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The very term duction is a misnomer. A complex activity is represented by the response to a particular demand situation, and to label it a duction is to attach to it all of the ambiguities, evasions, and misapprehensions of the past, an almost insurmountable handicap to any form of understanding. A duction seems like such a simple thing. The only need is to indicate a target, place prism power before the viewing eyes and ask when two are seen rather than one. Whatever the dioptric power of the prism employed when the twoness occurred is the measure of the duction in that direction, at that distance.

Stating the matter thus baldly puts one in mind of Wordsworth's *Peter Bell*:

> A primrose by a river's brim
> A yellow primrose was to him,
> And it was nothing more.

Yet in that primrose, had it been fully understood, was that secret of life itself, the secret men have sought to unfold since the first member of the species lifted his eyes from the grubs to the stars, from the earth on which he trod to the heavens. He alone, because of his newly developed prefrontal lobe and all the elaborations of development that went with it, could contemplate a heavens and a future.

The taking of a duction requires a target, prism of sufficient power, and a seeing human being who makes a single interpretation of two inputs. The eyes must turn, behind the prism, if a single interpretation of two inputs is to continue. The organism must match those inputs. An old ophthalmological measurement disclosed that when there is more than a 12 percent difference in the intensity of illumination to the two eyes, suppression takes place in the lesser-illuminated eye.

Dr. Darrell Boyd Harmon in *The Co-ordinated Classroom* describes constants for efficient visual tasks: "Within certain limits, the line running between the two eyes...on the plane of the face, and lines projected from the two eyes to the point of fixation... form an isosceles triangle. The line of sight...forms the perpendicular of this triangle. As the child's eyes move back and forth over the work he is seeing, this isosceles triangle is momentarily altered, but normally the movements producing these alterations will not be great enough to induce stresses, energy uses, or image distortions beyond the child's reserves or tolerances.

"These linear eye movements (such as following a line of type) when kept within the child's physiological tolerances, and any posture shifts within these same tolerances which put the plane of the face out of parallel with the plane of the materials, do not produce over +/-20-degree changes in any of the right angles represented by...the perpendicular relationships of the line of sight to both the plane of the face and the plane of the materials."

Suspension of Vision

Dr. Harmon further notes that when either the angle formed by the line of sight and the plane of the face, or that formed by the line of sight and the plane of the materials, is "changed from 90 degrees by an amount greater than 20 degrees,...just as this angular change passes the 20-degree limit of tolerance, it can be shown by an application of the appropriate laws of illumination that the light to one eye has then been reduced 12 percent below the light to the other eye... Angular changes greater than 20 degrees reduce the illumination to one eye as compared to that of the other eye by an amount greater than 12 percent. The suspension of the vision in one eye due to this angular reduction of illumination can be demonstrated by attempting to stimulate a protective change of posture by passing a hand in front of the eye suspected of having been suspended in function. If no protective response, such as pulling the head back, is elicited, vision has been suspended."

Starting at the point of optimal posture and equality of illumination, there must be a curve of deteriorating matching between the inputs of the two eyes. Finally, the difference becomes too great. The reader will recall the quotation from Professor Ward Halstead: "distortions of the outer world, impressed upon the brain, and hence the mind." He can readily understand that there would be a steady deterioration in the operation of what Dr. Halstead has labeled mind before the difficulty became so great that suspension would ensue.

Low Duction Power

The ability to move an eye bears no apparent relation to the magnitude of the measurable duction. Early in the development of functional thinking in optometry, attention was called to this observation. The "low-duction" patient, whose base-out to break was something less than 20 prism diopters, could nonetheless turn the eye clear in to the nose and outward until limited by the outer canthus. There was no loss of ability to extend and contract the participating muscles of the eye. The reason for the low duction power must lie somewhere else.

A check on the "accommodative facility" showed the ability to shift from clearness at far to clearness at ten inches, a four-diopter difference, without difficulty and without hesitation. The assumption would be that accommodation was adequate. A retaking of the duction continued to show low dioptric power.

These papers have considered the significance of the measurements made in the Analytical Examination. Increasing emphasis has been placed on the idea that vision is an operation within an interpreted space volume. This would seem to be increasingly substantiated in the effects that contact lenses have upon the duction findings. Contact lenses, changing the peripheral interpretation as they do, bring quite radical changes in duction findings. There seems to be almost a characteristic pattern of increased ductions at far and decreased ductions at near.

A study was made for the National Safety Council in the laboratories of Professor Samuel Renshaw on the effect of the wearing of periphery-restricting goggles. It was found that the restrictions brought characteristic discomfort at far but very little at near point.

These references are not digressions from the main theme. They touch upon the very vital point of asking what is being measured when a duction finding is taken. The duction measurement must be a reflection of some far more complex problem than the original assumptions indicated. It is presumed that the alteration of the peripheral interpretive magnitudes can and does alter the quantification of ductions. It would seem to follow that ductions are of quite elaborate origins. They therefore are capable of yielding aggregates of information that transcend any limited concept of indications of contractility and extensibility of muscle.

Lens Application Limits

The first significance of any finding in the Analytical Examination is the role it plays in the indication of lens acceptance and quantities of lenses to be prescribed. This is as true of ductions as of all other findings. Their first and vitally important role is to establish the limits of lens application. The significant durability of the original formulation of the use and interpretation of ductions laid out some thirty years ago is cause for pleasure and amazement. Elaborations have come into the understanding, but the basic principles have remained unaltered.

Properly speaking, there are four duction findings. Taken with prisms, they represent the alignment-identification changes impelled by the area of demand; that is, the target presented. The blur-out findings are included in the discussion of blur findings. The notion has been presented that blur findings produced by the introduction of prisms represent an investigation of the centering-alignment-identification sequence. It might well be held that the so-called break-point, when diplopia appears, is an investigation of the alignment-identification sequence.

Three Possible Contingencies

The methodology of the four areas of investigation is simple. The target is usually the Snellen type. This is arranged by the examiner at his option. Some practitioners prefer the whole of the graded-size Snellen chart, of familiar use. The patient, in this instance, is instructed to look at the 20/20 line. He is to hold it until blurred and then finally blurred out. The patient is then instructed to "tell me when it doubles, moves, or clears."

The foregoing are the three possible contingencies. When two targets are seen, the organism is employing both inputs as excitors for the instigation of the whole energy sequence. When the target moves, the organism has ceased to interpretively employ one of the sequences and is operating on the instigation from one input. The same significance attaches to the report that the target is no longer blurred but has cleared. The report of "clearing" and "moving" are actually reports of the same phenomenon. The person has ceased to utilize both inputs as instigators of an energy sequence and is utilizing but one for that degree of interpretation.

In these two situations, the total method of operation may be different. The means employed within the organism may not be the same. In both instances, only one input is being utilized interpretatively at the moment. The insistence on the idea that only one input is being used interpretatively is valuable, for it leads to a further realization that there are two closed energy sequences.

Two recent works have brought forceful realization that these two energy sequences can, under certain circumstances, have a different interpretive volume of space. One is that of Dr. Ned Harris and co-workers at Ohio State University, June, 1959, on the development of varying-sized after images. The other is that of Dr. Frank Root, delivered at the Conference of Theoretical Optometry and Visual Training in St. Louis, January, 1959, and published in the Optometric Weekly, July 9, 1959, pp. 1355-1359, "A Tachistoscopic Method of Testing and Training Speed of Visual Perception Using Anaglyphs." Under the direction of Dr. Harmon, with the collaboration of the Doctors Nelson and Greeman of San Antonio, Texas, a myographic film was developed at the Neurological Institute in Austin. It shows clearly that when there is an electrical stimulation of one of the neck muscles, the patient draws an observed rectangle as distorted. Likewise, the space eikonometer shows spatial distortion. If there is a spatial distortion that produces an inequality, the organism can have two speeds, so to speak, of the utilization of the two closed energy sequences.

Thrust and Counter-thrust

In the taking of ductions, the organism, with whatever adaptations it must employ, continues to use all of the two sequences possible in the attempt to retain whatever degree of matching of the two utilized inputs is permitted under the stresses being imposed. To state it otherwise, the organism strives to retain binocularity. Dr. Bruce Wolff has pointed out that there is a value to binocularity that goes beyond the sheer matter of obtaining a better Vernier of space calculation at near. There is a need for the matter of equilibria that can be summed up under the concept of "thrust and counter-thrust." For every movement, there must be a counter-movement.

Ordinarily, the student thinks of movement as something that can be observed. This Golden Paper series of the Optometric Extension Program has insisted that the covert movement patterns, which lie behind and control the overt, are far more extensive and elaborate than the observable and quantifiable overt patterns. The tension of the six muscles of the back shown by the film of the young man reading through lenses that were inadequate, too greatly powered, or distorting would not have been classified as overt in most offices. It could not be seen with the naked eye nor felt with the sensitive palm. However, the electrodes showed it as real movement. The "overtness" or "covertness" appears to be a matter of how fine the measuring tool. The day may come when all movement with the elaborations of the CNS will be quantifiable. Then all will be overt. The movement pattern of an original idea would be very interesting.

Comparison of Ductions

Ductions would seem to provide an interesting example of this matter of the necessity for thrust and counterthrust. From the very first, the teachings of the Graduate Clinic Foundation have insisted that one duction finding is of small value. The very real value in duction findings is in the comparison of the base-out duction with the base-in duction at far-point, and of the base-out duction with the base-in duction at near-point. The relationship between them is far more important than the actual dioptric values found. This is especially true at the near point. The far point is affected by the very same situation that makes the subjective at far a different matter than the measurements made at the near point. There is a barrier.

The Kinesthetic Barrier

A chapter on "The Kinesthetic Barrier in Space" would make interesting reading. In the study made in this series of the significance of the subjective, note was made of the limit to the localization away in space with a convex lens at far-point, which does not exist at near. Hence, the subjective can be brought to a limit, and the refractionists can say, "This is the totality of the refractive error." This is impossible at the near-point. Within near space, there is an almost unlimited possibility of movement. A different method is necessary at near than at far, to find the lens that will be acceptable. The same barrier exists in the taking and interpretation of ductions at far.

The statement was made, in the consideration of the equilibrium (or blur) findings, that there was only one blur finding taken at far. It is a critical finding. It is a most sensitive mirroring of what is happening within the total movement pattern of vision when the demand area is within near space. It has no opposite. There is no base-in to blur at far-point that has ever come into common usage in the interpretation of visual behavior. With the growing information relating to the space volume, it is possible that a usable method of investigating and interpreting the base-in to blur at far will emerge. To date, apparently, none has appeared.

The break findings are equally affected. The base-out to break has a mean expected of some 19 prism diopters. This is a minimum when the plottings are on an average distribution curve. It will readily be seen why it was convenient to use a minimum.

The primary reason for making an Analytical Examination is to find the lenses best accepted by this person. The world is accepted, for the unquestionable information emerges from the work of Harmon, recorded on film, that the value of the lenses being given is the proper localization away within the space volume, rather than the classical idea of correcting a refractive error. The whole concept of the why of lens application changes in the mind of the refractionists once the refractive error is visualized as the end product of an adaption (or to use Skinner's term, "operant behavior") to an energy.

The prism base-in to break has a minimum expected or mean of 9 prism diopters. Yet the eye will rotate as far to the outer canthus as it will to the inner. The difference cannot be in the potential extensibility and contractility of muscle. The limitation must be in behavior. Therein lies the story that is almost as significant as the story of life that would have been revealed had the observer not been willing to see a primrose as just a primrose and nothing more. In the total learning pattern of the individual, there has not been a single moment when the eyes turn abductive-wise from parallelism and continue to see binocularly.

Learning and Stress

It is just possible to say that there has been no opportunity for learning the interpretive matching of the energy sequences with the two eyes abducted from parallelism. There should be just a brief reference to the idea of the photon scatter, per unit of retinal area per unit of time, that sets up the ionic volleys that become the "programming." From this latter, encoding takes place. In the great integrative process, it triggers the search for meaning. The final efferent-motor-exteriorization-operant behavior that sums up in the word information must change when eyes are abducted. When that pattern is brought as far as it can possibly go while the organism continues to interpret, doubling will take place.

Naturally, then, the base-out to break is dioptrically high when compared to the base-in to break. However, they are both subject to another great factor in organismic behavior. That is, under stress, there is a constriction of all involved behavior patterns. A duction is a behavior pattern.

There is a great deal of difference between the sophisticated duction behavior pattern and the sheer heliotropism of the newly born. A study of the sheer microanatomy of the eye and its connection with the central nervous system will show the quadrants of the retina literally anatomically developed so this will happen. It is an essential precursor of the development of the later and more precise canonical position attainment. The nerves have not proliferated to the fovea when the child is born. They are not completed until about the sixteenth week of life (Ida Mann). Unless they had a force that would bring the fovea "to bear" to what McCulloch calls "reducing the vector to zero," man's final ability to achieve a complete and finely organized figure-ground structuring would have been impossible.

Organization and Behavior

When the "stretch" upon the interpretive matching grows too great, the organism surrenders the maintenance of a single interpretation of integrated sequences. Diplopia results, with a clearing of the contour discrimination of the viewed target. It would seem almost a self-evident truth that if these are measurements of a behavior pattern and there is a constriction of the operation of the behavior pattern, there would be a restriction the quantifiable measurements. This appears to be precisely what happens when stress does produce a constriction within the operational field of the person. The organism reacts to the "threat," constriction of movement patterns follow, and there is a drop in the duction. The larger quantifiable drop will be in the area of the space volume undergoing the greater alteration. This is as true of the ductions taken in near space as of those taken in far space.

The second aspect of the duction is the activity known as the "recover" finding. Thoughtful analysts of clinical optometry have said they wished the blur findings were taken utterly separately and differently from the break findings. They seem to be only very distantly related. This is not true of the recovery findings. They are so intimately related that they seem almost of the same quality, so to speak.

From the foregoing, it should be quite clear that the basic theme of this paper is that there is an organization of behavior within the total visual complex that gives representation when the target demands of the duction findings are met. The recovery findings are of that same organization but reflect its effectiveness rather than its strength. A duction is not a measure of the strength of a muscle. Dr. Renshaw has justifiably poked the finger of scientific scorn at the term "fusion center." He states that as a student of neurology all his life, he has not only never located such a center but has never met a reputable neurologist or histologist who ever pretended to have found such an anatomical or even operational area.

Two Spatial Volumes

Fusion, then, would seem to be experiential. The organism, for purposes of its own, has learned to interpret two sequences as one. In so doing, it not only utilizes both volumes of space, for each closed energy sequence must have a spatial volume; it also so encompasses them within its total behavior pattern that a considerable stress can be put on it without forcing a separation. In time, the break-point is reached.

Stress on the interpretive behaviors brings a constriction in their operation. When there has been a separation into two volumes of space (diplopia), the dissociating probe, the prism, is slowly reduced. It would seem highly probable that the more recent the discordancy, the more difficult it would be for the organism to have developed an adaption to the stress-altered behavior. This element of interpretation of the magnitude, duration, and direction of the stress impact has made the syndrome derived from the ductions one of the reliable and definitive syndromes in the writing of equations for lenses.

Methodology of Ductions

It is assumed that the refractionist has taken all four ductions. He is now surveying the totality of his information. The ductions at far-point cannot be compared directly. The limitation on the base-in to break forbids it. Therefore, the far-point ductions are compared in terms of their relation to the minimum break or expected. It is said, then, that "as compared to the mean for each finding, the dioptric power which is low in comparison to its mean is deemed to be the low finding."

The case typing, or indication for lenses, is always based on the differences in the duction findings. When these are too nearly alike to make decision possible, the weight of evidence is given to the recovery. Suppose the break on #10 is 10 prism diopters and on #11 is 4.50 prism diopters, with a recovery on #10 of 3 prism diopters and on #11 of 3 prism diopters also. The weight of evidence would then be towards calling the #10 finding low as compared to #11.

At the near point, the minimum break findings are almost equal. It is therefore more nearly feasible to actually compare one duction with the other in quantitative values. The real difference at near-point is that the recovery should be somewhat higher on the base-in-to-break finding than on the base-out.

The question before the optometrist, in relation to any patient is: What lens shall he be given? There is never a question as to whether a lens is needed. The lens may be more sorely needed by one person than by another. There may be a greater awareness of a need on the part of one person than another. However, any person operating within the demands of our culture will operate more effectively behind an appropriate lens than without one.

Lens Directive Syndromes

Based on the ideas outlined earlier, there are some very direct applications of the information derived from ductions. These are used by any person who thinks in the dynamic operation of vision. Many elaborations have come to these fundamental applications. However, the elaborations themselves stem originally form these very simple lens directive syndromes:

1. When the base-in to break at far (#11) and the base-out to break at near (#16B) are BOTH low, the full plus is acceptable at all points.

Note the word acceptable. It is always an excellent rule to avoid giving the full plus at far if there is any effective way of doing it. However, when this duction syndrome occurs, whatever the indicated plus may be at far is ACCEPTABLE at far, and whatever the indicated plus may be at near is acceptable at near. This does not imply that the same plus is acceptable at all points. The subjective may be +1.25 and the prescriptible near net +0.75. Then the +1.25 would not be acceptable at near.

The syndrome merely says: "When #11 and #16B are low, full plus is acceptable at all points." Today, that statement would be modified by saying, "The basic typing holds. Further investigation into how visual space is organized modified that indication."

2. Classically (and still correctly), when #11 and #17B are both low, the full plus is indicated at near, but it is highly advisable to cut plus at far. The duction syndrome goes no further than just that. It has been widely interpreted as saying, "In a 'B2' case, give bifocals with plus add at near." The typing does not say this, nor has it ever said it. The duction syndrome simply says, "Give full plus at near, and cut the plus at far."

There has been more rejoicing over the development of what is known as the "B2" syndrome than over any other one lens fitting information that has ever been developed. The modernization of the operation of the world around us in which we must live seems to produce organismic conditions that tend more and more to create "B2" cases. The more naturally demanding and less mechanized the environs, the more "B1" cases are encountered.

3. The third great lens fitting syndrome that derives from ductions is that of "#10 low and #16B low." The same implications exist when the syndrome

is "#10 low and #17B low." Especially when the base-out-to-break findings at far and near (Nos. 10 and 16B) are low, the rule reads, "Cut plus at all points." It does not seem to matter what the originating factor may be. When those two indicators altered space volume stand together, the optometrist is wise to heed them.

These, then, are the ductions. It is well to remember that characteristically, the altered ductions at far are mirroring of the constricted space volumes shown in restricted ductions at near. The ductions would seem to be an exploration into the altered space volume of the person. Energy impacts force an alteration in the equilibria of the space volume. The break findings show the force and the direction of the distortion. The recoveries show the degree or magnitude of the adaptations that have been made. Together, they form one of the first and most dependable indicators of what lenses should be given and the probabilities of those lenses being worn.

Together with the ductions, the phorias tell what has happened to the space world of the person as a product of his adaptation to an energy. The February paper will be concerned with the latter.

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