Vision Science III - Binocular Vision
Lab 4 - Stereoscopic Threshold

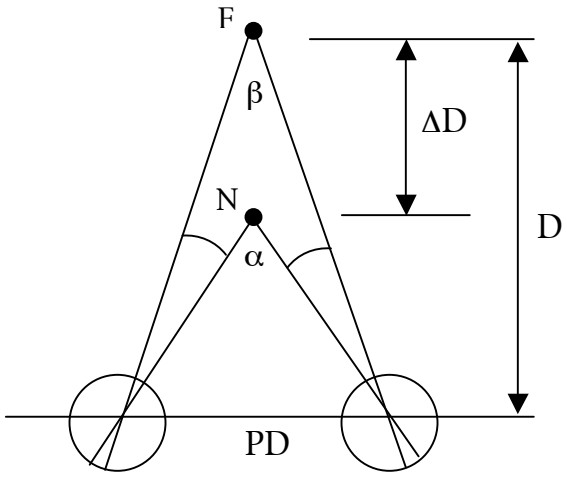
INTRODUCTION
Stereopsis is the strong sense of relative depth perception, which is based on **retinal disparity**. Since the horopter is the locus of points that have identical oculocentric directions, the images of any object located on the horopter will have zero disparity. The horopter is therefore also known as the zero disparity locus for object points. The fixation point is one point on the horopter. If the observer maintains steady fixation while an object is moved off the horopter, images of that object will fall on non-corresponding retinal points. If the disparity is extremely small, it will not be apparent that the object has moved off the horopter. However, when a sufficient amount of disparity is created, stereopsis will be stimulated, and the subject will be able to tell that the object is located at a different distance. The minimum angular disparity necessary to elicit stereoscopic depth perception is known as the **stereoacuity threshold**. The threshold can vary depending on test conditions and location in the visual field. For a stationary target, stereoacuity thresholds may be as small as **2-10 arc seconds**. The purpose of today's lab is to measure your stereoacuity threshold.

GEOMETRY OF STEREOACUITY
For two objects located on the midline (Figure 1), the stereoacuity can be measured by finding the angular disparity (η) between the objects.

$$\eta = \angle\alpha - \angle\beta \tag{1}$$

In our apparatus, we will be comparing the disparity between two objects, one of which is in the midline and another that is slightly displaced.

Figure 1. While maintaining steady fixation on Point F, Point N is moved until the angular disparity is enough to stimulate perception of stereoscopic depth. The difference between the angles is the stereoacuity threshold.



If distance D is relatively large compared to PD, the angular subtense in <u>radians</u> for angles α and β can be computed by Equations 2 and 3 respectively.

$$\angle\alpha = \frac{PD}{\left(D - (\Delta D)\right)} \tag{2}$$

$$\angle\beta = \frac{PD}{D} \tag{3}$$

You may compute the disparity by measuring the two angles then taking their difference. Or you may use the following approximate formula.

$$\eta = \frac{PD(\Delta D)}{D^2} \qquad (4)$$

METHOD 1

A Howard-Dolman apparatus can be used to measure stereoacuity thresholds. It provides a fixation point and other rods whose distance from the observer can be varied. A window and uniform background minimize monocular depth cues when judging the distance to the rods.

1) Position the fixation rod and one adjacent moveable rod of the Howard-Dolman device 200 cm in front of the subject's forehead (approximated egocenter).
2) Starting from a point on the horopter (equidistant with the fixation point), randomly adjust the moveable rod nearer or farther, until the observer can first perceive that it is located at a different distance from the fixation rod.
3) Record five distal and five proximal thresholds for ΔD and compute the mean. Compute distal and proximal stereoacuity threshold in arc seconds by the angles and formula.

	1	2	3	4	5	Mean ΔD	η (by angles)	η by formula
Proximal								
Distal								

METHOD 2

In this experiment, randomly place the moveable rod well distal or proximal to the fixation rod, and move it toward the horopter it until the subjects first thinks it is equidistant with the fixation point. Record the rod's position in the top row of the table below. Measure from the horopter. Distances nearer than the fixation point are negative; positions farther are positive. Include values and signs in the table. Repeat for at least ten measurements, using five distal and five proximal approaches.

1) Compute the mean position (include sign).
2) Compute the deviation (absolute value) of each measurement (1-10) from the mean. Record this value in the second row of the table.
3) Compute the mean of the deviations, to estimate the ΔD value.
4) Use this value to compute the stereoacuity threshold in arc seconds.

	1	2	3	4	5	6	7	8	9	10	mean
Position											
Deviation											

What is the mean stereoacuity threshold by this method?

STEREOPSIS & MONOVISION

How much does monovision afffect stereopsis? To find out, repeat the above measurements with a +1.50 D lens over one eye.

	1	2	3	4	5	6	7	8	9	10	mean
Position											
Deviation											

What is the mean stereoacuity threshold by this method with the simulated monovison?

Also, use the Titmus stereoacuity book to measure the stereoscopic threshold with and without the +1.50 lens. Normal stereoacuity (arc sec):

Titmus stereoacuity with +1.50 over one eye: