Spatial Transformation Properties of Prism and Neuroplasticity (another part)

Mark T. Dean, OD

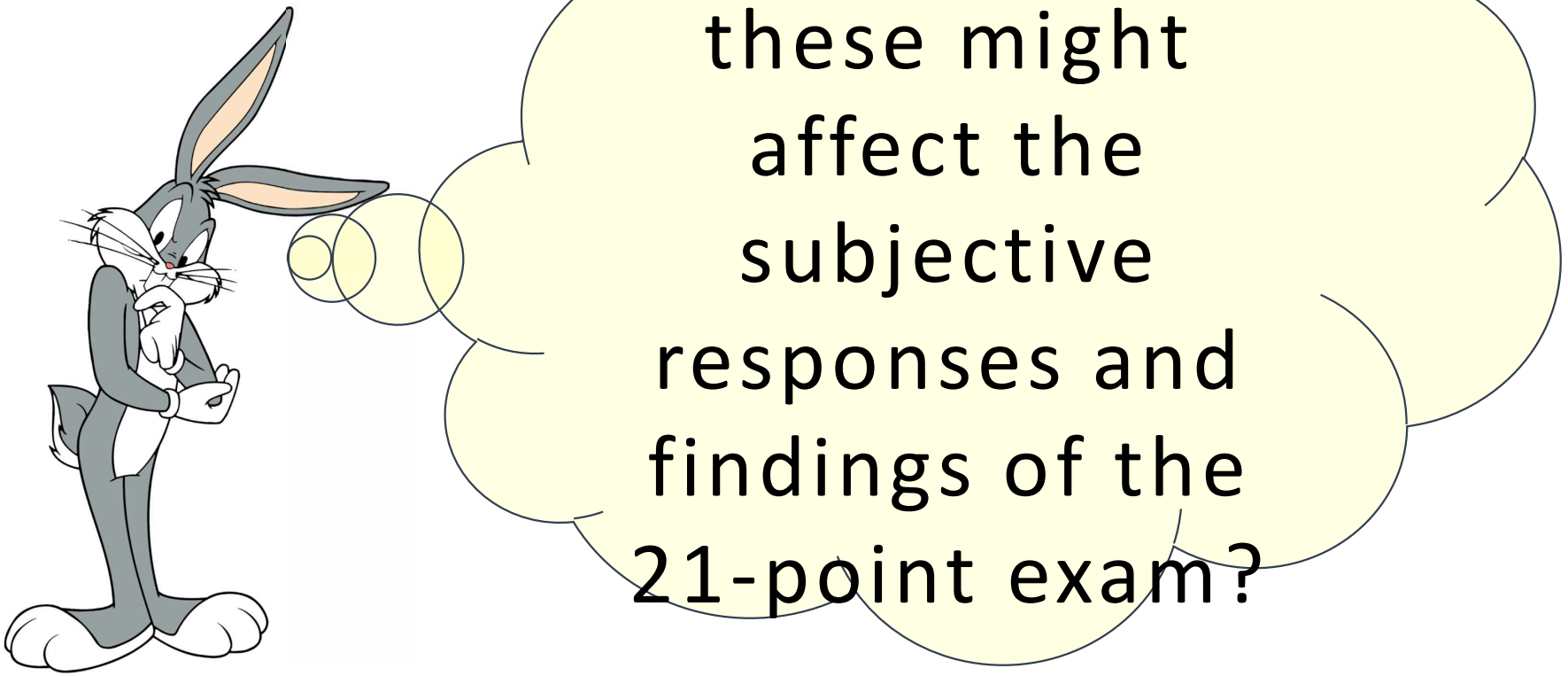
KISS 2024

I have no financial interest in anything I am talking about today.

Two New Spatial Transformation Properties of Prism

Asymmetric Dioptric Change

Asymmetric Angular Magnification


I wonder how these might affect the subjective responses and findings of the 21-point exam?

Physiological Optics

Spatial Transformation Properties

Visual Perception

Neuroplasticity

Physiological Optics of the Spatial Properties of Prism

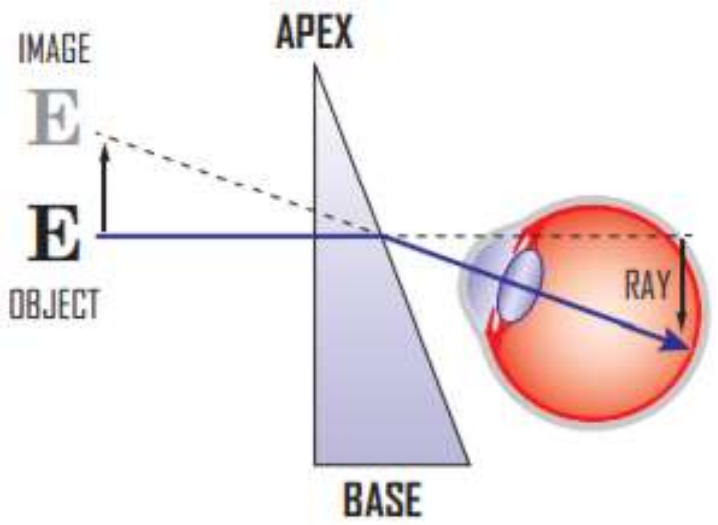
Ocular Rotation

Adaptive Spatial Alignment

Primary and Secondary Effects

Primary effect: is to deviate rays of light towards the base.

Secondary effect: induce a movement of the image target in the direction of the apex.



When we maintain fixation on the object our eyes move in the direction of the apex.

Adaptive Spatial Alignment

Visual processing monitors an ongoing activity through visual, proprioceptive and kinesthetic feedback, to develop a more integrated perceptual-motor relationship.

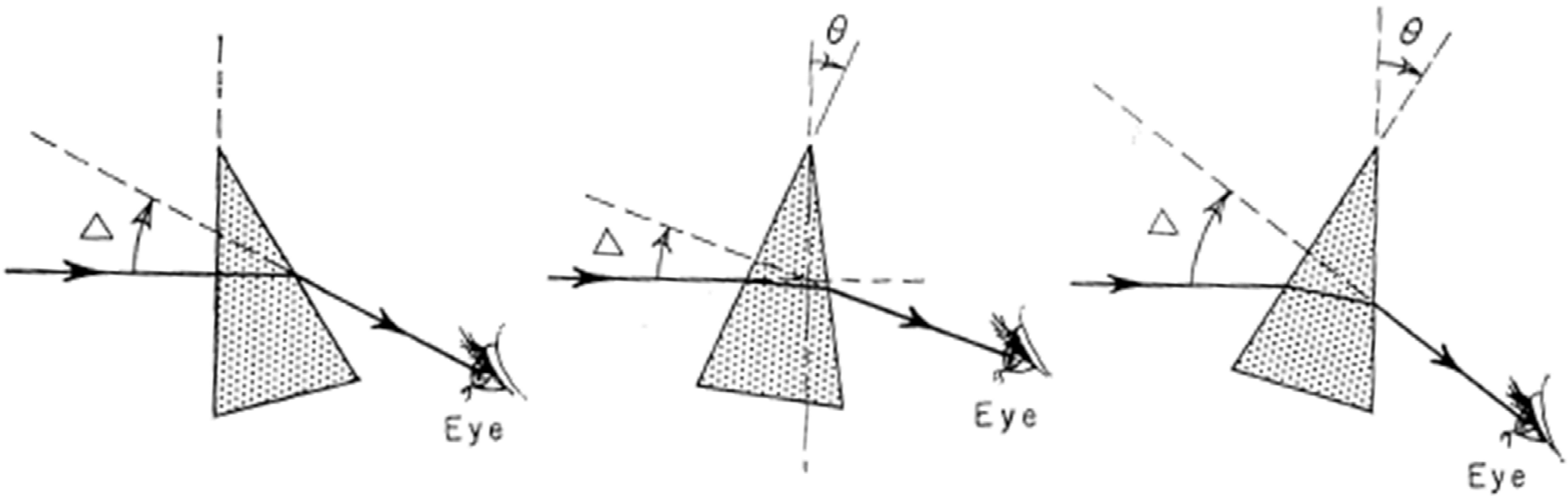
Spatial Transformation Properties of Prism

Variable Prismatic Deviation

Asymmetric Angular Deviation

Asymmetric Linear Magnification

Variable Prismatic Deviation



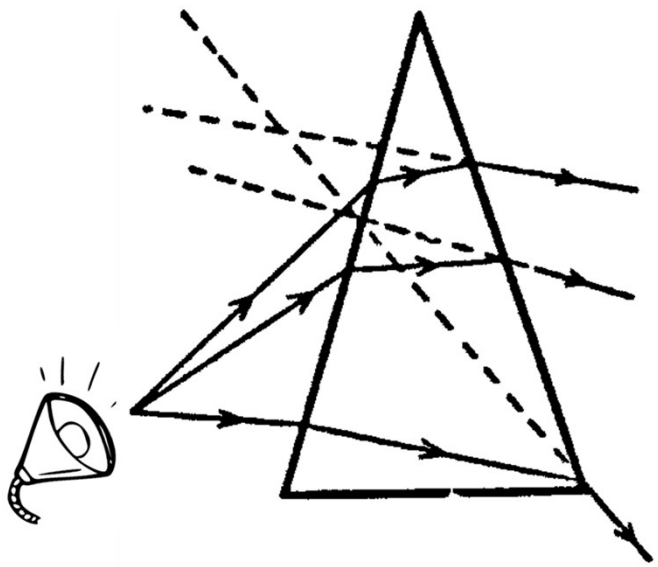
The deviation changes as the apex is rotated towards the eye; the deviation will first decrease and then increase.

Asymmetric Angular Deviation

As light strikes the prism:

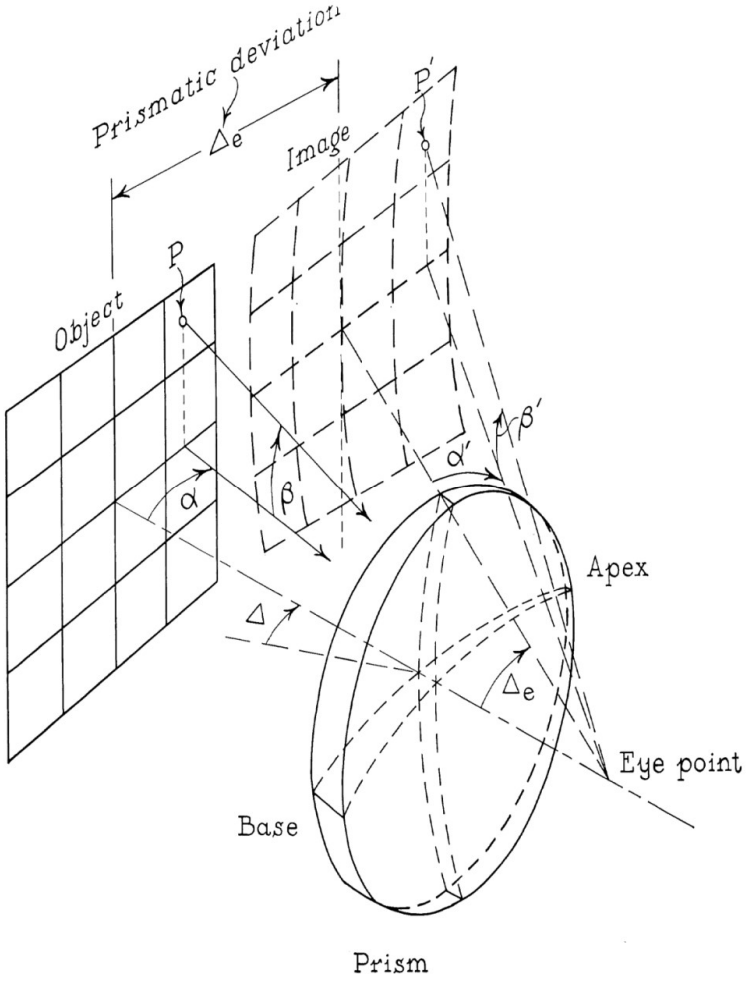
The various pencil rays of light emitted from the object will meet the prism at different angles.

The degree of deviation then depends on the angle the pencil rays of light make with the surface of the prism.



Asymmetric Angular Deviation

Asymmetric LInear Magnification



Looking at this from the frontal plane aspect:

Perceived non-linear spatial expansion of the image (whole world) from the base to the apex.

Asymmetric Linear Magnification

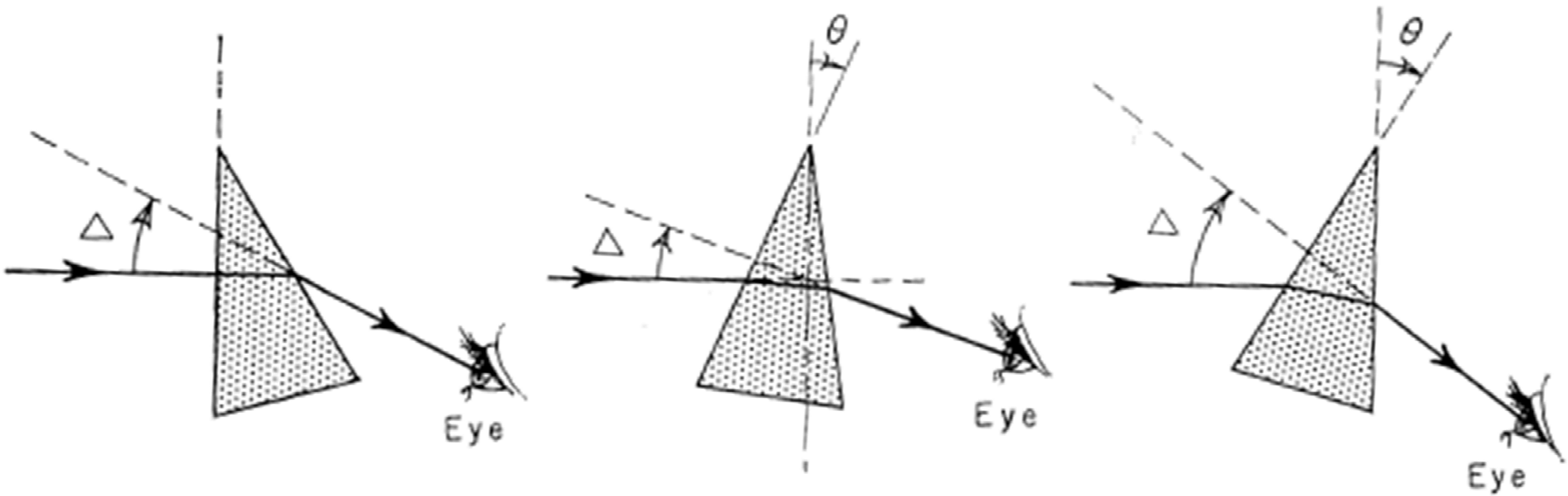
Visual Perception of the Spatial Properties of Prism

Changes in Image Size

Changes in Orientation

Perceived 3-D Rotation of Space

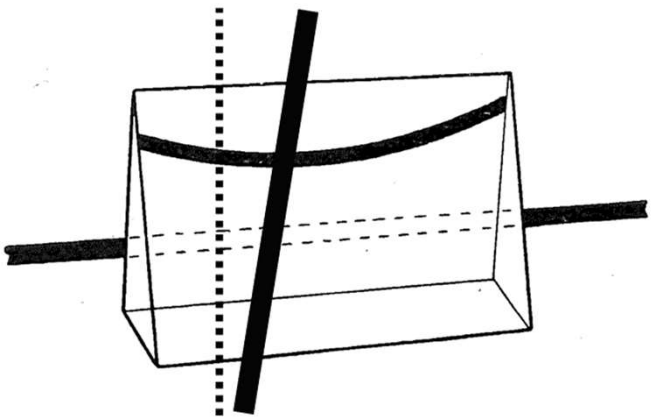
Variable Image Size



As the prism apex is rotated towards the eye, there is an asymmetric change in image size.

Orientation

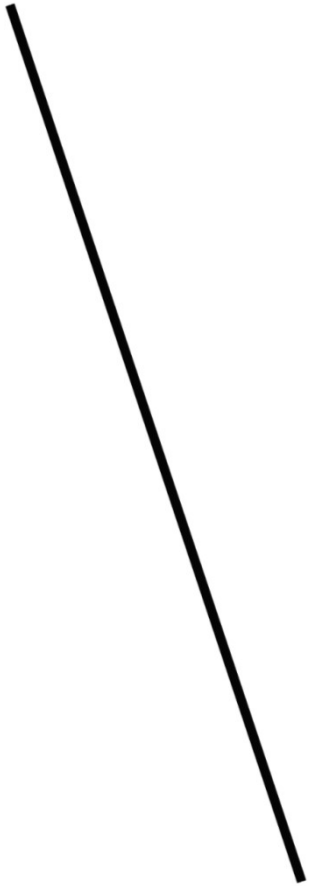
When a prism is held close to the eye and no matter which part of the prism you look through:



Straight lines perpendicular to the base apex line will appear curved.

Straight lines parallel to the base apex line will appear tilted.

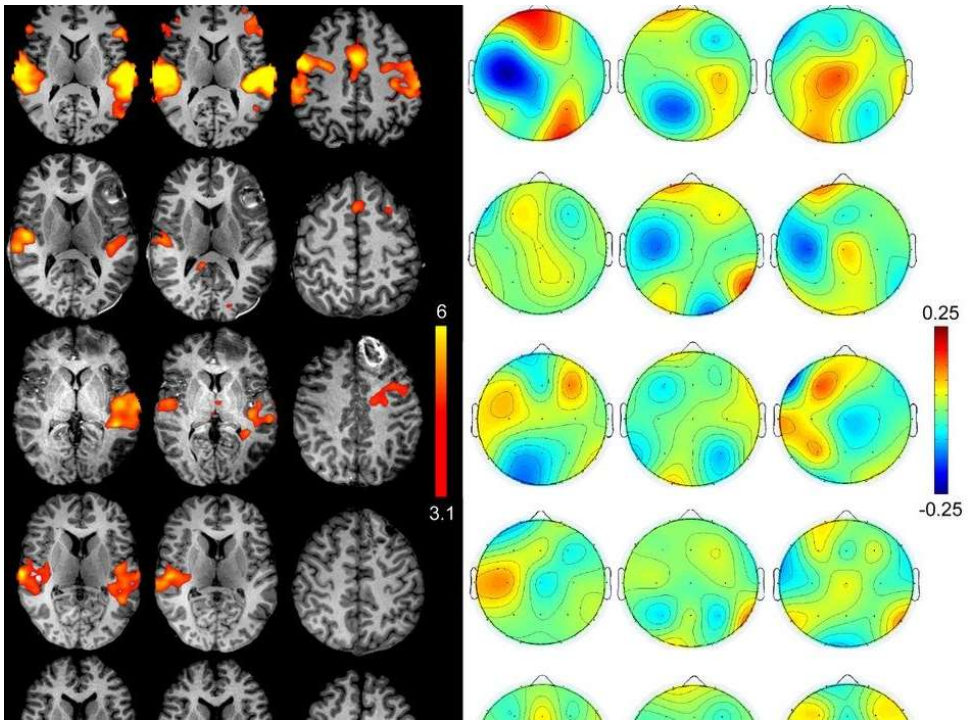
Base Down



Neuroplasticity of the Spatial Properties of Prism

Alters Neurological Function

Alters Neurological Function



Studies show that different parts of the brain change with the application of prism.

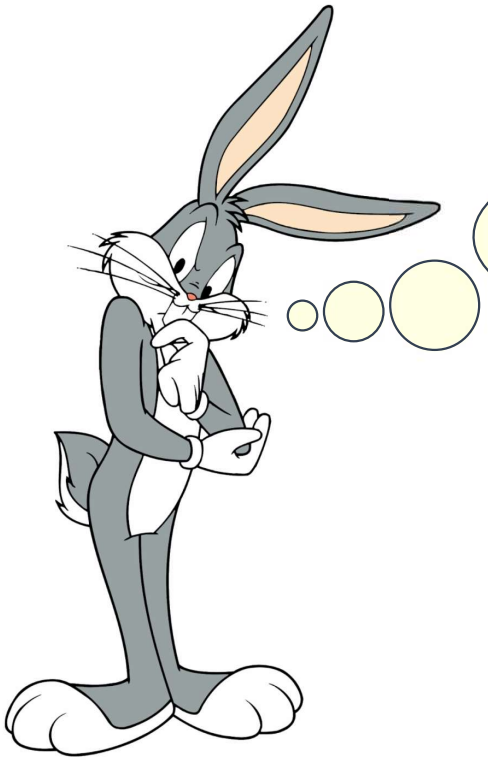
Two New Spatial Transformation Properties of Prism

Asymmetric Dioptric Change

Asymmetric Angular Magnification

Does a plano prism have sphero-cylinder properties?

Does a plano prism affect accommodation?



Does a plano prism have sphero-cylinder power?

Asymmetric Dioptric Change

"What is the effect of a plano prism?"

Hyperopes were observed to look towards the base.

Myopes were observed to look through the apex.

Emmetropes preferred to look through the center.

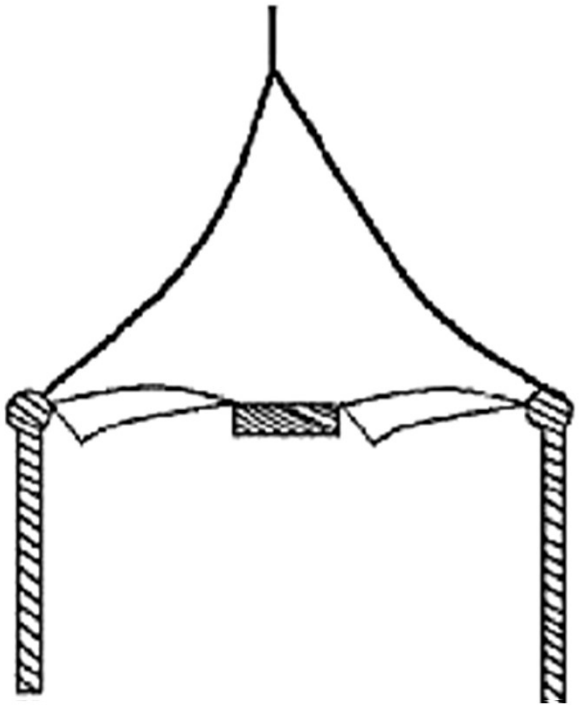
John Streff, OD

Asymmetric Dioptric Change

A double blind study:

1. 58 sixth grade students in the study.
2. Distance retinoscopy by one doctor.
3. Head turn measured by another doctor.
4. Two matching pairs of 10 diopter yoke prisms (BR and BL); ocular base curve -6.75 with a front edge bevel.

Asymmetric Dioptric Change



Head turn was measured by a plumb line attached to a cantilever on the frame hovering over a large protractor.

The chin was placed in a rotating chin rest.

Instructions: "Rotate your head until the letters on the chart are clearest."

Asymmetric Dioptric Change

Study conclusions:

1. Hyperopes over +1 diopter turned their head towards the apex so they could look through the base of the prism.
2. Myopes over -1 diopter turned their head towards the base so they could look through the apex of the prism.
3. Emmetropic patients preferred to look through the center of the prism.

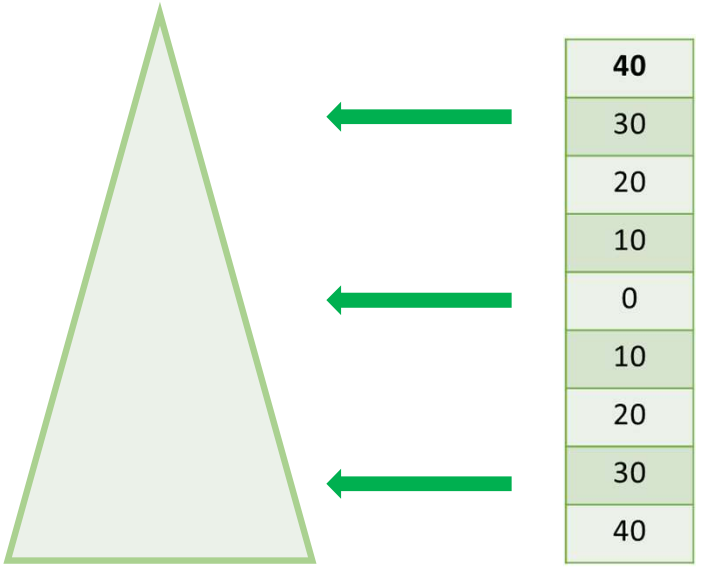
Asymmetric Dioptric Change

Above +1.00	BR(x) M = 10.0°	SD = 14.2°	BL(o) M = 8.4°	SD = 8.7°
+1.00 to +0.50	6.4°	7.7°	1.8°	10.8°
+0.50 to Plano	0.5°	8.8°	-7.6°	8.6°
Plano to -1.00	-10.6°	10.4°	-13.5°	7.7°
More than -1.00	-25.1°	5.1°	-27.1°	4.6°

The amount of head turn was related to the amount of the subjective prescription.

Asymmetric Dioptric Change

The viewing angle is different with each part of the prism.



Asymmetric Dioptric Change

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 -0.27 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 x 090

Asymmetric Dioptric Change

Angle of View for 1 Diopter Prism	Angle of View	Power at Axis 180	Power at Axis 90	Amount of Cylinder	Dioptrics
	40	+0.12	+0.06	+0.06	+0.12 -0.06 x 180
Towards the Base	30	+0.08	+0.04	+0.04	+0.08 -0.04 x 180
	20	+0.05	+0.03	+0.02	+0.05 -0.02 x 180
	10	+0.02	+0.01	+0.01	+0.02 -0.01 x 180
	0	-0.01	-0.00	-0.00	-0.00
Towards the Apex	10	-0.05	-0.02	-0.03	-0.02 -0.03 x 090
	20	-0.09	-0.04	-0.05	-0.04 -0.05 x 090
	30	-0.15	-0.05	-0.10	-0.05 -0.10 x 090
	40	-0.21	-0.07	-0.14	-0.07 -0.14 x 090

Asymmetric Dioptric Change

Steeper: -6.75 Base Curve has less aberration

Flatter: Plano base curve has more aberration

Angle of View	Power at Axis 180°	Power at Axis 90°	Amount of Cylinder
Toward Base 40°	+1.53 Diopters	+0.64 Diopters	+0.89 Diopters
Toward Apex 40°	-1.54	-0.62	-0.92

Center-Beveled induced optics are more symmetrical.

Asymmetric Dioptric Change

Hyperope Theory Summary

They turned their head so they could look through the base of the prism.

There is effective plus power in the base and hyperopes prefer plus.

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

Asymmetric Dioptric Change

Myope Theory Summary

They turned their head so they could look through the apex of the prism.

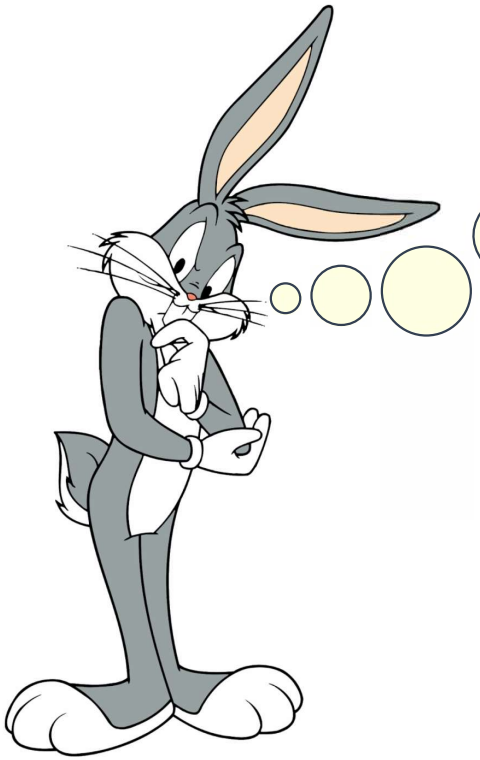
There is effective minus power in the apex and myopes prefer minus.

There is a rotational translocation of space where there is the perception of objects being closer.

Asymmetric Dioptric Change

The amount of induced optics depends on:

1. The ocular base curve of the prism.
2. The location of the bevel.
3. Prism power (angle of prismatic deviation).
4. The angle of incidence of the subject's sighting line.



Does a plano prism affect accommodation?

Prism distortion and accommodative change*

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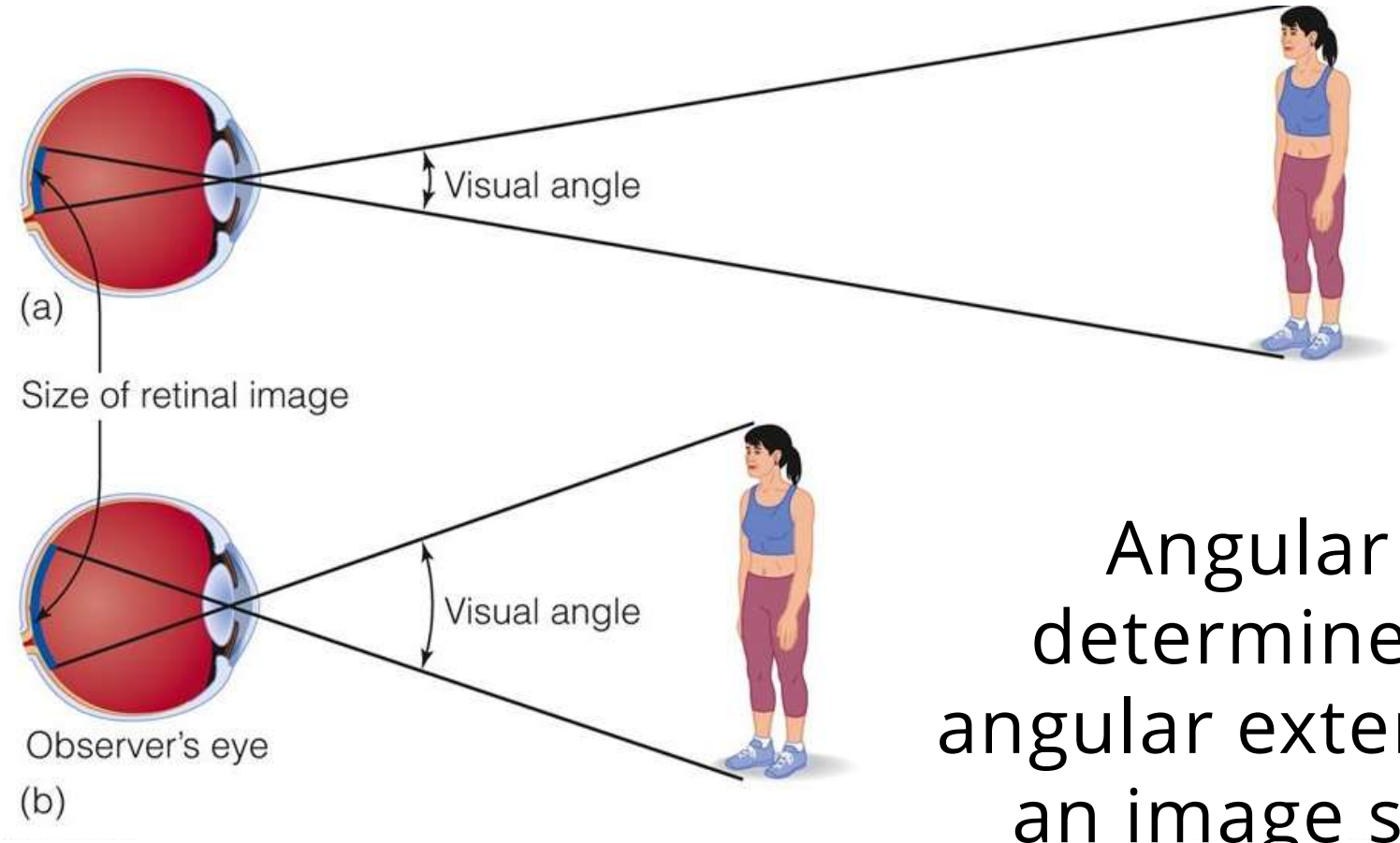
Angular magnification property of prism induced under accommodation.

Asymmetric Angular Magnification



Angular size is determined by the angular extent of retina an image subtense.

Asymmetric Angular Magnification

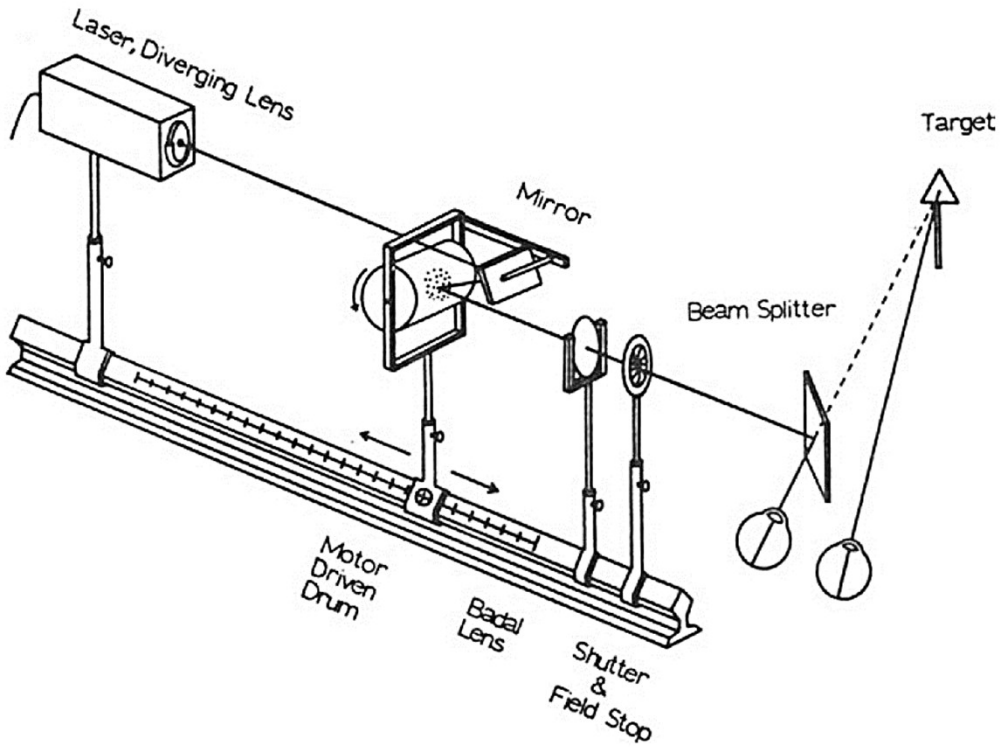
Holding a book (object) closer, increases the angular magnification.

Asymmetric Angular Magnification

Meter Test Distance	Feet Test Distance	Inches Test Distance
0.5	1.64	19.68
1.0	3.28	39.37
2.0	6.56	78.74
4.0	13.12	157.48

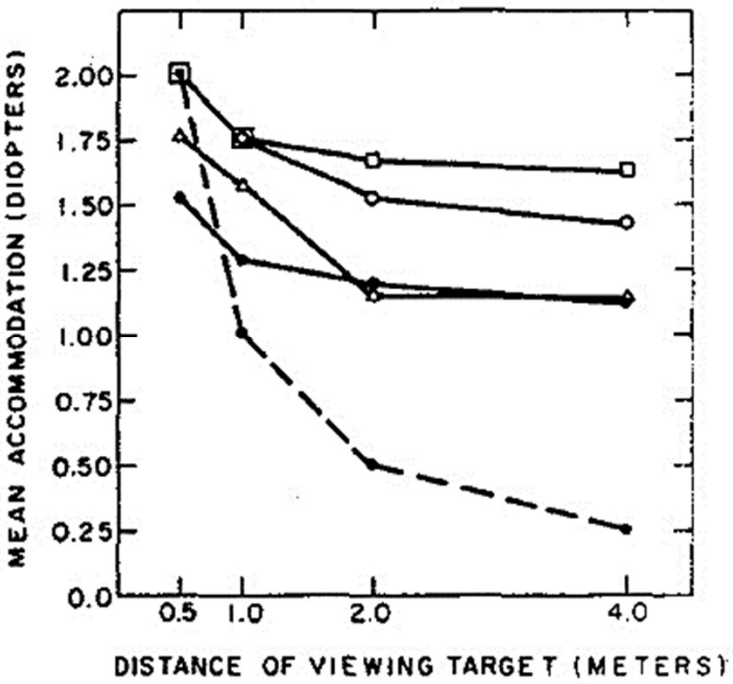
The four targets subtended a constant visual angle of 1.0 deg in height.

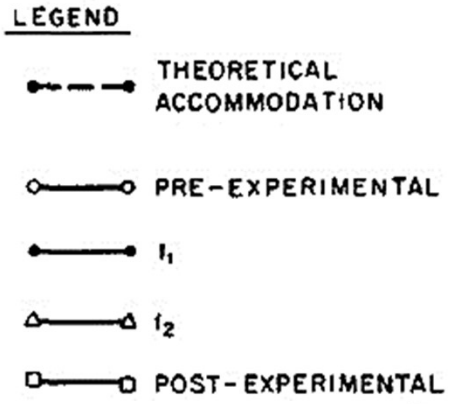
Asymmetric Angular Magnification



Accommodation was made with the laser optometer.

Asymmetric Angular Magnification

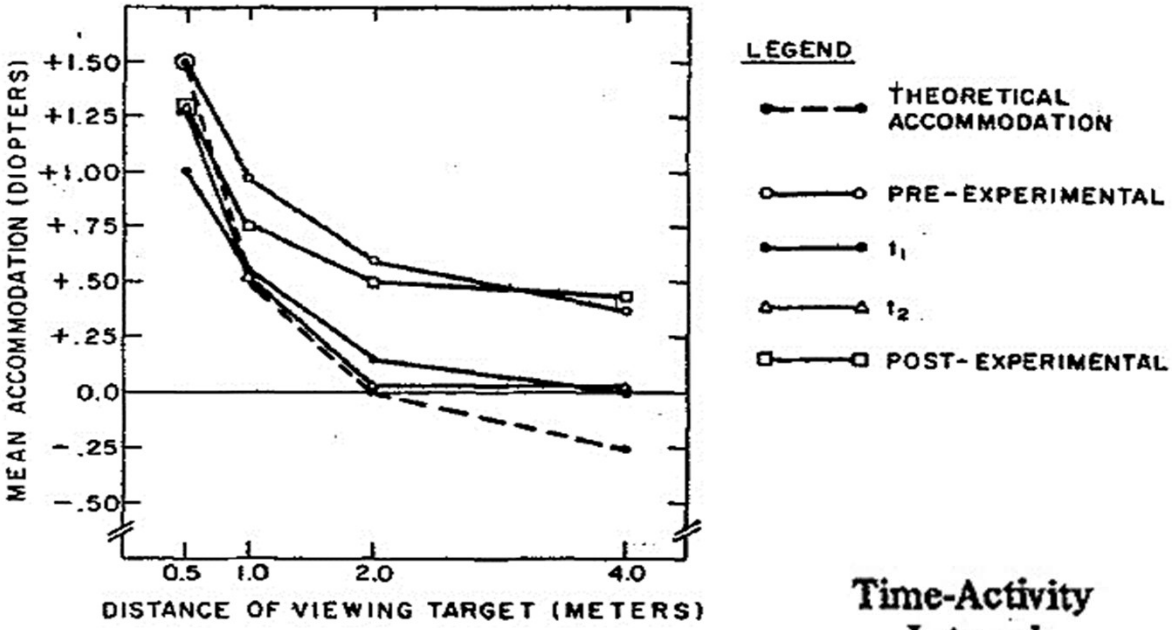




Experiment 1
Lower Contrast Targets

Time of Measure	Target Distance (in Meters) 0.5	1.0	2.0	4.0
Theoretical Value of Accommodation	+2.000	+1.000	+0.50	+0.25
Preexperimental	+2.004	+1.754	+1.534	+1.431
Experimental T_1	+1.536	+1.288	+1.208	+1.146
Experimental T_2	+1.773	+1.589	+1.180	+1.159
Postexperimental	+2.010	+1.759	+1.715	+1.630

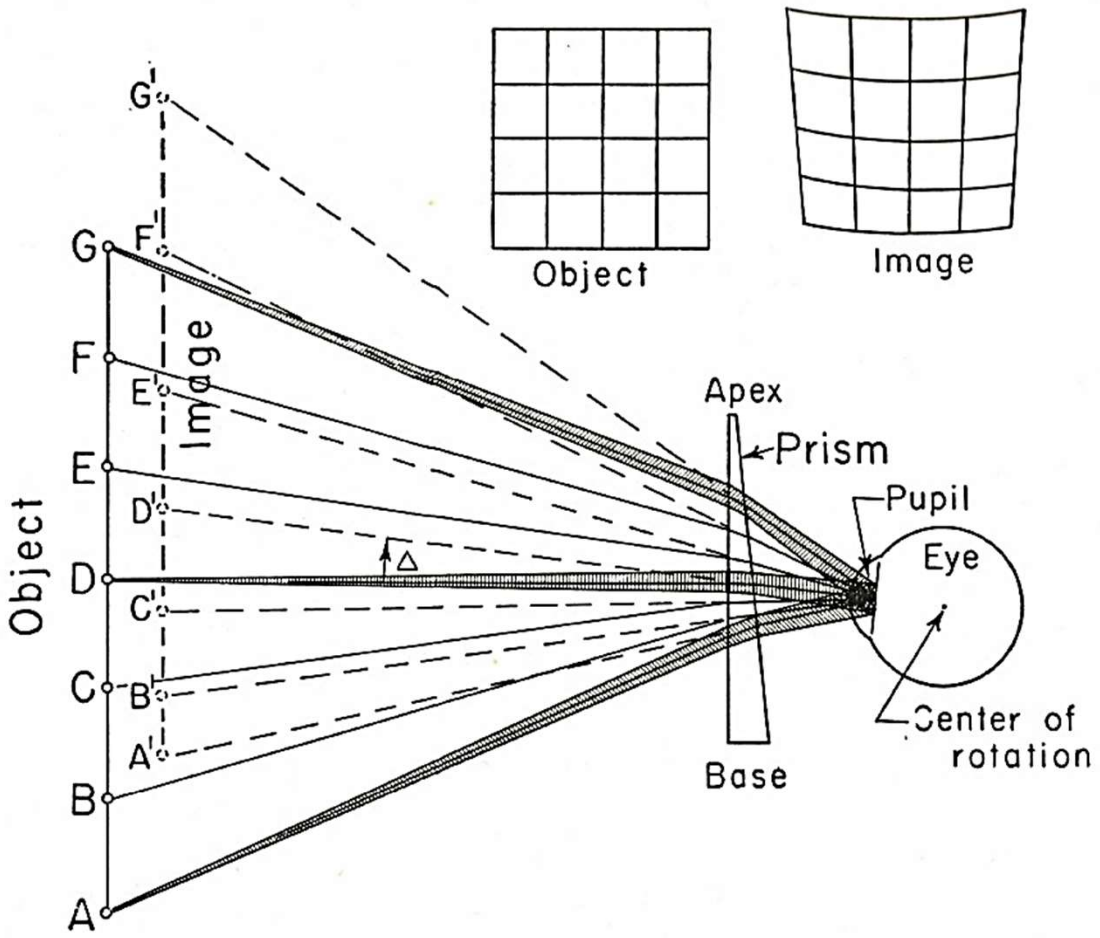
Asymmetric Angular Magnification



Experiment 2
Higher Contrast
Targets

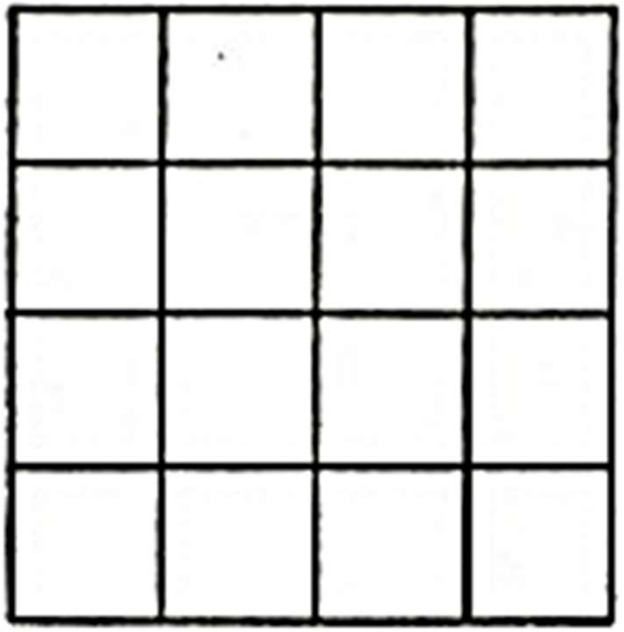
Time-Activity Interval	Target Distance (in Meters) 0.5	1.0	2.0	4.0
Theoretical Value of Accommodation	+1.500	+0.500	0.000	−0.250
Preexperimental	+2.031	+0.969	+0.584	+0.375
Experimental T_1	+1.063	+0.563	+0.156	−0.031
Experimental T_2	+1.281	+0.531	+0.188	+0.219
Postexperimental	+1.188	+0.750	+0.500	+0.438

Asymmetric Angular Magnification

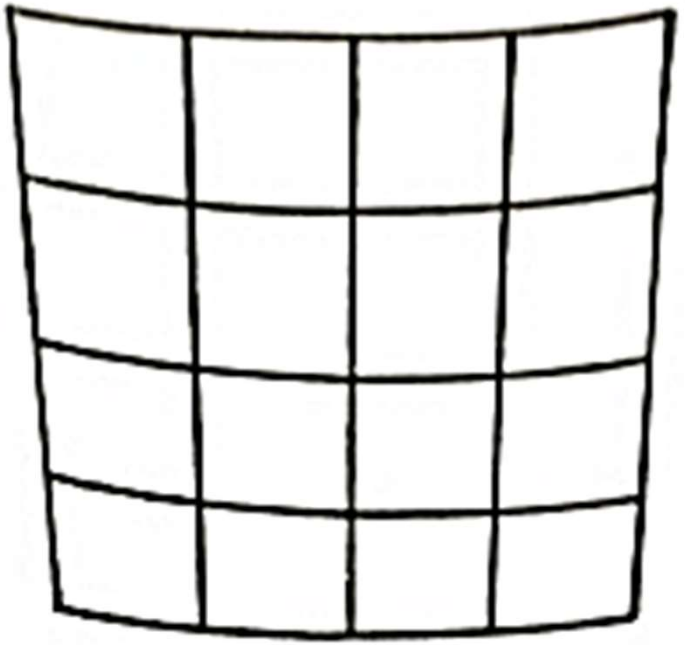


Asymmetric Linear Magnification

Asymmetric Angular Magnification



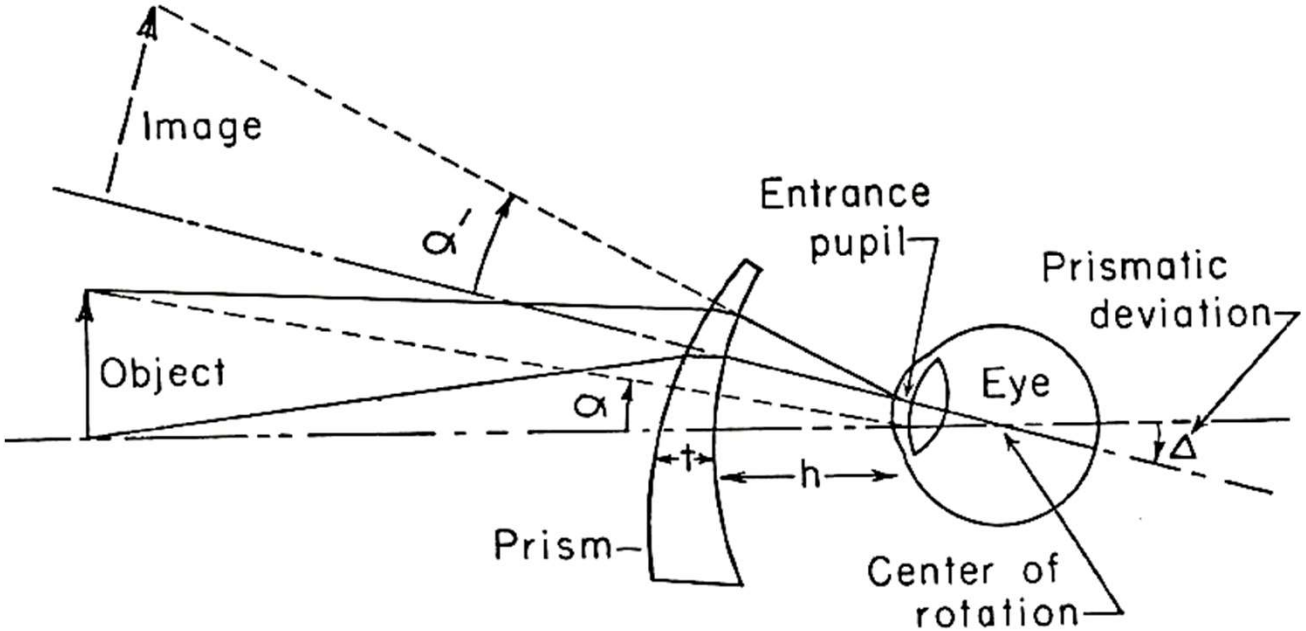
Object



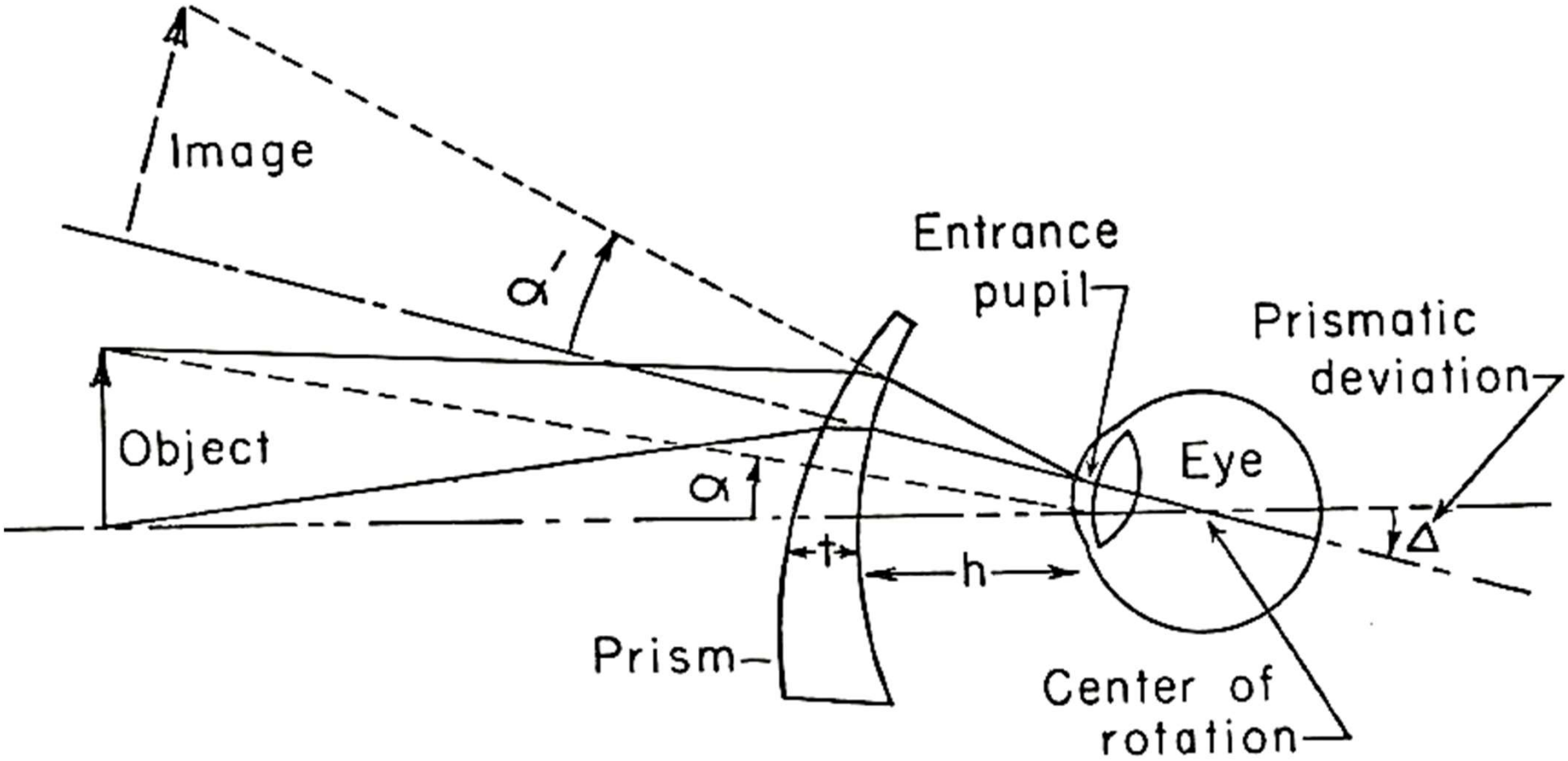
Image

Asymmetric Angular Magnification

An increasing angular magnification of the image toward the apex in the base-apex line.



Asymmetric Angular Magnification



Asymmetric Angular Magnification

The angular magnification depends on:

1. The ocular base curve of the prism.
2. The distance from the eye.
3. Prism power (Angle of prismatic deviation).
4. The thickness of the prism.
5. The orientation of the prism before the eye.

Ocular Effects of the Spatial Properties of Prism

Ocular Rotation

Refractive Properties

Reduces Accommodation Effort

"An ophthalmic prism placed before the eye, in addition to causing a general prismatic displacement of the image towards the apex, also introduces a distortion of that image. This fact is discussed in the literature and is fairly widely known, being

Being that spatial distortions, including **angular magnification** and **sphero-cylinder** properties, are present in the Risley prism, how do might these distortions affect the subjective responses in the phoria and duction measures in the 21-point exam?


Today these are my thoughts, but tonight I’m reading a book.


Thank You for
Your Attention!
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