Brock String and the Horopter: A Perspective

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Over the past number of years, we have been involved in the teaching of both normal and abnormal binocular vision at several optometry colleges, national and international vision meetings, and vision research institutes and hospitals. This has involved both the underlying theory and its multitude of clinical implications, including the sensory, motor, and perceptual domains and their interactions. The area of “binocular vision” is a critical topic in the field of vision care, since binocular vision abnormalities are prevalent in the general population, as well as in ‘special’ populations including those with neurological disorders such as cerebral palsy and traumatic brain injury.

A question that has been posed to us on more than one occasion, frequently with a look ranging from inquisitiveness to distain, is, “Why the horopter?” Certainly, this is a fair question. Unfortunately, the horopter seems to be misunderstood by many, and hence the question. In our lectures, we have always emphasized the concept of the horopter and its clinical importance, with its clinical analog being the all-important “Brock String.”

Our immediate reply to this question has been, “Why not, as the concept of the horopter is the underpinning for, and basis of, nearly ALL aspects of normal and abnormal binocular vision.” This answer usually results in a pause, sometimes followed by the request for an explanation, which we gladly provide in great detail with numerous clinical examples.

The horopter is a wonderful pedagogical and clinical tool, as it blends and integrates basic aspects of physiological optics, binocular visual information processing, and binocular visual perception, with optometric clinical care, especially with respect to the understanding and conceptualization of both normal and abnormal binocular vision. For example, the horopter’s clinical analog, the Brock string, can be readily used to treat convergence insufficiency in the clinic, and it can also be used as a simple home therapy tool.

The term horopter translates as “boundary of the observer”, which is a nice way to conceptualize a ‘virtual’, binocularly-based region of visual perceptual and physical space. It represents the directional projection of corresponding retinal points (CRPs) into the visual field/visual space of the observer, horizontally (and vertically along the midline, although this aspect is rarely used clinically), with respect to one’s ‘egocenter’ which serves as the visual-directional, or “zero sensory-motor-perceptual”, visuo-spatial reference point.

Some key examples of this in the basic and clinical domains of the horopter and the

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related Brock string, respectively, and their interdependence, are provided below (See Figure 1):

1. They provide a psychophysically and perceptually-based spatial map of correspondence, i.e., CRPs.

2. They provide a reflection and sense of Panum’s fusional areas (PFAs) projected into visual space, as those regions both immediately in front of and behind the horopter for which single vision (i.e., haplopia) is typically present represent PFAs. Within this region, haplopia would be present 50% of the time at its proximal and distal limits, and 100% of the time at the horopter itself, as it is a probability distribution function. That is, the farther a target is from the horopter or bifixation bead, the greater the probability that diplopia would be perceived. And, the greater the retinal eccentricity, the greater the linear and angular extent of PFAs in visual space and at the retina, respectively. Thus, targets should be tested both along the midline, as is the usual case, and perhaps as well at different retinal eccentricities, for example with a second Brock string, while the patient bifixates on the midline bead of the first one (Figure 2).

3. They provide a reference point for stereopsis. Stereoacuity is best at the horopter, as the number of overlapping binocular receptive fields from the two eyes is maximal here. Further away from the horopter, as well as with greater retinal eccentricity, stereoacuity is not as good, and this is also true for BS/BS1 and BS2 at their respective horopter regions.

4. They provide an indicator of vergence accuracy. Vergence is most accurate when the two perceived Brock strings intersect precisely with the intended fixation bead. This is also true for the horopter, but its resolution is greater yielding one’s resultant fixation disparity, or steady-state vergence error, of a few minutes of arc.
5. They can be used to assess for the presence of normal retinal correspondence (NRC) versus abnormal retinal correspondence (ARC) in strabismus. With the Brock string in ARC, one obtains the red-green, split-field response, while with the horopter, one obtains the “horopter notch” reflecting marked spatial/directional discontinuity.

6. They can be used for visual-feedback-based remediation training when diplopia is present to guide the appropriate vergence response to result in the desired haplopia. Similarly, they can be used to demonstrate normal physiological diplopia.

7. They can be used to identify regions of binocular suppression, especially in strabismus. This clinical information can be used to “break down” the regions of binocular suppression via string movement, string flashing, adding beads, increasing bead size, etc., with the Brock string. More accurate and quantitative assessment of suppression can be ascertained by use of a stereocampimeter, synoptophore, or amblyoscope, or other such instruments and devices. It is also possible to do so with the horopter.

8. They can be used to demonstrate the difference between, and assess for normality of, oculocentric (i.e., monocular eye/fovea-based, except in eccentric fixation) versus egocentric (i.e., midline, binocular body-based) visual localization per the famous Hering window demonstration.4,5

9. They provide coarse information regarding relative/absolute perceived distance in visual space. With changes in vergence, both the cortical oculomotor innervational signal and the proprioceptive eye-muscle-based signal provide information related to vergence magnitude (and perhaps also vergence ‘effort’). Such information can be used to assess for, and then train, proper visual binocular localization in depth.

For example, as the patient attempts to bifixate and focus upon the middle bead of the Brock string, the clinician can ascertain information related to the sensory state, such as the perceived and simultaneous presence of diplopia of the far and near beads, split-field ARC response, intermittent suppression, perceived absolute and relative distance of the beads and other targets in space, as well as gross vergence accuracy, to name a few. The possibilities for creativity in this area are limitless.

So remember, both the Brock string and the horopter can be the clinician’s best friend!

REFERENCES

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