Prisms and Perception

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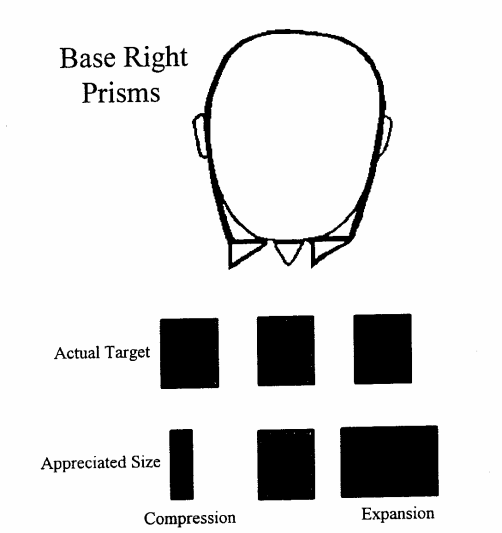
Over the past year, at various times, for periods going on from a few moments to several hours at a time, I have found myself totally consumed with trying to understand why I see things the way I do through prisms. At times I thought that a simple answer would emerge as soon as the next resource was consulted, or the next expert was spoken to, or the next experiment tried. I was certain that I was missing something critical which would help me understand. At times my confusion and feeling of helplessness was near total.

I am both sorry and happy to say that I have yet to emerge from this period of confusion with a full understanding of why I see the world the way I do through prisms. I am sorry because I had hoped that I would have found that key already and been in a position to share it with anyone interested. I am happy because I am coming to respect much more the power of lenses as transformers of our lighted world which provide us many opportunities to see things in different ways, as well as to effect different and very powerful changes in our patients. Over the course of this paper I hope to share those areas of continuing genuine confusion that I have, in hopes that what might emerge from the dialogue following the paper would further my personal search for understanding prisms.

Confusion 1 - My Diagram Must be Wrong!

In a paper published by OEPF earlier this year by me entitled "The Behavioral Use of Prisms,"[1] in the first few pages I spoke about my experiences with prisms as transformers of space. I included the following diagram which phenomenologically matched my perception of how I saw the world through flat prisms. When I looked straight ahead through the prisms, although the object was shifted to one side the object appeared neither expanded nor compressed. When I looked obliquely at another similar object through the base, the object appeared to me to be compressed in the dimension along the base apex line. When I looked obliquely at another similar object through the apex, the object appeared to me to be expanded laterally in the same dimension.



I could make the same thing happen with a single object if I looked at the object and turned my head from side to side while fixating the object. In one position of my head I was looking at the object through the base and in the other I was looking through the apex. NOTE: I was not sliding the prisms from side to side but was looking obliquely through the prism.

Within a few days of the distribution of the monograph I got some feedback which indicated that the diagram was incorrect. I got out my prisms and saw it the way I had written it. I then had some correspondence which indicated a possible reason for the discrepancy. Those who had spoken up had had experiences with curved prisms versus the flat prisms I had used. I had not had any curved prisms and had to wait to get some made up to check my observations.

An excellent article authored by Dr. John Streff entitled "Optical Effects of 'Plano' Prisms With Curved Surfaces"[2] was brought to my attention. This paper showed that the curved prisms used by Dr. Streff had significant induced astigmatism due to oblique incidence, which caused there to be significant effective plus power through the base and minus power through the apex. Based on the signs of the powers through these curved prisms, it was argued that my diagram was incorrect and that compression should be seen through the apex where there is minus power and that expansion should be seen through the base where there is effective plus power.

Once I got my curved prisms made up I indeed confirmed the plus and minus effects of the curved prisms in much the same manner as Dr. Streff mentioned using uncompensated low hyperopes and myopes and having them look at acuity charts and seeing which part of the prism they selected to view the chart through. The article done by Dr. Streff indicates that ray tracing had been done by two different groups which confirmed the plus and minus effects of the curved prisms.

All this was intellectually nice to know but I was still confused. As soon as I put on the flat prisms I saw things exactly as I had diagrammed it and the plus and minus effect did not seem to be present. Was there some key difference between flat and curved prisms?

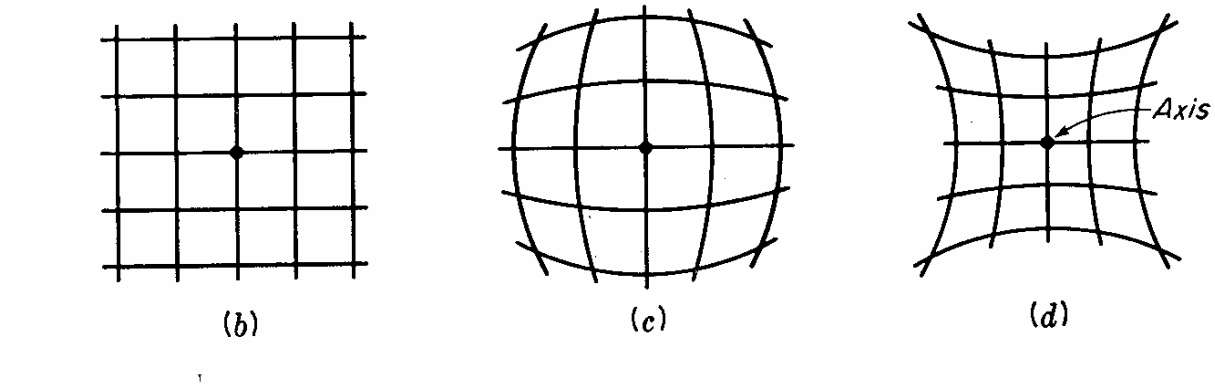
Confusion 2 - What is *Distortion*?

Well I was sure that geometric optics would have the answer for me. In my correspondences the word *distortion* had come up several times. I dismissed the word because its use was not consistent with how I used it on an everyday basis. I soon found out that it was my usage of the word *distortion* which was distorted! I was using the word *distortion* to mean *any transformation of the image which was done in an irregular manner which could not be described by any simple equation*. As an example, I pointed to the distortion on the image

that occurs when looking through a polycarbonate lens placed in a metal frame which is overly tightened around the lens. The resulting waviness is a distortion of the image and it has no regularity and cannot be written out by a simple equation. This to me was distortion. Well, I was wrong!

In going back over my geometric optics texts[3,4], I rediscovered the *Seidel Sums* which relate to the five monochromatic aberrations of optical systems. A lens free of all 5 aberrations would have no aberrations. Jenkins & White state, "No optical system can be made to satisfy all these conditions at once. Therefore it is customary to treat each sum separately, and the vanishing of certain ones corresponds to the absence of certain aberrations."[5] If S1=0 then the lens has no *spherical aberration*. If both S1 and S2 are both zero then the lens also has no *coma*. In the case of S1, S2, S3 and S4 all being equal to zero then the lens would be free of *astigmatism* and *curvature of field*. Finally, the condition of S5 also being equal to zero would eliminate *distortion*.

"To be free of distortion a system must have uniform lateral magnification over its entire field."[6] The types of distortion are the familiar pincushion and barrel distortions as shown below.



Unfortunately, I was not able to find diagrams of the distortion pattern one would get from prisms, either flat or curved. Clearly the curved lenses as described by Streff had significant astigmatism which seemed directly related to the curvatures chosen and the thickness of the prism. The flat prism seemed void of significant astigmatism but seemed to have a reverse effect on space for me. Was the effect of the flat prism distortion? I wondered if consulting some books on perception would help.

Confusion 3 - Perception Experts Disagree Also?

I consulted three books that I had on my book shelves, "Sight and Mind, An Introduction to Visual Perception" by Kaufman, "Vision and Visual Perception", edited by Graham, and "An Introduction to Perception" by Rock. I was excited when I saw the following diagram from page 320 of Rock's book.

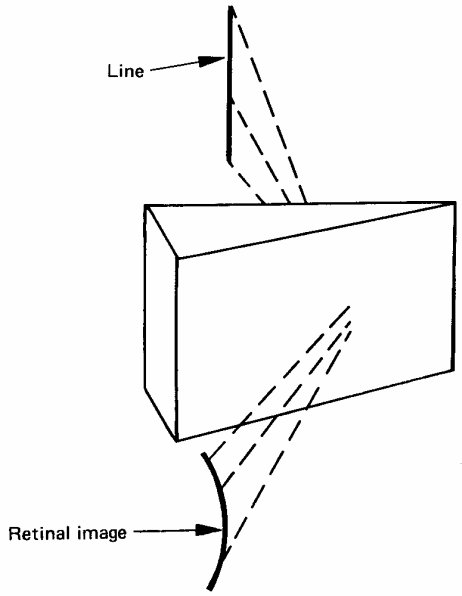


Figure 7-24

A few pages before Rock was dealing with the central question, "What makes a straight line look different from a curved line?"[10] He stated that, "The only factor that can be specified would seem to be the parallelism of the various contiguous segments of a line to one another."[11] See Rocks' diagram 7-22.

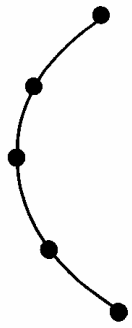


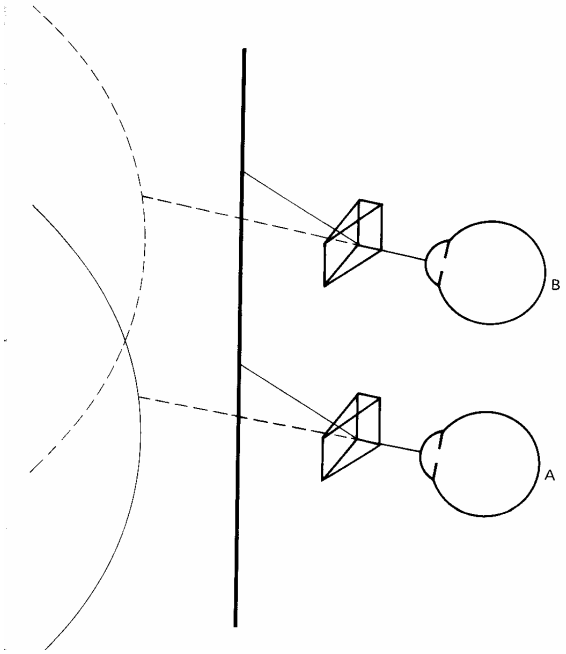
Figure 7-22

In the above figure the arc is broken down into several short segments. One way to test to see if the arc is a line is to compare the degree of parallelism from one segment to another. If each segment were found to be parallel to each other, then the whole arc would be a line. The line is a special case of an arc with an infinitely long radius. Rock continues, "Presumably the difference in the slope of the retinal image of the component segments is

the basis of our ability to discriminate straight from curved lines. If so, it would seem to follow that the retinal image must be straight for the perception to be that of a straight line."[12]

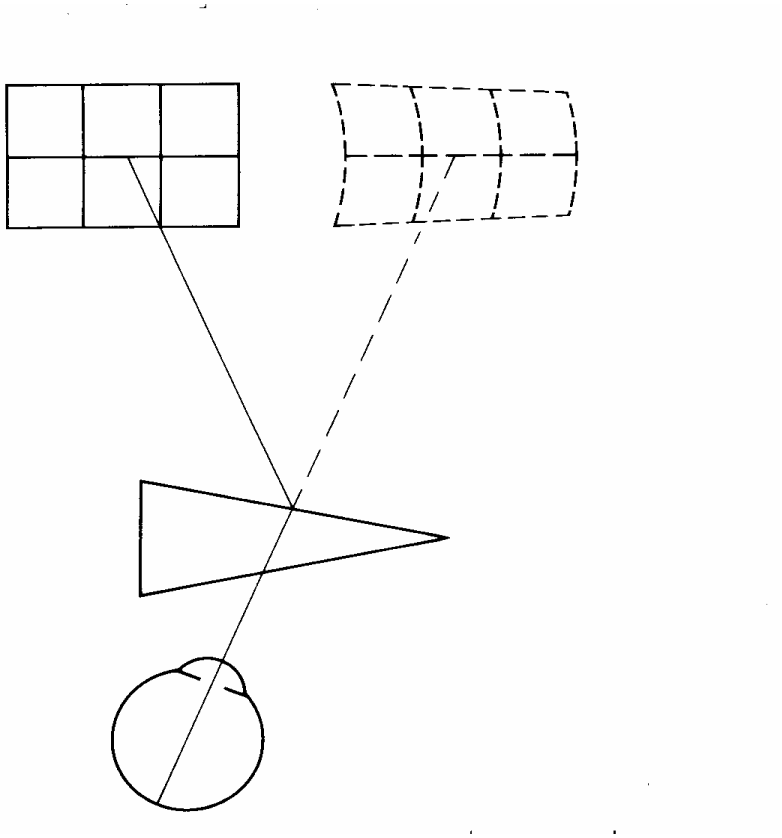
Rock's explanation for the curving of straight lines is consistent with the geometric optics term distortion. "A wedge prism has the effect of curving the retinal image of all straight lines that are parallel to the base of the prism. The reason for this is that the angle of incidence of the rays of light from the ends of the line to the prism is greater than the angle of incidence of the rays of light from the center of the line. The greater the angle of incidence, the greater is the refractory displacement effect of the prism."[13]

Now I thought I was on the verge of settling my confusion here but no! I ran for my prisms and saw that the door frame appeared curved all right, but in exactly the opposite direction as Rock's figure.



Before proceeding to Rock's explanation I show here a diagram in Kaufman's book from page 443 which shows exactly the opposite curvature of the line. Several comments need to be made about this figure. The first is that the prisms in the figure are reversible figures and could be seen in either of two different orientations either base right or base left. This increases the ambiguity of the figure. Therefore, my first impression which has the figure as being opposite to the way I see things may be correct if the prisms are flipped perceptually! Secondly, the figure is showing the person looking at the vertical line from two different vantage points and looking at two different places on the vertical line. It would be as if one were looking at a door jamb at one instance and then later in time looked at a place higher up on the door jamb. If the door jamb were truly curved the tangent point would not be exactly where the person fixated at both instances. At at least one of the fixations the person would be looking along the curve and not at the tangent point. When one looks at a straight door jamb with yoked prisms the tangent point is wherever the person fixates.

To add to my confusion earlier in Kauffman, on page 414, the following diagram appeared.
All the diagrams showed flat prisms. I was more confused than ever!



Earlier in his book, Rock dealt with our ability to adapt to the primary shift in location in space induced by prisms. He wondered if we would easily adapt to this curvature. Would we also rather quickly straighten out the curved appearance of things that we knew were straight, such as door frames? It turns out that there is some adaptation but it is very small and it does not last very long. Rock then wondered why we would adapt to the displacement so easily but not to the curvature.

Not All Curvatures of Space are the Same

A real curved rod in space will be projected differently on our retinas as we move through space. The following is Rock's diagram 7-25.

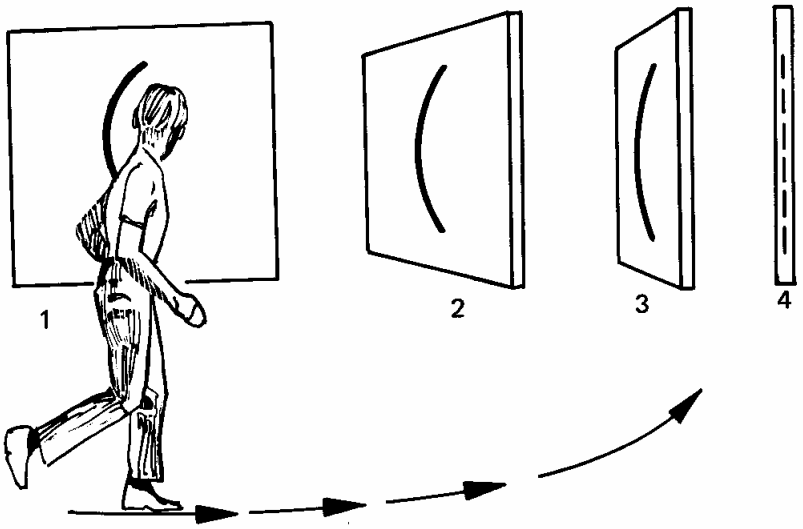


Figure 7-25

A straight line viewed through a prism is different. Rock states, "When a straight line is seen through a prism, its retinal image is curved, but the curvature of this image never changes as we change our position in relation to the line." "So the fact that the image does not transform as we move around a rod is potential information that the rod is a straight one. We do not know if the perceptual system makes use of such information."[14]

Next Rock shifted to the effect many of us see and use in vision therapy when lateral yoked prisms are used on the walking rail. This is the apparent curvature of the walking rail and the mismatch produced between the perception of the walking rail and the direction of action that needs to be given to walk on the rail and to stay on the rail

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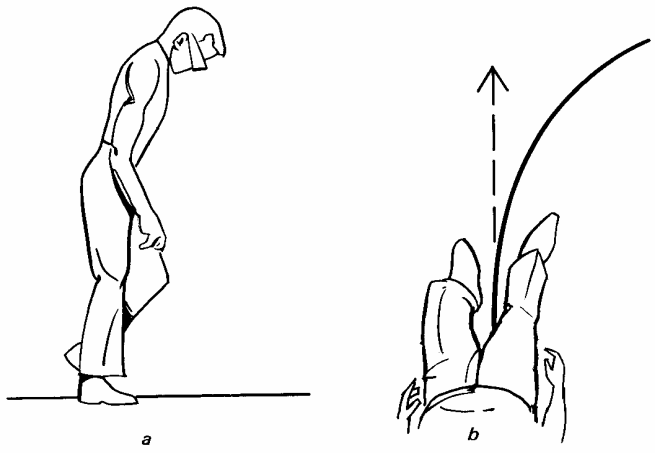

Figure 7-26

Rock speculates about whether we may use the flow of images over time as a way to know whether we are dealing with a real straight object or a real curved object. The following diagrams from Rock illustrate these differential movement flows in the optical array.

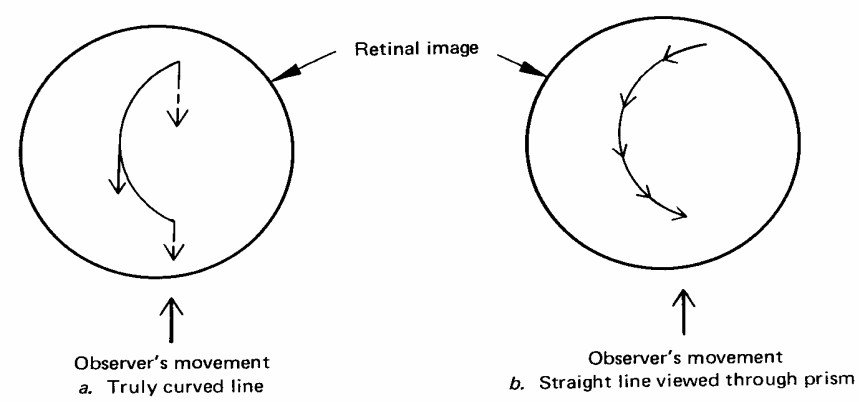

Figure 7-27

More Food For Thought

In my mind none of this is settled by any stretch of the imagination. There are many more prismatic transformations that I do not understand which I would like to. I look forward to learning more about prisms and their effects. I am hoping that some of you might be able to help me more fully understand what's going on.

References

1. Harris, Paul, "The Behavioral Use of Prisms", OEP Vision Therapy, pp 1-32, OEPF, Inc., Volume 37/Number 4 1996 ISBN 0-943599-78-4
2. Streff, John, "Optical Effects of 'Plano' Prisms With Curved Surfaces", JAOA, Volume 44, Number 7, July 1973 pp 717-721.
3. Jenkins, Francis A., White, Harvey E., "Fundamentals of Optics", McGraw-Hill, New York, Fourth Edition, 1976
4. Southall, James P.C., "Mirrors, Prisms and Lenses, A Text-Book of Geometrical Optics", The Macmillan Company, New York, Third Edition, 1946.
5. ibid. 3. p 151.
6. ibid. 3. p 171.
7. Kaufman, Lloyd, "Sight and Mind, An Introduction to Visual Perception", Oxford University Press, 1974
8. Graham, Clarence H., "Vision and Visual Perception", John Wiley & Sons, Inc. New York, 1965
9. Rock, Irvin, "An Introduction to Perception", Macmillan Publishing Co., Inc., New York, 1975
10. ibid. 9. p 318
11. ibid. 9. p 318
12. ibid. 9. p 318
13. ibid. 9. p 319
14. ibid. 9. p 321-322