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Spatial Transformation Properties of Prism (another part)

After my presentation a couple of years ago, I was asked if there were any additional properties of prism. I have found a couple that I don't remember talking about or have not heard addressed before.

Asymmetric dioptric change and Asymmetric angular magnification.

The physiological affects are ocular rotation and Adaptive spatial alignment.

Ocular rotation is rotation of the eye towards the apex and adaptive spatial alignment is the change in motor behavior with visual processing monitoring the movement to develop a more integrated perceptual-motor relationship.

More advanced properties talk about:

1. **Variable dioptric deviation**: When the apex of the prism is rotated towards the eye the deviation angle changes.
2. **Asymmetric angular deviation**: The various pencils of light from an object strike the prism at different angles and therefore the deviated angle also varies.
3. **Asymmetric linear magnification**: There is a non-linear spatial expansion of the image from the base to the apex.

Perceptual changes noted are

1. **Variable image size**: When the apex is rotated towards the eye angular magnification changes and the image size will vary.
2. **Perpendicular lines**: Straight lines perpendicular to the base apex line will appear curved.
3. **Parallel lines**: Straight lines parallel to the base apex line will appear tilted.
4. **Rotational translocation of space**: The space will appear to rotate and not just deviate in some direction.
5. **Neuroplasticity**: Some studies show there is a change in the neurology with the application of a prism.

1. Asymmetric dioptric change

2. Asymmetric angular magnification

So, what are these and what behaviors can be observed?

The first question to ask is, “Does a plano prism have sphero-cylinder power? Why would I ask that? It is a pl lens and when measuring in the lensometer it says pl.

I read a paper written by John Streff, OD when he was at the Gesell Institute of Child Development about the titled “Optical effects of “Plano” prisms with curved surfaces.

When John started working with Yoked Prism, he noted there seemed to be a patterned head posture shift. He observed:

1. Hyperopes tended to turn their head towards the apex so that they could look through the base of the lens.
2. Myopes tended to turn their head towards the base so that they could look through the apex.
3. Emmetropes preferred to keep their head straight and look through the center of the prism.

He set up a double-blind study:

1. Including 58 sixth grade students.
2. Distance retinoscopy was performed by one doctor
3. Head turn was measured by another doctor
4. 10 Diopter yoke prism BR and BL with a base curve of -6.75 on a front edge bevel.

The frames had a special attachment fixed to the temples that allowed a plumb line to hover over a large protractor.

The instruction set was: “Rotate your head until the letters on the chart are clearest.”

The results confirmed his observations:

1. Hyperopes oriented to look through the base
2. Myopes oriented to look through the apex
3. Emmetropes oriented to look through the center of the prism.

This made sense because when considering the spatial transformational properties of the prism.

1. There is the tilting where objects appear closer in the apex and further away in the base.
2. Naturally then the hyperope likes to have things further away and the myopes like to have things closer.

However, when John measured the diopters in the prism, he showed that there was a range of sphero-cylinder powers throughout the lens, depending which part of the lens measured.

This table shows the statistics for the head rotation.

This next table shows that they measured the dioptric power through different parts of the lens.

1. The magnified table shows that there is almost a 3.33 diopter change in the 180
2. There is almost 1.31 diopters at 090
3. There is almost 2.00 cylinder difference.

This suggests then, that a plano prism is not really plano.

I had a patient who required a large prism, 12.00 to maintain fusion. His prescription is +0.25-0.50x075 with a +2.00 add. His acuity is 20/20+. With the prism his acuity dropped to 20/40, even though the prescription checked out on the lensometer to be the prescription that I had written.

To somewhat bring this into the realm of "micro prism", I interpolated the data to show that even in the "micro" or small prism there is some dioptric power and there is a little bit of dioptric power in the prism.

In addition, it was determined that the base curve and the position of the bevel influences the dioptric distortion.

So, in summary of John's work:

Hyperope Theory Summary

1. They turned their head so they could look through the base of the prism.
2. There is effective plus power in the base and hyperopes prefer plus.

3. There is a rotational translocation of space where there is the perception of objects being farther away in the base of the prism.

Myope Theory Summary

1. They turned their head so they could look through the apex of the prism.
2. There is effective minus power in the apex and myopes prefer minus.
3. There is a rotational translocation of space where there is the perception of objects being closer.

The next question I have is: Does a plano prism effect accommodation? If so, how?

I have always been under the assumption that the relationship with prism and accommodation through the accommodative/vergence relationship. Change vergence-change accommodation and vice versa.

An article written by John Cegalis intrigued me when he alluded that it was the angular magnification property of prism that induced under accommodation.

To experiment, he designed 4 charts to be placed at four distances such that each chart subtended a visual angle of 1.0 degree in height. Then using a Laser-Badal optometer he measured the accommodative response. The subject looks at a granular speckle pattern and the movement of the pattern is directly related to the accommodative response of the eye.

The experiments were completed with the subjects wearing a 13.00 BL Yoke Prism. Side note, it is interesting that in the majority of the literature, a BL prism is use, just curious.

Under accommodation: is when the pattern moves with the motion of the head.

Over accommodation: is when the pattern moves against the movement of the head.

Ideal focal plane: is when there is no pattern movement when the head moves.

The results indicate that the binocular ophthalmic prisms induced a change of accommodation in a "passive" viewing condition in the direction of relaxed accommodation.

Optically induced relaxation was apparent at all the experimental target distances during the initial exposure.

Note: Even though there was more relaxation of accommodation at distance, the amount of relaxation was greater at near.

He found the same general results with higher contrast targets.

I think that he was looking more for a trend than an absolute. The trend is that the prism contributed to under accommodation.

His conclusion was that angular magnification was contributing to the under accommodation.

What is angular magnification and would it affect accommodation?

Remember from earlier, the spatial transformation property of asymmetric linear magnification. In the frontal plane, along the frontal plane, there is the perceived non-linear spatial expansion of the image from the base to the apex.

Angular magnification the angular extent of the retina an image subtense, what is the retinal size of the image. The closer an object is the larger the angle of subtense, as can be seen in the picture.

Both flat and curved prism show a similar asymmetric linear magnification of the image and this change in image size changes the angle.

It is thought that the larger appearing image required less accommodation effort.

In conclusion, prisms have a lot of properties and here are a couple of more.

1. Another physical property of prism is that they do have sphero-cylinder powers:
    a. Slightly more plus in the base and more minus in the apex.
    b. The behavior observation is the tendency for hyperopes to look more through the base and myopes to look more through the apex.
2. Another spatial transformation property is angular magnification
    a. There is a gradual increase in the linear magnification which affects the angular magnification and changes the angle of subtense.
    b. The increase in the angle of subtense affects accommodation to reduce accommodative effort.

These properties may also relate to my earlier comments about the variety of base directions that seem applicable for the same general binocular vision problem. Maybe it

is these affects on the spatial organization and reduced accommodative demand such that in some cases the base orientation may not be critical.

We do have to keep in mind too that prism, micro and large have the same spatial transformation properties and that changes in behavioral performance depends on the level of perceptual sensitivity of the person.

Thank you for your attention!

Here are questions for the group to discuss

1. **Do plano prisms have sphero-cylindrical diopter properties?**
2. **Do plano prisms affect accommodation?**
3. **What is the affect of prism distortion on the subjective responses in the phoria and duction measures in the 21-point exam?**