From the OEP Archive • Functional Optometry in Theory and Practice: Cross Cylinder Findings

AM Skeffington, OD, LHD

Originally published in the OEP Papers, Nov 1959; Series 32(2)

The problem of understanding what is measured in any form of visual examination increases in complexity when the demonstrations spoken of in last month's issue are considered:

1. The retinoscope changes in the sightless man
2. The effects of convex lenses on tension patterns of the muscles of the back, and changes in blood pressure and respiration
3. The transient differences in meridians observed with a retinoscope, and findings observed with a target like the "dangled bell"

The subjective was the finding discussed last month. The notion that it is the measurement of some sort of inadequacy in maintaining an effective conjugate focus with the target becomes hopelessly oversimplified. The idea was advanced that the subjective finding represents both a basic set in the construction of a personal visual space world and a measure of freedoms of operation within that set. This visual space world is formed within the envelope of the skin by the aggregation of experiences in the actual physical manipulation of spatial things. These become abstracted, and derivatives of derivatives develop, leading to the elaboration of visual functioning that is required in such complex acts as reading.

The subjective is considered as a "base line" for all subsequent quantifiable measurements because it is the simplest means of obtaining a measurement that contains a definite and necessary end point. With the target prescribed (as it is in any standard refractive procedure), the distance maintained, and adequate illumination, the subjective lends itself ideally to the zero point from which to start all subsequent measurements. One must remember that this zero point is surrounded by ranges, and that the group of findings known as the "subjective" is operational in design.

The standardized procedure was described for obtaining such a measurement. There was no attempt to establish a rigid methodology. Certain fundamental requirements were stated. When these are observed, the basic requirements for such a base line are fulfilled, and the examination can proceed.

From the discussion so far, the student will gather that the idea of prescribing the "formula" obtained in the subjective as a permanently worn lens purporting to correct a refractive error is somewhat naïve. There may be a "refractive error" in the sense that there is an end product of some sort of adaptation to an energy. Experienced trauma and birth deficiencies provide special problems. The transformation of a basic set in which contour discrimination is maintained into another set in which it is lost in no way signals the end of our investigation into that individual's visual problem. It simply provides his base-line measurement.

Three Space Areas

Dr. Darell Boyd Harmon seems to have demonstrated and recorded with a camera that there is a definite "step function" in space at about 16 inches from the seeing eye. There has come to be wide agreement that there is a definite difference in visual space in a range that is in the area of the distance of the outstretched manipulating hand. It appears quite probable but does not enter into the necessary considerations at this time that there is a third "space" somewhat intermediate between the area of the manipulating, outstretched hand and the final point of practical paralleled convergence. The primary consideration in this paper is the determination of another base line, at the area of near space.

The student is asked to hold in his mind the realization that the property of a convex lens is to localize away. Until the public showing of the films that verified it, the statement had to be made as a notion behind which there was a sufficiently respectable mass of evidence that it could be used as a working hypothesis. Today this is no longer the case. The statement can be made as a verified conclusion.

Once this idea is accepted, it becomes necessary to ask, in every case when lenses are prescribed, what the value of this localization away is. This is not an academic question to be referred to the theoretical scientist and of no practical application to the man in the office. On the contrary, it goes to the very heart of the day-by-day problem of the acceptance or tacit rejection of any lens by any patient. In the ten-day laboratory-project-discussion at Ohio State University the last two weeks in June of '59, the one constantly

recurring question was the matter of determining the acceptance or rejection of a lens that represented some quantified measurement.

Highly Practical Problems

Questions constantly arose as to why some myopes accept their minus and some reject it. Some hyperopes seem to demand not only their full plus lens as indicated but would appear to be happy with even more. Some astigmats refuse their astigmatic correction, and others accept it and ask for increase. These are highly practical problems, important to every optometrist, who must, of necessity, supply lenses. They pertain to all forms of lenses.

The practitioner who feels that he has avoided this problem by the use of contact lenses is inhabiting a world of unreality. The acceptance of contact lenses and the ultimate learning to tolerate a foreign body in the eye have more aspects than just corneal sensitivity. There is also the question as to what those lenses do to the individual's space world. The myope who has come, in desperation or vanity, to undertake contact lenses, remains the person who has learned a restricted space world. Any lens affects that space world.

It seems obvious and absurdly simple to state that the space world that has been learned is within the person. Yet it is one of the important matters for hourly consideration. The space world is within one. It has been learned. It is part of the experimental background of the person. The physiological optics of the external visual mechanism are utilized in this experimental complex, to effect what is needed to best serve the immediate responses and purposes of that person. It is well to again repeat the words of E.D. Adrian, "how a particular pattern of nerve impulses can produce an idea; or the other way around, how a thought can decide which nerve cells are to come into action" (Physical Basis of Mind, London, Basil Blackwell, p.5).

Two Lens Functions

Unless there is some reason, within the organism, that makes localization away of significance to that organism, there is no reason for the use of such a lens. If such a reason exists, then it is important to know what that particular lens does to that particular person. It is important to know the degrees of freedom that exist within that person to meet the continuing stresses inevitable in meeting the energies of the environment. It should be noted at this point that one use of a lens is to induce a desirable direction of movement within the degrees of freedom exhibited by the organism. This is a far different function of a lens than that of acting as a bridge between the "refractive error state" and the external environment. In the latter use, the "state of refractive error" represents the embedding of an extended movement pattern through transformation. Our prime consideration is to enhance the performance of the individual whether or not he has made a transformation.

Crossed Cylinder Procedure

The assessment of a degree of freedom at the "near space" of the person is accomplished, as one method, by the use of the crossed cylinder. Essentially, the crossed cylinder is another method of using the organism's spatial computing processes to determine the magnitude of the operational degree of freedom, at the near point. The method is simple. The interpretation is worthy of a great deal of mature consideration. The measurements are made with the subjective quantification as a base.

Characteristically, the crossed cylinder target is placed before the patient. The acuity is reduced by the introduction of convex lenses to the point where the lines of the target are just visible. The question is put as to whether the sets of lines are equally dark. If not, the cylinders are adjusted so that any uncorrected amount of cylinder will be less than the powers of the crossed cylinders to be used.

With the target lines of practically equal blackness, one eye is occluded and the crossed cylinders introduced. The question is put, "Which lines are the blacker, the up-and-down or the crosswise lines?" The large amount of convex lenses before the eyes should insure that the "up-and-down" lines are the blacker. When this is the report, the convex lens is reduced until the lines are reported equally clear or equally slightly blurred. Further reduction of the convex lens powers should bring out the "crosswise lines" as being blacker. Increase in plus to the point of equal blackness brings the point of recording. That is the gross cross cylinder finding.

The subjective at far is just that. The gross cross cylinder at near is only a beginning. Two measurements are made to allow the eventuation of a "net" finding: the gross cross cylinder and the associated phoria.

Spatial Learning Factor

There is one prime and extremely important difference between the quantification of the subjective at far and the crossed cylinders at near. That is the factor of spatial learning. From the moment the newborn first opens his eyes until the optometrist puts a base-in prism before him, there has never been a split second when the child diverged his eyes and

continued binocular seeing at far point. A solid, blank, and for the moment unscalable wall sets a definite limit to how far that person can extend out from himself the manipulation of his space world.

That is not the case at near. From that area in space where the demand is made, there is a possible extended manipulation from near to his already determined limit at far. The limitation is only that of his own freedom within his own visual processes.

Consequently, something more is required at the near area than at far. Some method of evaluating the degrees of freedom in the totality of the energy sequence is required. It is necessary to have some means of allowing the centering phase of the total integrated dual effector system to become observable. This makes it necessary to take the accompanying phoria. The two measurements are taken to allow the eventuation of a "test."

Dr. Harmon has illustrated the circuits of the labyrinthine and kinesthetic balance with gravity and the visual balancing with light. As the organism learns to operate in its visual space world, these circuits are brought into resonance in terms of energies from real objects located within and beyond arm's reach. This is the contrast with the use of symbols at near point. They have meaning only as derivatives of the spatial manipulation of real objects.

When the organism "sets" itself for problem solving in a highly demanding situation, the labyrinthine and kinesthetic circuiting are still in balance with gravity, and the visual circuits are no longer in resonance with the other two. The light energy from the task is coming from a concentrated source at near point. Yet to solve the problem, this energy must trigger derivatives of covert movement patterns that have been learned over a broad range or volume of spatial experience. For optimum response, there must be a maximum resonance.

The convex lens has the property of localizing away in space in relation to the organismic set. Hence, it reestablishes resonance. If too much "plus" is applied and the organism relocalizes too far away, the circuits will go out of resonance on the other end of the range, and the achievement potential of the organism is again reduced. The primary need is to investigate what the convex lens has done to this localization. This is probed by taking a phoria as an indicator.

The Essential Information

The essential information being sought is how much convex lens can be put before the individual without going beyond his operational range and yet get the maximum effect of localization away. There are two crossed cylinder findings and therefore two nets to be obtained. The two nets are, again, products of two different manipulations of space.

The unfused cross cylinder finding is known in the Analytical sequence as #14A. It is deliberately taken with a minimum of demand, yet with controls adequate to assure reliability in the measurement. As the name implies, it is taken with one input at a time. With a target that is not demanding in itself, the greatest possible freedom to "localize away" is provided. The same target is used for fixation while the phoria is measured.

The fused cross cylinder is taken under quite a different set of conditions. The target is viewed with both inputs activated, yet with one target localized. This is binocularity. The associated phoria is taken under the more demanding situation of the target being the reduced Snellen, and the patient reading, as nearly as possible, the 20/20 line.

Some very explicit statements need to be made here. Stated in terms of dioptrics, from a target seen at twenty feet to a target seen at 16 inches, the demanded change in accommodation is 2.50 D. Note that the word is "change." From a position of alignment at twenty feet to a position of alignment on the target at 16 inches, the demanded change in convergence is 15 prism diopters. This would appear to hold only if the targets presented comparable demands at far and near. When the demand at near is greater than the target demands at far, the relationship is altered.

Use of Nets

This would seem to be the source of the discussions as to whether the demand relationship between accommodation and convergence was in the nature of 6 to 1 or of 4 to 1. For all practical purposes of calculation, it can be said that in the lesser demand situation of the unfused crossed cylinders and phoria, the relation appears nearer that of 6 to 1. In the more demanding relation of the fused crossed cylinder and associated phoria, the demand is nearer the 4 to 1.

The fused cross cylinder is utilized in the investigation of how the person has structured his space world. In these considerations, a part of the syndrome of adaptation is the matter of whether the fused or the unfused is the higher. Should the optometrist wish to use only one of these determinations as a guide to fitting lenses for the demanding near point, he would be far more conservatively safe in using the fused cross cylinder finding, when that is acceptable in the equilibrium findings (to be considered in the next

paper). The likelihood of that dioptric finding being acceptable is far higher than is true of the unfused net.

To restate the matter for emphasis, the fused cross cylinder is used in the development of a syndrome of adaptation in time. It is a more differentially valuable finding than the unfused and is far more likely to be an acceptable lens for the point in space, if it is acceptable in the equilibrium findings.

Computation of Space

Consideration may now be given to the matter of why the crossed cylinders produce the effect vocalized as "the up-and-down or the crosswise lines the blacker." What is this matter of phenomenally experienced greater density of one set of lines, set in opposite directions? This reverts almost wholly to a consideration of how each individual computes space. The use of the language "computes" does not imply that vision operates as a true servomechanism. It does not.

Vision is a closed energy sequence, but there are many areas of difference in the operation of vision and the predetermined operation of a servomechanism. The latter operates on the basis of error. It is definitely open to question as to whether the visual mechanism likewise operates on the basis of magnitude of error. There would seem to be no question but that the organism computes. It does not matter whether one prefers to speak of the "memorial properties" or any other term. The fact is that a triggering is set up by excitations of the retinal elements, differing only in intensity. The frequency of the "off and on" signals is dictated by the intensity of photon bombardment of the retina, per unit of retinal area, per unit of time.

When there is a greater concentration of photons, there will be a greater intensity of ionic volleys propagated from that area. The introduction of a cylinder changes the whole pattern of the photon scatter. A concentration of photons is produced along the power of the lens, and a lessened concentration along the axis of the lens. This alteration in the input "programming" would seem to produce the interpretation of the one set of lines being blacker than the other. An "interval of Sturm" is created. Gullstrand fought out that battle in the 1890s. It is the interpretation of that "effect of Sturm" that becomes important in this year of expanded understandings.

When the photon scatter grows in concentration in a given retinal area, there will be an interpretation by the computing processes of that target being nearer. This depends on the origin of the energy and the area in which it is immersed, or better yet, of that area of which it is a part. The target appears blacker and clearer and, in effect, nearer. The opposing set of lines has a lessened concentration of photons, reducing the intensity per unit of retinal area per unit of time. It will therefore be computed as being farther, less black, and less clear.

Attainment of Equilibrium

The organism always moves to the attainment of the best possible equilibrium between any opposing forces, within itself or in transaction with the forces of the environment. This always-existing trend towards an equilibrium of forces makes possible the effectiveness of the crossed cylinder findings. Consider the method. First, it is determined that none of the end products of stress-producing distortions in the sphericity of the eye itself are present. Such an end product is quantifiable astigmatism measurable at the far point.

In passing, it may be well to note that in the description of the presently observed transient differences in meridians, the term "astigmatism" is not employed. The term is reserved for the condition where such differences have become embedded in structure and so are relatively stable. The transient differences, such as those observed in the spatial shifts and especially when the shift is from far to near, do not come under the designation of astigmia. They really are transient differences in meridians. When persisted in, they may become embedded and therefore quantifiable and measurable. Then they are true astigmias. At the moment of transience, they are not astigmatism.

When the lines of the target appear of practically equal density, the crossed cylinders are inserted. Sufficient convex lens power is inserted to localize away until the target lines appear blurred. This causes a localizing away, to the far end of the potential degrees of freedom within the total visual complex, all the experimental factors, the interwoven relationships between the effector systems that are yet of their own characteristics even though they are one operation.

The "Optimal Zone"

As the convex lens power is reduced, gradually the interpretation of contour grows in definiteness. The series of lines which represent the margins of the differences in photon scatter, that are interpreted as being at the relative limit of the operational range, become the darker. The examiner knows that he is nearing the point of equilibrium, or the "optimal zone" of Dr. S.K. Lesser's description. When the report can be given that the lines are of equal density, the "optimal zone" under the conditions of the test has been reached.

With further reduction of the amount of convex lens, the opposite lines, the horizontal, should appear the blacker. The examiner then knows he has moved the photon scatter into that area where the localization is too near the organism. Then the selection is made on the basis of "either where the lines are equally black, or if there is no such point, the last lens which left the vertical lines the blacker."

The crossed cylinders, used in this way, are a valuable tool for investigating the degree of freedom the patient has available to achieve resonance with the energies triggered by the near-point demand. The subjective provides a base from which to investigate what the organism has done to its balancing mechanisms in order to survive and meet demands of our culture. It is just a base. The crossed cylinder is more specific. It provokes a response to specific demands at near point. Because the demand is at near point, it will tend to be out of resonance with the antigravity circuiting and other circuiting which, through initial learning, achieved resonance in "solid" three-dimensional space.

Finding a "Net"

Some means is needed to determine the actual operational boundaries of the interpretive process. Otherwise the lenses supplied, while permitting perfectly good acuity, might localize away beyond the operational field of freedom and so be rejected as remedial lenses. Unhappily for those who yearn for greatest freedom of understanding, it remains necessary to talk in terms of numbers. There are so many diopters of this and so many diopters of that. It is an enormous oversimplification of the operation to state that from parallel alignment at far to an alignment at 16 inches, there is a change of 15 prism diopters. It is likewise an oversimplification to state that from a position of target discrimination at far to a comparably discriminable target at near, the change in accommodation is 2.50 D. Nonetheless, it is necessary to use some method of numbers for designating.

The readers of these papers certainly do not hold the idea that when an exophoria is measured, there is an actual deviation of the alignment axes from one point to another. Simple observation refutes that ancient notion. It is still necessary, however, to give a numbers label to that shift in interpretive (and therefore phenomenal) space that is measured in certain ways and has a certain and predictable effect on the acceptance of a lens. The freedom in spatial localization attained by the dissociation procedure, revealing a quantity of exophoria, indicates that a certain degree of freedom in the identification process will result. When both inputs are engaged with the same target and with a common alignment, this freedom will not be present.

The process makes it necessary to consider the crossed cylinder finding a "gross" finding. The diopters of exophoria give an intimation of the artificially produced freedom in spatial manipulation. To find a "net," or the operational degree of freedom in the visual process, it is necessary to reduce the amount of convex lens indicated by that amount which was made available for measurement by the dissociation-produced spatial freedom. For each 6 prism diopters exophoria shown, 1.00 D of the indicated convex lens power is subtracted from the cross cylinder finding. The resulting amount is the net.

"Base-Line" Findings

The whole procedure is repeated with the dissociating prism removed and binocularity in force. Since this finding is made under the demand conditions of binocularity and a target of fine contour discrimination, the freedom in space will be less. This finding is used in the more elaborate interpretations that include the syndromes of adaptation and of spatial organization. Hence, a greater precision of interpretation is indicated. When the convex lens powers are reduced, as in the unfused, the vertical lines clearer (or blacker) yield to equality or greater density in the horizontal. Now, however, if there is an immediate shift from vertical to horizontal darker, the choice is that lens power which FIRST brought the horizontal into pre-eminence.

These two findings constitute the "base line" for the near-point. It is true that the subsequent findings of the Analytical are not taken through them. They are nonetheless considered in the final determination of what the indicated lens may be. That is the process known as determining the "prescriptible near net." The cross cylinder net may or may not be the "prescriptible near net." This most desirably would be determined by an understanding of what the spatial organization may be.

The reader of these papers has already gathered that, while the names of the findings are the same and the basic procedures are familiar, there is a significant expansion in the ideas concerning them. This expansion does not at all negate what has been known about them. It has simply expanded the comprehension of what the person being examined has done to meet the demands imposed on the organism.

Interpretation of Findings

The crossed cylinders would appear to provide information as to operation within the volume of

space. In so doing, they provide a means of arriving at an operational conclusion as to what particular lens each certain person will accept most effectively. There would also appear some possible conclusions as to the derivative effects of this probe. Granting that the higher intellectual processes are derivatives of the vestibular-antigravity-kinesthetic patterns, deviations from an optimal performance should bring significance to the surface that will allow some further clinical conclusions.

Three characteristic responses to the cross cylinders can be observed:

1. The lines remain all even no matter what lens is used.
2. The vertical lines are blacker unless minus lens power is added.
3. The horizontal lines remain blacker unless plus lens power is added.

1. In the first response, there seems to be an "over fixation" on the page. The individual tends to see words (perhaps even letters or syllables) more than getting meaning. Characteristically, he tends to be a word reader and have trouble grasping the context of a situation. The patient's adjustment mechanism to internal energies is rigid, i.e., "in a rut" or "monotone." As in the case of the embedded emmetrope at far, the activity of this circuiting lacks peaks and nulls.
2. The vertical lines blacker unless minus is added seems typical of the laboriously striving person, the "digger." He must (and does) dig hard for information, often too hard. His internal balancing mechanisms are set in "high gain" position, and the parasympathetic is trying to balance the system by reducing the concentration of photons per unit of retinal area per unit of time, thus rebalancing the system. The addition of minus tunes the visual circuiting to resonance with the "off-tuned" circuits that are the result of adverse responses to a stressful demand. These circuits remain off-tuned even with the minus added.
3. Where the horizontal lines remain blacker until plus is added, the amount of plus gives an indication of the amount of freedom in the process.

"Lag" of Accommodation

This must be "netted" by consideration of how this circuit is resonating with the circuits primarily responsible for localization. It is unfortunate that the standard unit of measurement for prims is the diopter rather than the meter angle. Assuming a pupillary distance of 60 mm, 6 prism diopters equal one meter angle. Expressed in terms of meter angles, the expected "lag" of 1.00 D of convex sphere quantification is equated with one-meter angle of convergence. Thus it is seen that the two circuits tend to shift outward from the organism in the same proportion.

In the fused cross cylinder, there is clinical allowance for the increased demand on the effector process of identification by using a ratio of 1.5 meter angles of convergence to 1.00 D of convex sphere. The amount of plus left over after the lag has been computed is the "net." This is the amount of freedom that will give the organism the greatest zone of resonance.

The Visual Process

The visual process has come to be recognized as the interpretation of a wonderfully organized space world. As it developed, there has been inbuilt, so to speak, a whole process of protection so that, no matter what the stresses upon that organism may be, there will continue to be the ability to know where a thing is in space, and what it is. This is sheer survival.

The person in the examination chair brings an age-old problem. The reason for the optometrist in the culture is that the impacts on the organism from the environment are not fleeting and transient. They are continued. The threat—literally—to that organism continues. The person makes such adaptation as is possible to preserve the largest magnitude of integrity of operation of the organism.

One of the great inventions of all times was the convex lens. Its use and stature have grown through the ages. Only since the advent of optometric investigation has the realization slowly spread that the property of a convex lens is to localize the spatial computing of an area farther away from the person. The motion picture film shown this year at Ohio State and at numerous Congresses has given photographic evidence of the validity of this concept. It brings the realization that a lens is a means of relieving stress-tensions created by the environmental demand. It also brings the realization that there is a definite range within which that lens is helpful, and there are areas where the lens is something less than helpful.

The precision of the area was startling. The film shows that an eighth of a diopter is critical! It will be seen why the full cross cylinder net would be hazardous as a lens application. The "prescriptible net" may or may not agree with that net. Therefore, the understanding of the method of arriving at the "prescriptible near net" will be the burden of the next paper in this series. The student and the study group

should give earnest discussion to the matter of the response of the organism to the changed photon scatter produced by any cylinder, its value in the cross cylinder, and its inclusion in any lens formula.

Skeffington AM. Functional optometry in theory and practice: Cross cylinder findings. Optom Vis Perf 2020;8(3):135-41.