



SCIENTIFIC LETTERS

Dynamic visual acuity and methods of measurement



Navigating the world through the visual system is quite different from visual activities performed in a static position, but the complexity and demand is high in both. Just as measured static visual acuity (SVA) in the examination setting does not precisely replicate the natural environment, dynamic visual acuity (DVA) acquisition is also inaccurate, but contributes considerably to understanding how observers comprehend and maneuver their surroundings.¹ DVA measurements have practical applications in vision training with binocular vision issues, sports vision,² low vision and traumatic or acquired brain injury.³ It affects everyday activities from driving, to locating items on a supermarket shelf while walking. Standardized norms or structured methods of DVA acquisition are as yet not widely accepted,¹ but the ability to rapidly detect deficiencies and appropriately retrain or enhance proficiency is possible. Implementing DVA as an integral part of the eye examination should be encouraged.

SVA measures the ability to distinguish the smallest sized target whose image is formed on the retina when both the observer and the target are stationary.² Kinetic visual acuity (KVA) measures the smallest size target seen as it is moving forward or backward with respect to the horopter of the observer.²

DVA measures target recognition during a state of relative motion between the observer and the target.⁴ It is the ability to perceive targets moving horizontally or vertically on a two dimensional plane. The movement can be predictable or random.

The DVA test demands three elements of the observer: predicting the target movement, subjectively resolving the target and the response time.

There are two common methods to measure DVA, either a moving target across the visual field of a stationary observer, requiring the use of pursuit eye movements (for targets at speeds of up to 50° per second) or saccades (faster targets) in order for the target image to fall on the fovea,⁴ or a stationary target and a moving observer.

The ability to minimize eye position error, to track smoothly and to inhibit reverse saccades were related to increased DVA. The correlation between eye movement quality and DVA performance has important implications when developing rehabilitation or training programs as post traumatic brain injury or sport vision training.⁵

The second method uses head rotation to stimulate movement which invokes the vestibulo-ocular reflex (VOR). VOR is a reflex triggered by the vestibular system which applies compensatory head movements to keep a relatively moving target on the fovea. Neural pathways and the extra-ocular muscles are involved.⁴

When head movement is too rapid and exceeds the target motion, it can cause retinal slip. If the slip exceeds 2–48/s, decrease in DVA occurs.⁶

In individuals with normal VOR, DVA during head movements is similar to SVA. Therefore, all other parameters being equal, a degradation of DVA of more than three lines indicates some sort of abnormality.^{3,4}

A study conducted in vestibulopathic adults showed the position of testing, whether sitting, standing or semitandem standing did not affect the DVA results. This translates to a probable positive cross-over effect either when acquiring measurements or during clinical training.⁷

DVA is influenced by parameters such as age, contrast, target speed, size, trajectory, exposure time, and color.

Devices to measure DVA

Though numerous devices have been developed to measure DVA, they were and still are primarily used for research or therapy. DVA can be implemented non-instrumentally. Assess SVA and provide the refraction that for best corrected visual acuity. The examiner then grasps observers' head above the ears and flexes the head forward 30° to bring the auricular horizontal semicircular canals to the horizontal testing plane. The examiner then oscillates the head approximately 30° from each side of the midline, horizontally, at a frequency of 2 Hz. Request the observer to read out the smallest targets possible. A loss of three or more lines of acuity is accepted to be indicative of an abnormality.

From approximately 1970 for 30 years, equipment incorporated a target projected on a rotating mirror at varying speeds with the observer with either a free-moving or fixed head position.

DVA devices evolved to include a computer and screen therefore improving on previous methods by providing both a modem with a rapid refresh frequency more closely artificially replicating continuous target movement as well as the ability to precisely adjust target trajectory, size, contrast,

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speed and display time. Some require specific head movement and changing targets (inVision™ device) while others fixed head position (DinVA 3.0 software 0).¹

The Dyop Chart2020 (Konan Medical, Hyogo, Japan) device may be falsely categorized as measuring DVA and therefore we shall elaborate. Though the visual target is dynamic, this method measures SVA as the target remains stationary in three dimensional space. It rotates around itself, projected consistently on the same (central fixation) retinal area, requiring no head or eye movement.⁸ Projected on a computer monitor, the target is comprised of a dynamically sized ring containing black and white segments of a calculated angle and area uniformly spinning on a neutral grey background. The endpoint acuity is the threshold when the rotation appears to stop. Acknowledging that changes in stimulus provokes an excitatory response from photoreceptors, this kinetic target more closely complements the visual response than a static target, requiring small eye movements to refresh photoreceptors.⁸ The ease of interpretation is an advantage where patients are less communicative, or illiterate. A correlation between the Dyop to Sloan and LogMAR E charts has been determined.⁸

Head mounted virtual reality (VR) devices are becoming more commonplace and may be programmed for DVA measurement.⁹ The nature of the apparatus allows the observer to move and experience moving targets more closely to a natural environment on the z axis, including the peripheral field unlike previous devices such as targets on a static computer screen, measuring KVA as well. Though image resolution continuously improves, the inferiority of VR devices compared to the retina can cause a discrepancy between the VOR and visual system. Excess display time of the image on a retinal area can result in an after-image, prejudicing results for example by allowing for a longer interpretation time. Researchers are still trying to understand the influence of the immersive medium on other systems such as accommodation and convergence.¹⁰ But advances in technology and their allowance for precise control over multiple target parameters regardless of head movement is encouraging that exploration in this area may produce a structured model of norms and acquisition protocol.

Conflicts of interest

The authors have no conflicts of interest to declare.

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Estimating the prevalence of heterochromia iridum from high-resolution digital yearbook portraits



Introduction

Heterochromia iridum (HI), or complete heterochromia, is a condition where an individual's irises are of two different colors.¹ It may be congenital, with or without a syndromic

relationship, or acquired through injury, medication, or other means.² Immaterial of its origin, HI is generally thought to be harmless and easily diagnosable. For these reasons, HI receives little attention in the medical literature, especially when it is not associated with a more concerning medical condition or cause. For example, a PubMed search on June 19, 2021 returned just 16 results for HI and complete heterochromia among its 32 million citations, and all 16 articles headlined HI's relationship with a syndrome, abnormality, or disease.³ Not surprisingly, a precise measure of HI's prevalence remains an open question, although it is considered rare.