre base-down prism over the left eye. Because the eyes cannot overcome the effect of the prism, the patient sees double and the corneal reflex is displaced in one eye. The right eye turns outwards (exophoria) and the reflex is displaced medially. The nature of the projection emanating from the right eye is readily determined by the position of the displaced corneal reflex.

(3) Prism-Reflex Test in the Study of Image Responses

(A) IN NORMALLY STRAIGHT EYES (Fig. 7)

The ability of the eyes to overcome prisms of increasing strength and to maintain binocular single vision is known as fustional amplitude. In terms of the prism-reflex test this means that the corneal reflexes remain in their normal central pupillary positions while the eyes converge or diverge with increasing strengths of base-in or base-out prisms. Near testing is carried out with a flashlight and graded prisms, and distance testing with a 50 or 75 watt lamp at 20 ft. In normal eyes the limit of prism convergence or divergence is reached as soon as the corneal reflex becomes displaced from the central position in either eye.

Fig. 7.—Prism convergence tested by the prism-reflex method. (A) The corneal reflexes are centred in both eyes before applying a base-out prism, and the eyes are straight. (B) The subject overcomes the effect of a base-out prism. The left eye turns in behind the prism while the right eye remains straight. The corneal reflexes remain centred on both pupils and the patient achieves binocular single vision.

(B) IN MANIFEST STRABISMUS

(i) Suppression.—Without the benefit of the prism-reflex test to control observation of the corneal reflexes, one is often uncertain whether one is dealing with normal binocular vision, with eyes that are apparently straight though actually deviating, or with abnormal visual suppression which may involve an extensive area of the retina. One first establishes whether the eyes are straight by using a flashlight as explained above. Increasing base-out and then base-in prisms are then applied to observe whether the eyes converge or diverge. In manifest strabismus the prism merely causes a change in the displacement of the corneal reflex; without observation of the corneal reflexes this may be interpreted as a fusional amplitude response because the patient continues to see single. Then, when the patient suddenly sees double with increasing prism strength, this may be erroneously interpreted as prism convergence or divergence. Only careful observation of the positions of the corneal reflexes will enable the observer to distinguish between a normal response and suppression.
(ii) Diplopia.—In binocular diplopia due to muscular paralysis, the corneal reflex is displaced in one eye. By observing the relative positions of the corneal reflexes (Fig. 8), the examiner can see at a glance the nature of the diplopia, the direction in which the false image is being projected, and the amount of separation of the true and false images; he will thus know whether the diplopia is real or imaginary. If the corneal reflex is displaced temporally, as in paralytic convergent strabismus, the false image will likewise be projected temporally in relation to the true image emanating from the fellow eye.

By the prism-reflex method, the examiner can bring the reflex back to the normal position in the deviating eye and produce a super-imposition of the dual images.

(iii) Retinal Correspondence.—The prism-reflex test enables the examiner to find out whether retinal correspondence is normal or abnormal in cases of manifest strabismus, and to measure the degree of abnormal retinal correspondence, if present, by using the corneal reflex as a controlled landmark.

A prerequisite to the existence of retinal correspondence is the presence of relative visual suppression and the avoidance of diplopia by suppression in the deviating eye. By applying a prism of sufficient strength to divert the light rays in the deviating eye beyond the suppression zone, one can induce double vision and observe the positions of the corneal reflexes in relation thereto. If the resulting diplopia and the relative positions of the double images conform to the displaced positions of the corneal reflexes or follow the laws of normal retinal projection, then the retinal correspondence is said to be normal even though it forms part of an abnormal state with visual suppression. If the resulting projections of the induced double images do not correspond with the displaced positions of the corneal reflexes induced by an appropriate prism, then the retinal correspondence is said to be abnormal.

To test for retinal correspondence in convergent strabismus by the prism-reflex method,
first note the temporal displacement of the corneal reflex in the deviating eye, and then bring it back to the central position with a base-out prism, which will allow the light rays to strike both foveae simultaneously. Thirdly, because of the suppression in one eye, add a supplementary prism, base-down and of sufficient strength to produce vertical diplopia. If the induced double images are in true vertical alignment (as in cases of latent strabismus without suppression), then the resulting retinal correspondence is said to be normal, and the corneal reflexes will also be seen in true vertical alignment. If, on the other hand, the dual images are arranged obliquely although the corneal reflexes are in vertical alignment, then the retinal correspondence is said to be abnormal because it does not follow the laws of normal retinal projection. The degree of abnormality can be measured by the strength of the supplementary prism which is required to bring the images into vertical alignment.

“A” and “V” Phenomena

The diagnosis of a syndrome without controlled observation of the corneal reflexes requires one to distinguish between a true abnormality and a simulated phenomenon or effect. Since a deviation may not be constant for any one position, let alone the three primary positions, and since the methods of testing may not be uniform, different deviation patterns have led some observers to compare them to the formation of the letters “A” and “V” and to call the appearance a “syndrome” or “phenomenon”. The labelling of such changing and labile deviations as specific conditions or syndromes establishes in the mind of the examiner the idea that the fault lies primarily in one or more of the ocular muscles, frequently without excluding possible extraneous factors.

Factors which may upset the measurement of ocular deviation are:

1. Post-operative effects on the insertions of the ocular muscles.
2. Innervational factors of central nervous origin (convergence or divergence centre), cranial nerve paralysis, or functional changes of extraneous or unexplained origin.
3. Refractive errors.
4. Blindness or amblyopia in one or both eyes.
5. Presbyopia.
6. Impaired fusional amplitude or abnormal image responses.

Conclusion

1. The corneal reflex is a reliable landmark in detecting ocular deviation, and enables an observer to prove objectively the presence of diplopia as well as indicating the projection of the false image.
2. The prism-reflex method is a simple objective test for the measurement of strabismus, and of such image responses as diplopia, fusional amplitude, suppression, and retinal correspondence.
3. A thorough examination to establish the existence of changing deviations with changes in the position of gaze must include the cardinal, the paraprimary, and the seven primary positions of gaze from the anatomical and functional standpoints, extraneous factors being ruled out.
4. Fusional amplitude is often confused with suppression, but by the prism-reflex method an objective distinction can be made between them.
(5) An ocular muscle syndrome, whether the "A" and "V" phenomena or the blind spot, should be based on conclusive proof of the nature and degree of the ocular deviations, taking the following facts into account:

(a) Readings may vary for different test distances;
(b) Innervational factors may lead to unreliable readings;
(c) Different methods of testing may produce different results.

REFERENCES

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