PERSPECTIVE

The Spatial Transformation Properties of Prism and Their Clinical Applications

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ABSTRACT

Prisms have traditionally been prescribed to compensate for ocular misalignment by shifting the apparent location of retinal images. This paper examines evidence that prism effects extend beyond chief-ray deviation and include spatial transformations arising from asymmetric angular deviation and nonlinear magnification. These optical properties can produce changes in perceived slant, curvature, spatial rotation, size, and distance.

The paper reconciles longstanding disagreements regarding prism-induced compression and expansion of space by distinguishing two-dimensional optical interpretations from three-dimensional perceptual frameworks. It further reviews how these spatial transformations may influence posture, movement, and visual behavior, with applications in vision therapy, neurorehabilitation, traumatic brain injury, autism, proprioceptive dysfunction, and learning-related visual disorders.

A broader understanding of prism optics and perception may allow clinicians to prescribe prisms more effectively, using the smallest amount necessary to achieve compensatory or therapeutic goals while optimizing visual behavior, orientation, posture, and sensorimotor organization.

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INTRODUCTION

What do prisms do? This is a question that has intrigued optometrists for many years. Traditionally, prisms have been and still are used to compensate for ocular misalignment. However, beginning in the 1960's, optometrists such as Dr. Bruce Wolff were incorporating them into their vision therapy programs to influence visual behavior.[1] More recently their application has been extended to the TBI population for rehabilitative purposes.[2]

During this discussion we will be addressing the aberrations created by the spatial properties of prism. When these are troublesome, patients are told to ignore them and eventually they will appear to go away. We will also touch upon the perceived compression or expansion of space which can potentially be beneficial. Seemingly there are paradoxes surrounding these observations. Specifically, how can there be compression or expansion in the same section of the prism, i.e. compression and expansion in the base or compression and expansion in the apex. The discussion will include knowing about and then using these aberrative properties as additional tools to consider when prescribing prism to treat perceptual and behavioral dysfunctions, and to affect a desired behavioral response in our patients.

Regarding the clinical application of prism specifically to observe behavioral changes, Dr. Robert Kraskin famously stated, "It's not what a lens does to a person, but what a person does with the lens".[3] This invites some specific questions. What

are the spatial properties of prism that affords a behavioral change in a person? Is changing the spatial location the only property that may affect a change in behavior? What role do aberrations of prisms and spatial transformations play in "what a person does with the lens", or prism in this case?

These questions have been a topic of discussion for many years and have sparked many lively debates, most notably between Dr. Paul Harris and Dr. John Streff with regard to the concept of expansion and compression of space. Dr. Harris wrote that when he looked through a prism, he observed that there was an expansion of space in the apex and compression of space in the base.[4] Dr. Streff wrote that he observed that there was a compression of space in the apex and expansion of space in the base.[5] These are very interesting concepts considering that the basic understanding of a prism is that it just shifts or transfers an image from one point in space to another creating an ocular rotation to adjust to that new position.

In this article we offer additional thoughts regarding the clinical benefits that these spatial transformations, as noted by Drs. Harris and Streff, create through the aberrations of the prism. A deeper understanding of these spatial transformation concepts and perceptual possibilities aids in the prediction of behavior when applying a prism. Utilizing this information becomes instrumental in designing or developing a more specific protocol when prescribing prism to affect the direction or development of a desired behavior pattern.

Summarizing to this point, the most commonly understood property of prism, as it applies to ophthalmic use, is to refract and redirect light with the amount of refraction value referred to as the total deviation or minimal angle. But there are questions associated with this that we will explore, such as: How does this simple property of redirecting light create the behavior changes observed in a person? How does the prism create the illusion of expansion and compression of space? How does the prism create the illusion of spatial distance changes?

THE FUNDAMENTAL PROPERTIES OF PRISM

Prism can be conceived as a refracting medium with surfaces that are inclined at a specific angle relative to each other. The primary spatial transformation property of prism is refraction or chief ray shifting.[6] In a prism, the chief ray is always refracted towards the base with the image appearing to shift in the direction of the apex. The ray incident to the front surface of the prism is refracted towards the base of the prism and the exiting ray is refracted towards the base of the prism. The total angle of deviation is defined when the chief ray passes through the prism where the angle of incidence is equal to the angle of emergence.

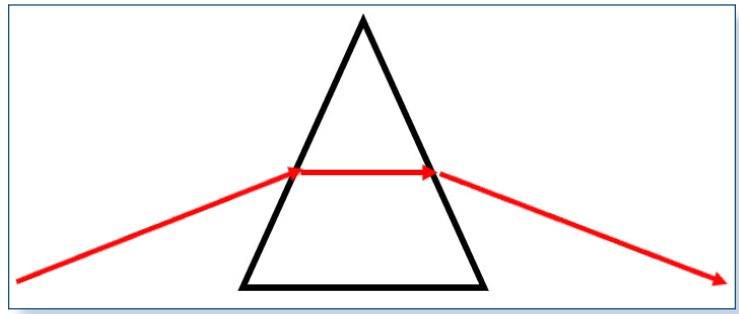


Figure 1. Minimal Ray Light Path

The total deviation is also referred to as the minimal angle or the minimal ray. When discussing prism, why does the conversation generally surround the minimal ray? Because the minimal ray light path is the most common property of prism as it applies to ophthalmic use (see Figure 1). The minimal or chief ray is determined when the path of the light ray is symmetrical, such that the angle of incidence to the (front surface) is identical to the angle of refraction (back surface) and parallel to the prism base as it traverses the prism. The optical strength or dioptric value of the prism is referenced by the total deviation or dioptric value. A one diopter value is defined as a refracting medium that produces an apparent displacement of 1 cm of the chief ray when measured at a distance of 1 meter.

The total deviation or minimal ray light path only applies to a prism placed in front of the eye when the face of the prism, the surface closest to

the object, is perpendicular to the direction of the incident light ray path or when the posterior surface of the prism is perpendicular to the eye (person). Other orientations produce a variable dioptric shift of the image depending on the angle of the prism in front of the eye and the resultant prismatic value is always more. While this may not be a major issue with smaller prism values, it does become a major issue with larger amounts of prism. This is also a point of consideration when attempting to measure an angle of ocular deviation and the imprecision of the resulting dioptric measurement which depends on how the prism is positioned in front of the patient.

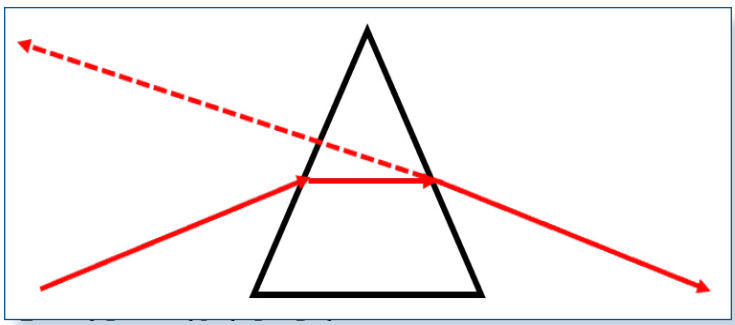


Figure 2. Projected Light Ray Path

An observer looking at an object through the prism will project the object to be displaced towards the apex of the prism (see Figure 2). The light path through the prism is refracted in the direction of the base, and the location of the object is perceived as shifted or translated in the direction of the apex.

We were taught how to calculate the amount of deviation. As noted earlier, one diopter of prism shifts the light path one centimeter in space for every meter of distance traveled through the air, which is convenient to know for taking tests and passing boards.

The conventional application of prism is therefore to shift the apparent location of images to match of the alignment of the two eyes so that they intersect in a manner that reduces the neuromuscular effort to maintain clear, single, and simultaneous binocular vision (CSSBV). However, as reviewed by Ogle,[7] there are other notable properties of prism that result in distortions related to nonuniform magnification. The distortion is characterized by: (1) an increasing angular magnification of the image toward the apex in the base-apex meridian, (2) a curvature of the images of lines perpendicular to the base-apex meridian, and (3) an increased slanting of the images of lines parallel to the base-apex line. Let's take a closer look.

Asymmetric Angular Deviation and Asymmetric Angular Magnification

In addition to what we have considered thus far, the rays of light approach the prism surface at different angles and are incident on different parts of the prism surface.[8] These rays of light have a different angle of incidence on the front surface. The variable thickness of the prism subtly affects the speed of transmission through the lens material. The longer the path through the medium of the lens the more it is slowed. As a result, the emerging rays of light all have different exiting angles.

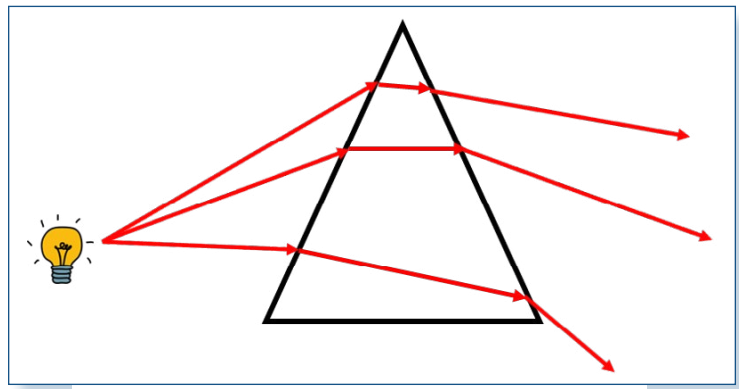


Figure 3. Asymmetric Angular Deviation

As can be seen in Figure 3, light emitted from the object point strikes the prism at different angles and the resultant deviation is different depending on the where the rays of light strike the prism. The deviated rays of light have greater deviation toward the base and less deviation toward the apex. This is referred to as asymmetric angular deviation.

Figure 4 shows that as the object is viewed through the prism, the projected angles of deviation of the image would have the opposite perception of the deviated side. In other words, the deviation would be perceived as a larger or expanded image

toward the apex and a smaller or contracted image toward the base.

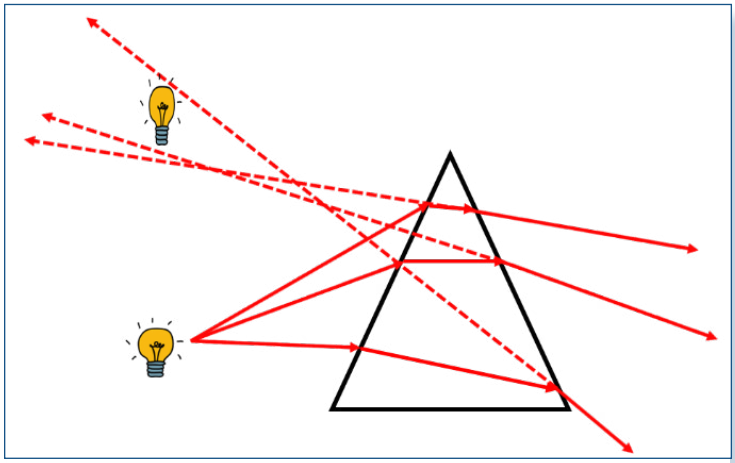


Figure 4. Asymmetric Angular Magnification

In the examples in the following discussion, we will primarily reference the spatial changes noted through a horizontal base left prism. Understanding the spatial changes with this prism, spatial observations can then be extrapolated to prism in any direction and applied to any prismatic diopter power, keeping in mind that the conscious awareness of the spatial change is generally more noticed with prism values greater than 5 diopters.

Compression and Expansion

Applying the principles of asymmetric angular magnification, there will be the perception of a compression of the square wave towards the base and expansion of the square wave towards the apex. This is demonstrated by looking through a base left prism at a square wave grating. When viewing the square wave grating in Figure 5a through the prism, look through any point on the base apex line, and without moving your eyes from that fixation point, compare the base side to the apex side of your fixation point. The square wave grating should appear as in Figure 5b, with perceived compression of space in the region of the base, and expansion of space in the region of the apex.

Slant

Along the line perpendicular to the base-apex line there is a simultaneous non-linear shrinkage (compression) of the object image toward the apex and increased size (expansion) towards the base. Projected images appear to change in height where the height is taller towards the base side of the center reference point and shorter towards the apex, as noted in Figure 5b. The behavioral observation of this size change would be that the floor or ceiling appears to tilt or slant. Since down space is easier to observe, the subjective observation would be uphill for a base down prism or downhill for a base up prism or a slant up to the right or left depending on the base direction of the prism. The slant is always upwards towards the apex of the prism, as in Figure 5b.

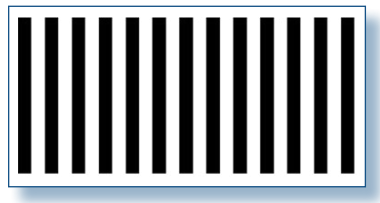


Figure 5a. Square Wave Grating

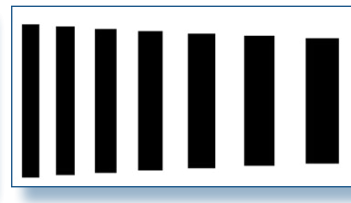


Figure 5b. Square Wave Grating viewd with Base Left Prism

Curvature

Another property of prism is curvature.[9] Along the line perpendicular to the base-apex line or parallel to the base, there is the perception of curvature. This is because light entering the prism from above or below has a different angle of incidence than light entering from straight ahead, such that different regions of a vertical line will be displaced differentially. The curvature also increases towards the apex of the prism as seen in Figure 6.

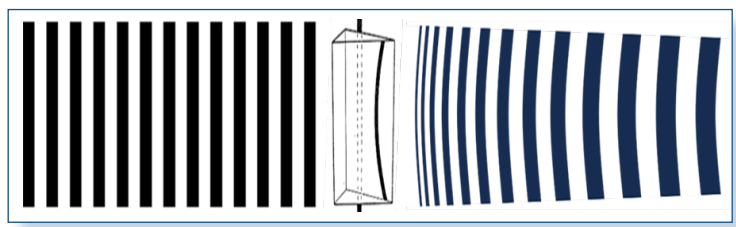


Figure 6. Shows the non-linear angular magnification along the line perpendicular to the base-apex line showing the gradual expansion of space from the base to the apex; the gradual increase in curvature from the base to the apex; the downward tilt towards the apex of the horizontal above horizontal center and the upward tilt towards the apex; and the perceived expansion of the spatial height in the base with compression of spatial height in the apex.

Thickness of Object Space

Up to this point we have described the non-linear relationships in the frontal plane, side-to-side and up-down. But how does a prism affect the space along a line perpendicular to a person, often referred to as the z-axis? If we could step out and look down on the object space, while someone is using a prism, what might we observe? Keeping with the illustration of using a base left prism and considering the spatial transformation properties noted above, and using the dashed lines representing the asymmetric angular magnification and the spatial perception previously illustrated, there would be a widening or expansion of space in the base and a narrowing or compression of space in the apex, as diagrammed in Figure 7. Doesn't this look like a prism?

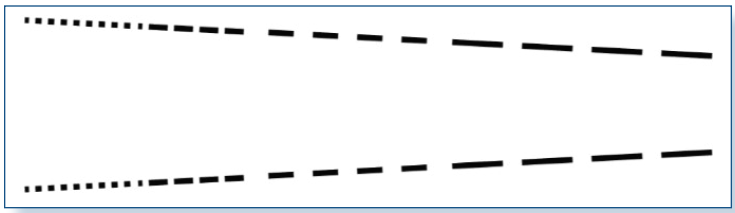


Figure 7. Expansion and Compression of Space

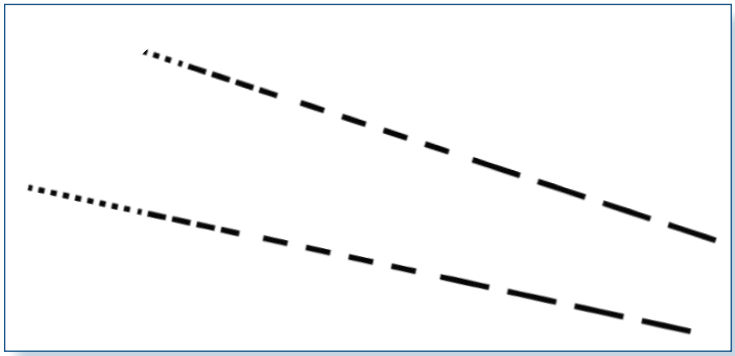


Figure 8. Spatial Rotation of Space

Rotational Relationship

Another spatial relationship associated with prism is the transformational spatial rotation of space. Objects do not just move side-to-side or up-to-down or appear closer or farther, rather there is a spatial rotation of the object space.

With a base left prism and looking at the object space from above, there is a rotation of space, as depicted in Figure 8.

After Effect

When wearing prism lenses for a period of time, adaptation occurs to these spatial transformations. While the observer might initially make errors in judgement based on their habitual frame of reference, perception ultimately shifts or recalibrates. Upon removal of the prism, the opposite perception occurs for a period of time until their baseline perception is restored.

Dioptric Values

Another property of prism is their interaction with dioptric power. Streff observed that students with myopia tended to rotate their heads so that they were looking through the apex of the prism for maximum clarity. Conversely those with hyperopia generally rotated their heads to look through the base of the prism to obtain maximum clarity. He addressed the optics of plano prisms through curved surface of +6.00 diopters front surface curvature, pointing out that there were dioptric changes that occur from the base to the apex. He found that in a 10-diopter prism there was an effective minus power through the apex and effective plus power

Table 1: Dioptric values of a 10-diopter prism

Angle of View for 10 Diopter Prism	Angle of View	Power at Axis 180	Power at Axis 90	Amount of Cylinder	Dioptrics
	40	+1.20	+0.54	+0.66	+1.20 -0.66 x 180
Towards the Base	30	+0.86	+0.41	+0.45	+0.86 -0.45 x 180
	20	+0.53	+0.26	+0.27	+0.53 -0.27 x 180
	10	+0.21	+0.10	+0.10	+0.21 -0.10 x 180
	0	-0.13	-0.06	-0.08	-0.06 -0.08 x 090
Towards the Apex	10	-0.52	-0.23	-0.29	-0.23 -0.29 x 090
	20	-0.98	-0.40	-0.58	-0.40 -0.58 x 090
	30	-1.52	-0.59	-0.93	-0.50 -0.93 x 090
	40	-2.13	-0.77	-1.36	-0.77 -1.36 x090

through the base.[10] (See Table 1) NOTE: for any prism value different than 10 prism diopters, these effects are still in play and are linearly proportional to the amount of prism used.

Streff's conclusion, in part, is that patients with myopia tended to prefer looking toward the apex due it affording them a view of the world through a lens with the spherical equivalent of -1.50. Looking through the apex gives the appearance of space moving closer to the individual. Patients with hyperopia look through the base because of the induced plus power that results from the oblique incidence of the rays hitting the lens. At the extreme, this is about +0.90 diopters.

BEHAVIORAL RESPONSE TO PRISMS

One can conceive of expected or canonic responses to prism on a monocular or yoked basis involving typical spatial shifts. This spatial transformation typically results in a shift in the center of gravity, with accompanying postural changes and pelvic rotation to the left or to the right with horizontal prism and postural shifts and pelvic rotation upward or downward with vertical prism, as noted in Table 2.

Table 2: Postural responses to the application of Prism. Adapted from Table 7.1, Canonic Responses to Prisms. Harris PA. The Use of Lenses to Improve Quality of Life After Brain Injury. In: P Suter and L. Harvey, eds. Vision Rehabilitation: Multidisciplinary Care of the Patient Following Brain Injury. Boca Raton: CRC Press, 2011:235.

	Eye Movement	Pelvis Shift
Base Down	upward	with center of gravity shift or postural change upward and pelvic rotation downward.
Base Up	downward	with center of gravity shift or postural change downward and pelvic rotation upward.
Base Right	leftward	with center of gravity shift or postural change and pelvic rotation to the right
Base Left	rightward	with center of gravity shift or postural change and pelvic rotation to the left

The Paradox in Compression vs. Expansion of Space

In the context of the optical, spatial, and behavioral properties of prism reviewed above, let's return to the apparent discrepancy between Dr. Paul Harris and Dr. John Streff regarding the compression and expansion of space.[11] As noted earlier, Dr. Harris wrote that there was expansion of space in the apex and compression of space in the base. Dr. Streff wrote that there was expansion of space in the base and compression of space in the apex. How can we reconcile such diametrically opposed views? What many have not understood is that Harris was working at the time primarily with flat prisms and all of Streff's work was done with curved prisms. It turns out that the induced plus and minus power, which is associated with curved prisms, is a major factor in how Streff described prismatic effects, which were absent in those prisms Harris worked with. Once understood, the differences melted away and both agreed on the primary spatial effects of prisms.

The resolution to this confusion lies in understanding the relationship between the two dimensional (2-D) spatial relationship of the physical optical properties of prism and a three dimensional 3-D perceptual interpretation spatial framework. In a conventional 2-D linear framework, prisms follow the physical properties referenced earlier. There is a shift of the image toward the apex and expansion or compression space differentially from the base to the apex in horizontal, vertical and z-axis space from the person outward. In a 3-D spatial relationship, the entire visual field undergoes spatial transformation across all directions and dimensions. This volume of 3-D space is represented in object and personal space by the frontal (vertical) plane, transverse (horizontal) plane and the sagittal (depth) plane with the corresponding x, y and z-axes. As the rays of light approach the prism, as illustrated in Figure 3, they encounter the prism surface varying angles and emerge at correspondingly different angles. This spatial transformation influences both the physical spatial property, as demonstrated in Figures 7 and 8, and the perceived spatial property, as illustrated in Figure 10. With prism, the spatial transformation property is the same in terms of quality but differs in terms of amount of deviation.

We'll delve more into that shortly, but before doing so a comment on terminology is in order. For orientation purposes, we will refer to the terms

of centrifugal and centripetal to describe perceived movements toward or away from the individual. The word centrifugal describes a force or an actual or perceived movement away from a center or axis plane, in optometry typically used as away from the self. Centripetal on the other hand describes a force or an actual or perceived movement toward a center or axis plane, in optometry typically used as toward the self. As an example, when one shifts from a distant part of the string to a place closer to them on the Brock String, and the eyes rotate to converge, there is a centripetal movement toward the individual. This is referenced as objects appearing to move inward or closer and matches what occurs through the apex of a base out prism. Conversely, centrifugal movement is referenced as objects appearing to move outward or further from the individual. The angular rotation of the eyes reflects a divergence movement and matches what occurs through a base in prism. In essence this type of distortion through the apex or base is an illusory translocation of space.

With regard to 3-D space, relational cues of relative size also come into play. The individual perceives that the expanded parts appear closer to us which would be a centripetal perception. The compressed parts appear further away and are referred to as a centrifugal perception.

The 3-D Spatial Relationship

Referencing a 3-D framework, Streff noted that there is the illusion of the compression of space toward the apex and expansion of space towards the base. His observation was related to the appearance of a spatial rotation. He reported that parts of an object (a wall for example in the frontal plane) appeared to look closer to him through the apex and further away in the base when looking through a large value base down prism. This illusion of the spatial rotation is a concept that involves the utilization of the perceptual cues of relative size and size constancy.

In a 3-D framework, cues of relative size result in the interpretation of the enlarged parts appearing closer and the compressed parts appearing further away. In essence, along with the displacement of the image, this type of distortion through the apex or base creates an illusory rotational translocation of space.

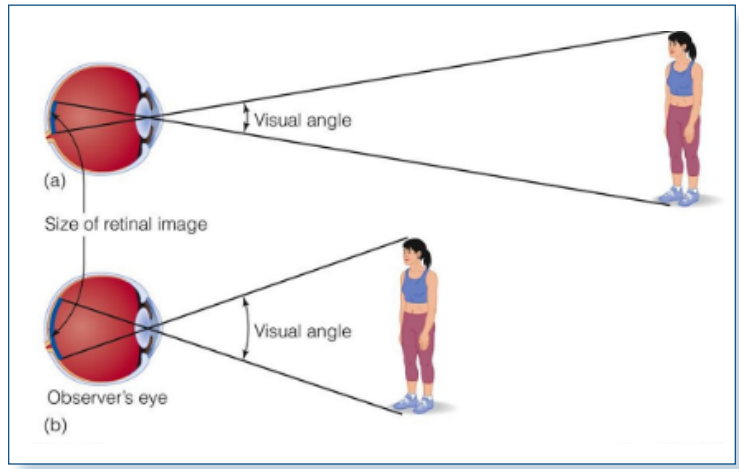
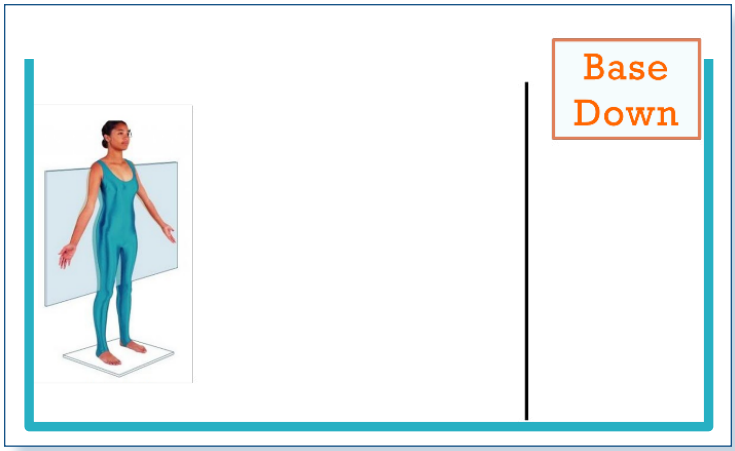


Figure 9. Relationship between visual angle and apparent distance.

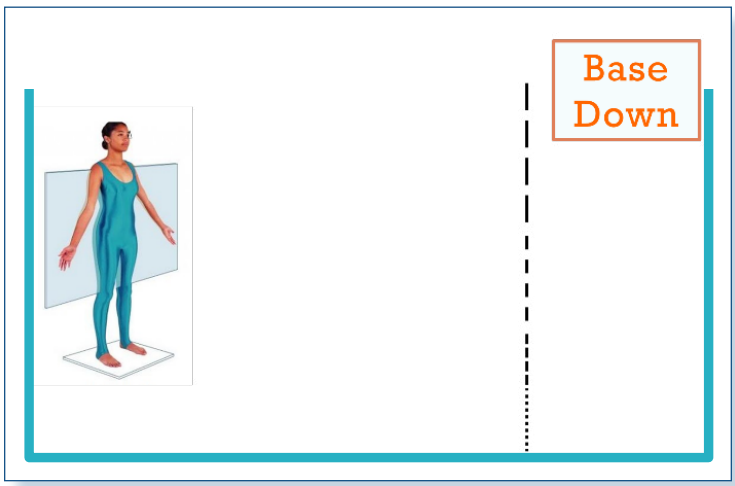
Relative size and size constancy dictates that when viewing an object that appears smaller in size, we perceive that object as farther away from us. When that same object appears larger, we perceive it as being closer to us, not larger. (See Figures 10 a and b).

When looking through the prism at the same object there are parts of that object that appear smaller and others that appear larger. Hence the illusion of compression or expansion of space along the base-apex line in a 3-D framework. Why is this? Recall our previous discussion about the non-linear magnification properties of the prism. In reference to where you are looking through the prism, the base side compresses space and the apex side expands space. Due to relative and size constancy perception, the parts of the object that look larger appear to be closer and the parts that look smaller are perceived to be further away. When looking at objects in the frontal plane you will note that there is a rotational tilt. With a base left prism, the left side of the object will look further away and the right side of the object will look closer to the person. With a base down prism, the lower area of regard will look further away (see Figure 1).

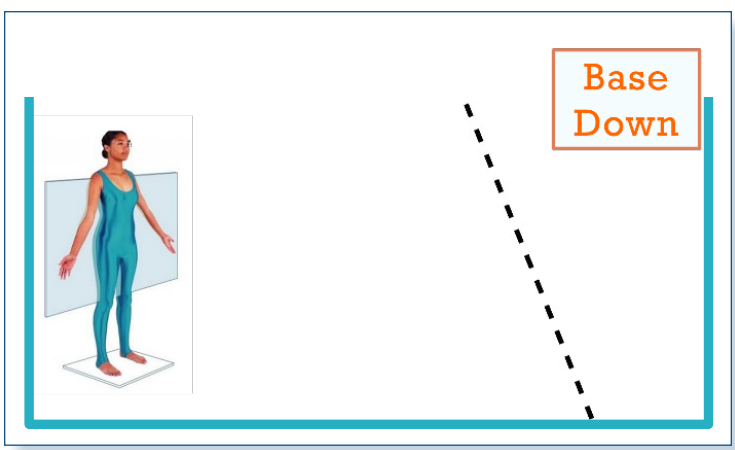
Streff wasn't the only one to write about this 3-D concept. Rock[12] in his book, The Nature of Perceptual Adaptation and Templeton and Howard[13] in their book, *Human Spatial Orientation*



In 10a, a person stands in front of a wall, represented by the black line, wearing a base down yoked prism.



In 10b, the wall, represented by the dotted line, is the non-linear spatial transformation created by the prism.



In 10c, the tilt of the wall is represented by the tilted dotted line and due to size constancy and relative size perception the wall appears uniform again.

Figure 10. The illusory effect of base down prism on perceived distance in the frontal plane.

also reference the illusion of a tilt in the frontal plane where the projected image appeared to be closer through the apex and further away through the base. The change in perceived space through the prism therefore depends on whether a linear or spatial framework is adopted, as depicted in Table 3.

Table 3: Illusory effects o prism.

Prism	Linear (2-D)	Spatial (3-D)
Apex	Wider (expansion)	Closer (centripetal)
Center	Neutral	Neutral
Base	Narrow (constriction)	Farther (centrifugal)

CONSIDERATIONS IN PRESCRIBING PRISMS

The standard conventional, or classical approach to prescribing prism for compensatory purposes is oriented toward neutralizing diplopia, or to satisfy comfort and performance criteria based on measurements of vergence dysfunction. The behavioral, developmental, and neuro-rehabilitative approach to prescribing prism for therapeutic purposes relies more heavily on the clinical observation of improvements in behavior and performance as prism is applied, bearing in mind the spatial transformation properties and postural behaviors noted above. It is noteworthy that the spatial transformation effect will most likely be perceived by the patient in the higher amounts of prism and generally used in active therapy. Although therapeutic prisms incorporated into the patient's prescription in lower amounts generally have less perceivable spatial transformation effects, they can still exert significant influence as will be discussed below.

Compensatory vs. Therapeutic Applications

Dr. Mel Kaplan[14] wrote that the two principal effects of prism, chief ray shifting used for compensatory purposes, and spatial transformation properties used for therapeutic purposes, cannot be separated from one another. They co-occur, and in some cases are interdependent. He noted that Skeffington, Getman, Apell, Streff and others reported that small lens powers may help some

patients make more profound changes at times than larger lens powers. This is because large powers tend to be more dissociative, with two prism diopters in any direction appearing to be the limit before some spatial distortion is present. Kaplan emphasized the application of yoked prisms, with bases in the same direction, and developed a specific protocol involving motor activities to gauge and refine the patient's response to prism.

As Harris notes, "The chief ray shifting effect of prisms cannot be separated from the spatial transformation of prisms. In many instances, the benefits of the prescribed prisms may result more from the spatial transformation than from the image shift."[2]

From a spatial transformation standpoint larger amounts might be used in vision therapy to induce positive disruptive changes in orientation and mobility whereas smaller amounts might be prescribed to influence proprioceptive orientation to provide a positive improvement in visual behavior for an improved relationship between where am I (Antigravity) and where is it (Centering). Some prism amounts and directions afford the patient an improvement in their performance where others show no change or a decrement in performance.

The decision to utilize prism therefore depends on their purpose. Prism may be purposefully disruptive at the outset, guiding the patient to re-organize visually. Therapeutic prism typically modifies the patient's behavior and performance and is designed to help the patient develop a different output with the anticipation that the prism may not be needed in the future. Therapeutic prism is often used in conjunction with an office-based vision therapy program.

Particularly as related to yoked prism, an overarching goal is to develop a more flexible relationship between the visual streams mediating "where am I" and "where is it" through neuro-muscular re-education. In his article on a rationale for the use of prisms in the vision therapy room, Dr. Robert Fox[15] focuses on the use of prisms in the range of 5 to 15 prism diopters and writes: "Prism is a powerful tool. The various optical distortions it provides allow for neural changes that affect the patient's sensory-motor and vestibular-anti-gravity systems." The basis for the induced distortions to which he refers are the spatial transformations noted above. In addition to making spatial adjustments for image shift, the person must allow for the illusion of tilts and slants of the visual world as well as size changes afforded by the prism. In this case, prisms alter the perceived reality to the point that the habitual visually directed neuromotor organization is no longer valid. The individual then interacts with the world to organize new spatial localization percepts using proprioceptive and kinesthetic feedback. Together with visual processing, ongoing activity to develop a more efficient and flexible relationship between the "where and I" and "where is it" systems is developed and monitored.

REPRESENTATIVE CLINICAL APPLICATIONS

A variety of tests and protocols have been proposed for determining the direction and amount of prism for therapeutic purposes, particularly as it pertains to yoked prism. Our intent is to provide some representative approaches, rather than to undertake an exhaustive literature review.

Egocentric Localization

Ciuffreda and Ludlam[16] address the spatial effects of yoked prism in terms of egocentric localization, citing the work of Padula as related to visual midline shift. In a variety of contexts, they have pointed out that visual midline shift is a misnomer because it is not a shift per se (e.g. lateral with respect to the body midline), but rather a polar-based, rotational deviation from the normal, midline-based reference point, thus reflecting one's three-dimensional, egocentrically-based, directional map of visual space.

Ciuffreda and Ludlam also address work done in conjunction with Suchoff using prism probes while the patient navigates the center of a long hallway. The application to hemianopia, with or without inattention, is beyond the scope of this paper. Their methodology highlights an important principle with regard to yoked prism in neuro-rehabilitation. The key point is that we as optometrists primarily are

concerned with how people move through space and watching their response to sets of prisms with them moving is necessary to seeing how the person can use them. The maximum amount of yoked prism they use is up to 10^ at distance and 15^ at near, but the typical values prescribed are in the 2^ to 6^ range. After a no-prism trial in navigating the hallway, the doctor or therapist observes the effect of yoked prism in various directions and amounts on improvement in ambulation and visual scanning and elicits subjective responses from the patient as well. They note that the minimum amount of prism that accomplishes this goal should be used, as larger amounts may cause spatial distortion due to the nonuniform magnification properties of prisms and/or substantial sensorimotor adaptation problems.

Visual Midline Shift

A midline shift is observed when the patient leans (tilts) to one side or the other or forwards or backwards, as originally introduced by Padula in the framework of the Visual Midline Shift Syndrome (VMSS).[17] It is thought that the VMSS is due to body control on the side of the neurological insult. Through the application prism, the individual may be observed to have better posture, have a more efficient gait and demonstrate more confidence with movement and motion. If this is truly a muscle weakness, how does the application of yoked prism assist the patient to walk in a more upright posture? As an alternative, VMSS may reflect alteration in visual perception which is different than muscle weakness. Applying the spatial transformation properties of prism noted above, a prism can be designed to alter the spatial perception to allow the person to see a more upright world and the person can then alter their posture to be more upright and erect.

Proprioceptive Dysfunction

Da Silva has streamlined a protocol for what is termed Postural Dysfunction Syndrome (PDS).[18] Formerly known as Proprioception Dysfunction Syndrome, this is an approach to prism prescribing which we might conceive of as a spatial vector at oblique axes, The amount of prism prescribed tends to be in the 1 to 4 prism diopter range with 2 to 3 prism diopters as the most frequently prescribed amount. The protocol involves observations of posture and movement ranges of the head, arms and feet in addition to visual observations of vergence and spot or sector scotomas. The prism orientations are typically in the oblique direction of 125 degrees in the right and 55 degrees in the left. In addition to the proprioception qualities of the prism values in his protocol there is also the consideration of the spatial transformation properties of prism that may be participating in the patient's overall behavior performance to the prism.

Postural Shifts

Yoked prisms are sometimes prescribed for specific populations to address particular visual characteristics.[19] Kaplan popularized this approach for children on the autistic spectrum. As reviewed by Dr. Stacey Coulter and her colleagues, yoked prism lenses are an optometric intervention that aims to improve visual spatial organization and visual integration abilities.[20] Consistent with our overview of the spatial transformations involved, they note that yoked prism lenses impact vision several ways. Generally larger amounts of prism values are considered for treatment in the autism population. They shift the field of vision, encourage a gaze shift toward the prism apex, and create a non-uniform change in magnification across the visual field, all of which alters their peripheral awareness. In addition, the spatial transformation properties create a visual perception that is vastly different than their habitual view of the world so now they have to "take inventory" and look around and begin to pay attention to their visual world.

With regard to children on the autistic spectrum who exhibit toe walking, in which their center of gravity is shifted forward, the theory is that yoked prism bases down will result in a postural shift upward thereby re-positioning the center of gravity. One might conceive of this as anterior visual midline shift. Additionally, there is the consideration that other spatial transformation

properties may play a role in shifting the center of gravity. With base down prism, the floor, being on the transverse plane, will now appear to slant upward and frontal plane space will have the illusion that it is up space is tilted towards them so the patient makes a postural counterbalance to right himself to having a world with parallel walls and floors. There is a school of thought that posits the inverse, namely that yoked prism bases up will result in transfer weight bearing from the toes to heels resulting in normalized heel-to-toe walking. This is because the initial shift in center of gravity will result in a postural shift forward that is destabilizing, and the child counteracts this by adopting a postural shift upward. With base up prism, the visual perceptual awareness skew in that the floor appears to tilt downwards and the frontal plane up space is perceived to tilt away from them. This creates an initial shift in center of gravity that results in a postural shift forward that is destabilizing, and the child counteracts this by adopting a postural shift upward.

The different schools of thought in using yoked prism as disruptive or stress-inducing, versus counter-stress, and their effects on perceived space and postural adjustment, were reviewed by Press.[21]

Visual-Auditory Localization

The Z-Bell test is a probe of visual-auditory localization developed by Dr. Deborah Zelinsky.[22] The patient is seated in various positions and asked to close their eyes. With eyes closed they are instructed to reach out and touch the bell after hearing the sound using different hands. The bell is placed in a variety of different positions relative to the person. Then lenses or prisms are applied and the patient is retested. The accuracy of spatial localization helps to determine the prism dioptric value and base direction as well as a lens value that synchronizes and balances visual-auditory spatial localization. This is reportedly effective with a variety of patients including those who have experienced stroke or traumatic brain injury (TBI). The mechanism through which prism changes localization has been posited to be that the low-level light impacting the non-image forming signals to the brainstem for controlling such processes as posture and spatial awareness.

Vision and Learning

In a set of articles with emphasis on vision and learning, Dr. Leonard Press proposed a protocol for the prescribing of small amounts of prism in the vertical and horizontal directions.[21] His approach utilizes a combination of associated and dissociated phoria measurements comparing distance to near findings in free space. Press noted that children who have vision-based reading difficulties often have a compression of visual space resulting in reduced vertical vergence ranges in both directions. This may be indicative of a crowding phenomenon, and when symmetrical can be an indication for the prescribing of small amounts of yoked prism. When combined with prism in the horizontal direction as indicated by testing, prism may result in a neuro-therapeutic effect based on stabilization as well as recalibration of visual space. Please see Appendix A for ancillary concepts that supplement these clinical applications.

CONCLUSION

We have discussed the spatial transformation properties of prism in the context of three principal factors. One is the deviation of light as a dioptric function of the angle relative to the eyes. The second is asymmetric angular deviation that results from differences in incident angles of reflected light relative to ray point origins. The third factor is asymmetric or nonlinear magnification. These properties result in the perception of compression or expansion of visual space along the base-apex line that vary depending on whether one adopts a 2-D or 3-D framework.

Beyond traditional considerations of prism that facilitates fusion and shifting of the visual field, the behavioral and performance changes that occur with spatial transformation properties of prism can be related in part to changes in angular rotation of the eye, adaptive shifts in the head and neck region, or postural changes translated through pelvic rotation. (See Table 3). This can occur with

prism in any orientation, but is most dramatic with yoked prism, particularly in the vertical direction.

Yoked base down prisms theoretically elevates visual gaze and stimulate an anterior rotation of the pelvis to create an extension and a more open body posture. In addition, there is the illusion of the expansion of space in lower space and compression of space in upper space. Yoked base up prisms theoretically depresses visual gaze, stimulate a posterior rotation of the pelvis to create a flexion in body posture to stimulate a more centered or grounded body posture and compress perceptual space.

We have reviewed how clinicians harness the various properties of prism in a variety of contexts, amounts, and directions based principally on their perceived alteration or transformation of visual space. The applications to asthenopia, diplopia, and visual field changes based on the chief ray light path, which is the conventional shifting of the image in space, have been amply covered elsewhere.[31,32]

NOTE: This article is based in part on a presentation given by Dr. Dean at the 50th Annual Meeting of COVD titled *Spatial Transformation Properties of Prism*. Available as General Session #8 at **https://tinyurl.com/3wvvspk2**

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REFERENCES

1. Jones B. Visual Behavior. Columbus, GA: Lockwood Press, 1995.
2. Harris PA. The Use of Lenses to Improve Quality of Life After Brain Injury. In: P Suter and L. Harvey, eds. Vision Rehabilitation: Multidisciplinary Care of the Patient Following Brain Injury. Boca Raton: CRC Press, 2011:213-281.
3. Kraskin RA. Lens Power in Action. Rev. Ed. Timonium, MD: Optometric Extension Program Foundation, 2002:83.
4. Harris PA. 1996. The Behavioral Use of Prisms. Vol. 37, No. 4. In: A Barber, ed. Tools of Behavioral Vision Care: Prisms. Santa Ana, CA: Optometric Extension Program Foundation,1996:1-32.
5. Streff J. Optical effects of "plano" prisms with curved surfaces. J Am Optom Assoc, 1973:44: 717-721. Reprinted in: Optom Vis Dev 2011;42(2):89-92.
6. Duke-Elder S. Geometrical Optics., Vol. V, Chap. 2 in Ophthalmic Optics and Refraction. St. Louis: The C.V. Mosby Company, 1970:49.
7. Ogle KN. Researches In Binocular Vision. Philadelphia, PA: W.B.Saunders Company, 1950:130.
8. Fincham WHA, Freeman MH. Optics. 9th ed. Chap. 4: Refraction and internal reflection at a plane surface — prisms and optical fibers. London Butterworts, 1980:49.
9. Ogle KN. Ophthalmic Prisms. Chap. IV in Optics, an Introduction for Ophthalmologists. 2nd ed. Springfield, IL: Charles C Thomas, Publisher;1968:67
10. Streff J. Optical effects of "plano" prisms with curved surfaces. Reprinted in: Optom Vis Dev 2011;42(2):89-92.
11. Harris P. Prisms and Perception. Presentation at the Invitational Robert Kraskin-Skeffington Symposium on Vision, January 1997. **https://tinyurl.com/ycyws9tt**.
12. Rock I. The Nature of Perceptual Adaptation. New York: Basic Books, Inc., 1966:177.
13. Howard IP, Templeton WB. Human Spatial Orientation. New York: John Wiley & Sons, 1966:211.
14. Kaplan M. Vertical Yoked Prisms. OEPF Curriculum II, February: 20-23, 1979.
15. Fox RS. A rationale for the use of prisms in the vision therapy room. J Behav Optom 2011;22(5):126-129.
16. Ciuffreda KJ, Ludlam DP. Egocentric Localization: Normal and Abnormal Aspects. In PS Suter and LH Harvey, editors. Vision Rehabilitation: Multidisciplinary Care of the Patient Following Brain Injury. Boca Raton: CRC Press, Taylor & Francis Group, 2011:193-211.
17. Padula WV. Neuro-Visual Processing Rehabilitation: An Interdisciplinary Approach. Timonium MD: Optometric Extension Program Foundation, 2012:78-89.
18. Alves da Silva O, Alves da Silva T. The eyes and proprioception. Vision Dev & Rehab 2019;5(2):130-47. **https://doi.org/j29t**.
19. Kaplan M. Seeing Through New Eyes: Changing the Lives of Children with Autism, Asperger Syndrome and Other Developmental Disabilities Through Vision Therapy. Philadelphia, PA: Jessica Kingsley Publishers, 2005.
20. Coulter RA, Bade A, Jenewein E, Tea YC, Woodmansee L, Groce AA, Warr C, Abdalla M. Prescribing yoked prism in patients with Autism Spectrum Disorder (ASD): A study of inter- and intra-examiner agreement using the Kaplan Nonverbal Battery. Vision Dev & Rehab 2019;5(2):84-99. **https://doi.org/rpvg**.
21. Press LJ. Topical review of the literature: Lenses and behavior. J Optom Vis Devel 1990;21(1): 5-21. **https://tinyurl.com/5b2kvfjn**
22. Elliott C, Putnam C, Zelinsky, D, et al. Using the Z-bell℠ Test to Remediate Spatial Deficiencies in Non-Image-Forming Retinal Processing. In: Arai, K., Kapoor, S. (eds) Advances in Computer Vision. CVC 2019. Advances in Intelligent Systems and Computing, vol 943. Springer, Cham. **https://doi.org/rpvf**.

23. Press LJ. The Art of Prescribing Low Amounts of Prism: Optimizing Outcomes. Optometric Clinical Practice 2025; 7(2):4. **https://doi.org/rpvd**
24. Hatch SW. The use of vertical yoked prisms in College of Optometrists in Vision Development members. Vision Dev & Rehab 2021;7(2):137-143. **https://doi.org/rpvc**.
25. **https://tinyurl.com/4wecnwxw**.
26. Michaelides E, Schutt CA. The correlation between the vestibule-ocular reflex and multi-focal ocular correction: implications for vestibular compensation. Am J Otolaryngology 2014;35(5):572-576. **https://doi.org/f2xrxs**.
27. Sheedy JE, Parsons SD. Vertical yoked prism - patient acceptance and postural adjustment. Ophthalmic Physiol Opt 1987;7(3):255-7.
28. Sulley A, Hawke R, Lorenzc KO, Toubouti Y, Olivares G. Resultant vertical prism in toric soft contact lenses. Contact Lens & Anterior Eye 2015;38(4):253-257. **https://doi.org/f7j89b**.
29. Petrosyan TS. An alternative use of lenses and prisms. Optom Vis Perf 2025;13(2):145-9.
30. Peckham, RM. The Modern Treatment of Binocular Imbalances. Geneva, NY: Shur-On Standard Optical Company, 1926.
31. Antony J. Prisms in Clinical Practice. Kerala Journal of Ophthalmology 29(2):79-85, May–Aug 2017. **https://doi.org/rpvb**.
32. Vicente GV. Prisms in Ophthalmic Optics. In: KM Riaz, D Wee, and GV Vicente, eds. Optics for the New Millennium. Springer Nature Switzerland AG 2022:15-32. **https://doi.org/rpt9**.



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Dr. Dean is a member of the Optometric Vision Development and Rehabilitation Association (OVDRA), in 2010 he completed the fellowship process. Members of OVDRA are optometrists who specialize in working with children and adults experiencing difficulties in the areas of binocular vision, focusing, eye teaming, strabismus and amblyopia and visual processing skill.

Dr. Dean coordinates with parents and educators in writing IEP programs and helping to write accommodations and 504 modifications. He also coordinates sensory integration programs with Occupational Therapy, Physical Therapy and Behavior Medical Specialties.

Dr. Dean is a member of the Neuro-Optometric Rehabilitative Association (NORA). Neuro-Optometric Rehabilitation is an individualize treatment regimen for patients with visual deficits as a direct result of physical disabilities, traumatic brain injury and other neurological insults. He provides treatment for people with visual field loss, double vision, visual balance disorders, visual midline shift syndrome, post trauma vision syndrome, light sensitivity and reading disorders.

Dr. Dean is also a member of the American Optometric Association (AOA); South Carolina Optometric Physicians Association (SCOPA); and the Optometric Extension Program Foundation (OEPF).

Spatial Transformation Effects

The spatial transformation effect depends on: base curve; distance from the eye; prismatic power; thickness of the prism and the orientation of the prism before the eye.

The World is a Prism, if You Had a Prism

The visual world can be conceptualized as behaving like a triangular prism because when viewed through a triangular prism, the entire visual space undergoes a systematic spatial transformation that correspond to the geometry of the prism itself. In a 2-D space, the reduction in object-space dimensions from the prism base toward the apex produces the perception of tilted spatial planes. Specifically, the floor appears to tilt upward towards the apex and the ceiling appears to tilt downward towards the apex, creating a visual configuration resembling the triangular geometry of a prism.

In 3-D space, the transformation extends across all spatial dimensions, with the perceived visual field becoming expanded and wider toward the prism base and compressed and narrower toward the apex. This altered spatial organization mirrors the three-dimensional structure of a triangular prism. When the frontal plane undergoes apparent tilt, the resulting spatial orientation reflects the angular characteristics of the prism geometry. Therefore, the shape of the prism itself provides a visual model for understanding how a prism transforms perceived space.

The Magnitude of Prism

A survey of COVD members on the prescribing of vertical yoked prism for their clinical population showed that among 123 respondents, 9.3% prescribed less than one prism diopter, 33.6% prescribed one prism diopter, and 41.1% prescribed two prism diopters.[22] This reinforces the concept that when the decision is made to prescribe prism, the least amount should be used that provided the maximum compensatory or therapeutic effect. It is not unusual to measure a large value only to have a small prism value allow the patient to have better performance.

Orientation and Mobility

It is common in low vision rehabilitation to test and train orientation and mobility, particularly when a patient is acclimating to optical aids. A widespread application of this is "the hallway test" in which the patient is asked to walk a corridor with and without yoked prisms in place to assess its effect of visually guided movement. It can be helpful to video-document these trials for demonstration purposes, and Merrill Bowan, OD has a YouTube channel dedicated to such demonstrations which includes the hallway test as well also other applications of microprism, generally defined as prism in the region of 1 to 2 prism diopters.[25]

Undesirable Prismatic Effects

It is well known that progressive addition lenses (PALs) induce varying degrees of peripheral spatial distortion, as well as variable gain in the vestibulo-ocular reflex (VOR) contributing to adaptive difficulties for some patients.[26] Lesser known is the fact that many ophthalmic laboratories incorporate yoked prism down as a lens thinning procedure to improve the aesthetic appearance and reduce the weight of the lens.[27] The amount of yoked prism is approximately two-thirds of the add power. That means the induced yoked prism base down effect on PALs will range from one-half to two prism diopters. It could well be that the adaptive difficulty encountered by some patients with PALs is related to the spatial transformation properties induced by yoked prism incorporated into lenses. Parenthetically a toric contact lens typically incorporates base down prism to minimize lens rotation, inducing anywhere from 0.52^ to 1.15^ through the optical center according to one study.[28]

Guided Illusory Effects

Given Prentice's Rule, any spectacle lens has an induced prismatic effect when looking away from the optical center. Analogously, in light of our earlier discussion about transformations of space, it should be clear that all prisms have induced spatial effects that simulate the size properties of dioptric lenses when looking away from the center of the prism (see Table 4). The clinician can harness this when the effect of a plus lens is desired, but the patient doesn't exhibit plus lens acceptance due to distance blur factors, or AC/A variables.

Typically, when prescribing a plus lens, the desired result is to create a centrifugal spatial shift where the virtual image is further away. To simulate that effect, the clinician can prescribe prism that results in expansion of space in the base. Petrosyan noted that yoked base down prism shares some spatial characteristics with plus lenses in that it expands visual space volume.[29] Although he didn't address the spatial characteristics of prism, Peckham identified one hundred years ago that base-in prism had a salient effect on increasing the patient's plus lens acceptance.[30] However, due to the differential effects of looking through the apex versus the prism, as well as the differential behavioral responses to prisms, clinical probes are necessary prior to prescribing, as the inverse of what is expected sometimes occurs.