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Review Article

Dynamic & static visual acuity chart – past, present & future: A brief review

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ABSTRACT

Background: This study is a review for the dynamic visual acuity (DVA) its various methods of assessment used in the past, at present and for the future in the clinical practice.

Materials and Methods: Various previously literatures from Google Scholar, PubMed, Medline Plus, Scopus were studied and reviewed thoroughly. Different techniques and methods which are used for the assessment of the dynamic visual acuity in the past and in the current clinical practice and also the use of immersive technology like AR/VR/MR for the future scenario for DVAT also reviewed in this study.

Conclusion: In many different environments and professions, such as driving, sports, and for special forces, the measurement of visual acuity, particularly the dynamic visual acuity, is crucial. As we all live in a three-dimensional environment, therefore, it is important to use immersive technology, such as AR, VR, and MR, to measure dynamic visual acuity since it can create a real-world environment while doing so and produce better findings.

1. Introduction

Visual acuity is a term used to describe how clearly someone can see, but it also describes how well they can distinguish details in space. So, visual acuity is the ability of the eye to identify various shapes and traits of objects at a specific distance. In other word, we can say that the spatial resolution of the visual processing system is measured by visual acuity. Visual acuity is one of the most important aspects to perceive the outer world. The visual system has a very complex system. To assess how well the visual system is functioning, it is very important to do the assessment of visual acuity on regular basis. The evaluation of visual acuity is one of a clinical vision examination's most crucial element. Assessment of visual acuity is crucial for assessing refractive error and also for the monitoring of many ocular structure's disorders.[1]

Refractive errors are recognised as the leading preventable cause of visual impairment on a global scale. Given the wide range in age, definitions of blindness, and examination techniques, it is difficult to determine the global magnitude of refractive error.[1] The biggest economic issue on a global basis is the frequency of refractive errors. The estimated prevalence of hyperopia, myopia & astigmatism is 11.7%, 4.6%, and 14.9% respectively. The estimated prevalence of myopia which is about 4.9% in South–East Asia to 18.2% in the Western Pacific, the hyperopia ranges from 2.2% in South-East Asia to 14.3% in America and the astigmatism which is about 9.8% in South-East Asian region to 27.2% in the America.[2] High refractive errors can lead to many disorders like amblyopia, which can cause limitations in a range of visual functions, such as visual acuity, which is necessary to carry

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out daily tasks.[3]

Digital technology is now a need and is used in many aspects of our everyday lives. The number of eye related problems has increased as a result of the constant usage of visual display terminals (VDTs). Numerous elements, like refractive error, light, contrast, and different eye defects can affect the visual acuity. Optical features like the cornea, crystalline lens, retina, and brain limit a person's visiual acuity physiologically. The size of the pupil and the aberrations determine the optical limitations of the eyes. The spherical aberration of normal eyes increases as the pupil dilates. So, Examining the visual acuity in relation to all these factors is crucial because the visual impairment brought on by significant refractive error gets worse with increase in age.[3–6]

1.1. Visual acuity test

There are two types of visual acuity test:

Static visual acuity test: The capacity to distinguish between small spatial separations in a stationary target is known as static visual acuity. There are several methods for evaluating visual acuity. In clinical practice, many approaches are there for assessing the static visual acuity. The most standardised approach for measuring static visual acuity is LogMAR and Snellen's. In each line of the LogMAR chart, there are 5 letters with equal size and spacing.(Figure 1)

Because each line has five characters, each letter is assigned the value 0.02. This test measures the visual acuity on basis of each letter, rather than for the whole line. This boosts the reliability of the assessment and enables a more precise description of visual acuity.[6,7]

The score is determined by the following formula: LogMAR VA = 0.1 + LogMAR value of the best line read - 0.02 X (number of optotypes read).

There are some other static visual acuity charts, which also use in the clinical practice for the evaluation of static visual acuity which are as follows:

1. **Bailey–Lovie:** There are 14 rows in the Bailey-Lovie chart, each with five letters. From the first row to the last row, the characters get smaller. This chart is thought to be more accurate than the Snellen chart.
2. **Tumbling E:** This chart features an 'E' letter in a capital format facing various orientations. The patient points the direction that the E letter faces while viewing each character.
3. **Landolt C:** Similar to the Tumbling E, this chart shows a C that, according to some, resembles a broken ring as it faces different directions.
4. **LEA symbols chart:** This chart is used in non-verbal kids for the purpose of visual acuity testing. This chart uses symbols and offers a play area to occupy the young patient while they get the examination. In tests of preschoolers' visual acuity, this chart outperforms the Snellen chart
5. **Freiburg visual acuity test:** This test is computerised and mechanised, and it shows huge Landolt C optotypes on the screen. Landolt C characters are displayed on the monitor in a variety of sizes and orientations.

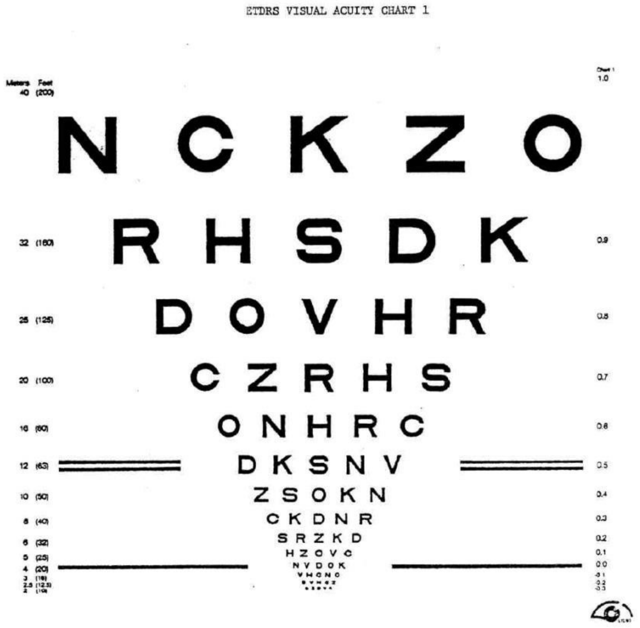

Figure 1: ETDRS visual acuity chart

1.2. Dynamic visual acuity

DVA is an important feature of the vision. It is the capacity to recognize the visuals of the objects when they are in the moving state.[8] In most of the activities of our daily livings, we are required to pay attention to a variety of things, the majority of which are in the moving state. Dynamic visual acuity is therefore closely related to our life. Additionally, there are distinctions between the neuronal conduction pathways and the factors influencing dynamic and static visual signals. There are two main processing pathways that make up the system for static visual acuity. Ventral pathway, which processes the object's quality information and ends in the inferior temporal lobe, second is the dorsal pathway, which processes spatial location information and eventually reaches the posterior parietal lobe.[9–13] In the actual world, we must pay close attention to many things, the vast majority of which are in motion. The dynamic visual acuity is impacted by a number of ocular diseases, including glaucoma, optic neuritis, and cataract, so it is important to assess it as part of the therapeutic strategy to enhance quality of life.[14–16]

Our daily lives are significantly impacted by the dynamic visual acuity. In a study by Marquez C. et al., 2017,[17,18] it was found that dynamic visual acuity declined with head movement at a rate of 150* per second. Although it's crucial to test and evaluate DVA in a clinical setting. Since we now only evaluate static visual acuity by relying on inadequate techniques. Although testing and assessing dynamic visual acuity in a clinical environment is essential. As we are currently relying on inadequate techniques to only evaluate the static visual acuity. Assessment of dynamic visual acuity is basically done by two ways, First, while keeping the head fixed and in a static position, the patient is instructed to identify a moving object. Second, while the head is moving, the patient is asked to identify or recognizes a stationary object. A potentially fruitful area of research and development is the evaluation of visual acuity for dynamic, moving objects. It is crucial to develop a standardised, well accepted method for accomplishing this since future comparisons must be based on exact measurements.

The ability to locate and track moving objects is necessary for many high-intensity sports, including basketball, tennis, baseball, hockey, and cricket. The same as in driving, a driver must monitor and locate other moving vehicles and pedestrians. Driver performance evaluations are crucial for determining who should not be allowed to drive because of the serious risk they pose to the safety of other road users.[19] So, it is very important to do a visual acuity that include moving targets. At present there are no standard methods for evaluating DVA. This is well known that when there is an increase in the velocity of an target, it results in the reduction of the visual acuity of a person. Which can be improved with training.

The majority of the external information that humans take in through their sensory organs enters through their eyes. Compared to other sensory organs, vision is more crucial to humans and either precedes or complements other senses. Visualising fixed external target, as that measured in a current static vision test, is significantly less complex and dynamic than actual vision. Along with the ability to see, human vision also includes colour vision, contrast vision, stereo vision, readability, field of vision, accommodative ability, eye movements, like saccades and pursuit.

1.3. Dynamic visual acuity tests

Visual acuity tests for dynamic vision can be classified into three types, dynamic visual acuity test when the optotypes are static, DVATs when the optotypes are moving and motion perception behavior tests. In this test, subjects move their heads passively & voluntarily are frequently utilised in Dynamic visual acuity test with static optotypes, which is primarily help to assess the vestibulo-ocular reflex. Dynamic visual acuity test with moving optotypes are primarily assess dynamic visual function by mechanically demonstrating optotypes or by using a computer display. Random dot kinematograms & object from motion protocol are two types of motion perception behaviour tests used to measure the brain's perceptual capacity for moving visual objects.[8]

1.3.1. Voluntary head moving dynamic visual acuity tests with static optotypes

Speed unsupervised test, in this type, the participants ask to identify the conventional Snellen chart in front of them while also freely oscillating their heads in the horizontally without any supervision of speed.[20] The smallest letter that can be recognised serves as the basis for DVA. In order to prevent influencing eye movements like smooth pursuit, the oscillation frequency employed should be at least 2 Hz.[21–23] Even though this test is convenient, but it is impossible to maintain a stable oscillation as frequency and the velocity of the oscillation always depend on the person. Additionally, employing non-VOR techniques like saccade in this test, the participants may be able to recognise optotypes at the same moment that the oscillation direction changes.[24,25] (Figure 2)

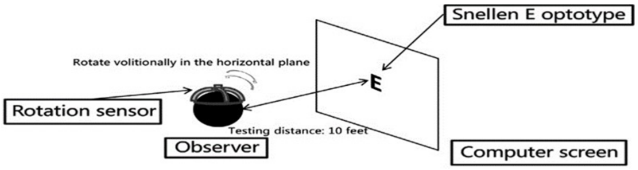

Figure 2: DVA test with a static head optotype

1.3.2. Dynamic visual acuity test with moving optotypes

Standardized optotypes are created in accordance with the logMAR chart, are loaded onto a mobile model cart using this test equipment with a moving loading device (Figure 3). In a descending sequence from left to right, the cart is loaded with several optotypes that each indicate a distinct visual acuity. The cart could go at a specific pace and in a specific direction. The outcome of this test is to successfully detect the smallest optotype, and participants are encouraged to do so while keeping their heads still.[26]

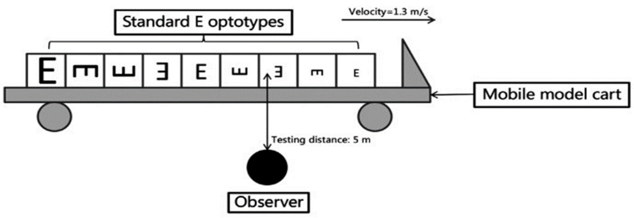

Figure 3: DVY test with a moving optotypes

KOWA HI-10 system: This device uses a vertically placed mirror on a turntable that is driven by a speed motor. A optotype is project on the mirror, which reflects the optotype on the screen. The turntable's rotation causes the optotype to move horizontally from left to right at different speeds. When the gap on the optotype is first accurately identified, the velocity of the optotype is progressively decrease, and the dynamic visual acuity is verified with the maximum speed.[14,27,28]

1.4. Motion perception behavior tests

In this type of test, a series of dots with a hidden design, such as a star, umbrella, or wine glass, are produced by a computer programme. The dots inside the pattern and those outside it are designed to travel in opposite directions. Participants will find it simpler to recognise the pattern as these dots move more quickly. The score is determined by the speed needed to recognise the pattern.[15–19] (Figure 4)

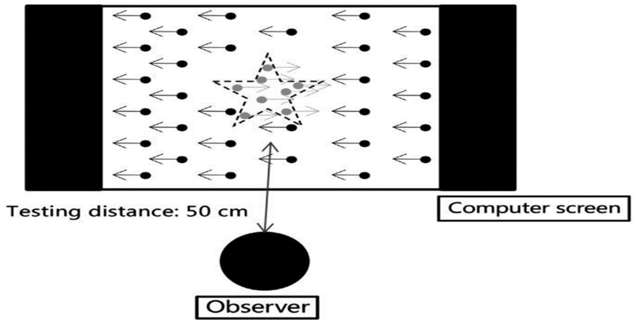

Figure 4: It is shown how a pattern of dots can be hidden. The dots inside the pattern and those outside it are set up to travel in opposite directions. In the actual procedure, all the dots are black; the grey dots in the illustration are there for clarity. Arrows are signs of motion

1.4.1. Random dot kinematograms

In this type test, a sequence of 0.1°-diameter white dots placed randomly over a dark backdrop. These dots are made up of both signal and noise dots. These dots are moved in varied patterns using a programme to identify various motion perception impairments.[18,19]

In this test, patients are instructed to keep their head steady and to fixate the eyes on a dot which is in the middle of the screen. They must decide between the side with signal dots and the focus of expansion. Results are recorded in accordance with the bare minimum signal strength necessary to distinguish between the FOE or the circle of signal dots.

2. Application of Immersive Technology in the Assessment Dynamic Visual Acuity

Various immersive technologies like virtual reality (VR), augmented reality (AR) and mixed reality (MR) have been used since their introduction in a variety of industries, including healthcare, defence, and education. Additionally, human visual features have been examined when using a head-mounted display (HMD). Information is displayed on a screen in the VR/AR HMD environment is according to the user's gaze and body motion. This enables the use of targets that are actually used in clinical practice and can offer a DVA test which is based on a setting that is realistic and resembles the subject's environment outside of a reading scenario.

While a virtual, augmented, or mixed reality headset's visual display is undoubtedly its most crucial component. An accurate and real-time computer vision and spatial tracking technologies are key to delivering an immersive experience. The majority of traditional VR platforms have utilised headset that are connected to a computer or game system. They depend on systems used for external tracking, such as infrared emitters and detectors.

3. Discussion

When compared to the visualisation of external information that is fixed, as in a vision test, visual system is considered a more sophisticated process. The range of visual abilities of human being which includes the ability to see, contrast vision, colour vision, stereovision, field of vision, accommodation and vergence system. Recent developments in VR technology have led to the creation of VR targets.

The virtual reality setting is similar to the actual test environment in that it causes the subject to move their bodies, but it has the drawback of obstructing their view. In mixed reality scenarios, where the virtual and real worlds are combined together, real-time rendering speed enables the consideration of more authentic visualisations. Natural visualisations are necessary for mixed reality applications. One potential method for this is ray tracing. In mixed reality and virtual reality for the consumer market, real-time ray tracing is gradually becoming a reality. This is taking place as computer hardware and display technology is advancing.

The promise of more contemporary technologies like MR/VR in the domains of education, gaming, entertainment and in medical is exhilarating immersive experiences. In order for users of VR, AR, and MR technology to have an immersive experience, they must be given authentic perceptual cues. For virtual, augmented, and mixed reality headsets to produce an immersive experience, precise and real-time location tracking as well as computer vision technology are required. The visual display is without a doubt the most important part.

4. Conclusion

The assessment of visual acuity especially the dynamic visual acuity (DVA) is very essential in various environment, skills and profession, like driving, sports, for special forces. The dynamic visual acuity (DVA) is affected like speed of a moving object decrease the dynamic visual acuity. A deficient DVA can impact a person in various way, but the DVA can also be improved. Dynamic visual acuity (DVA) is unquestionably significant in the current world, particularly for sports, driving, the special forces, and pilots. The dynamic visual acuity can get impacted by the fact that we all exist in a three-dimensional environment and are frequently surrounded by several moving things. However, despite the importance of the dynamic visual acuity, the conventional static charts are still in use to evaluate the visual acuity or even there are no standardized methods in the evaluation of DVA which are available in the current clinical practice. So, there is an importance of using various immersive technology, like AR/VR/MR in the assessment of dynamic visual acuity, which can give a real-world environment while evaluating the DVA and also can give better results.

5. Source of Funding

None.

6. Conflict of Interest

None.

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