The Markowitz Potential Visual Acuity Test (M-PVA)

Assessment of visual acuity is the most common test used in visual sciences. Visual input is analyzed as a 3- stage hierarchical sequence, beginning with detection of contrast between a target and its background, followed by resolution of patterns into spatially separate elements of strokes and the space between them, and ending with recognition or identification of a particular arrangement of elements as one of several possible meaningful messages.

Each stage in this process can be viewed as a separate visual acuity function with its own inherent limitations. Contrast sensitivity or acuity, the foundation for visual recognition, is limited by optical attenuation such as defocus and diffraction and chromatic contrast. Resolution acuity is limited by the size of receptive fields of visual neurons. Recognition acuity is limited by literacy and cognitive factors as well as by oculomotor abilities responsible for landing images on the fovea or preferred retinal loci.[1]

Due to the fact that in the process of visual perception contrast sensitivity precedes resolution acuity and both precede recognition acuity, inherent limitations of each one acts as a limiting factor to the next one in the 3-stage hierarchical sequence described above.

Resolution acuity offers individuals abilities for best visual function when unhindered by inherent limitations of all three aspects of visual perception. After removing limitations listed above, the resolution of spatially separate elements was measured to be as high as 85 cycles/degree (cpd) (equivalent to Snellen 20/7) in the macular area, and as high as 30 cpd (20/20) in the peripheral retinal area at 100% contrast. [2]

In low vision cases limitations as described above reduce further estimates of visual acuity when measured with routine recognition test charts as the ETDRS. The need to assess potential visual function abilities in low vision cases is great, in a similar way as encountered in cases where cataract surgery is contemplated. The tool that helps cataract surgeons determine what the outcome of surgery will be - the potential acuity meter (PAM) – provides estimates in the macular area. Low vision patients require a

different sort of test able to measure PVA on the residual retinal areas outside the macula. For this purpose standard acuity tests currently in use such as the Snellen and ETDRS charts are limited in the sense that they depend on good central macular functions, which are functions lost in patients with low vision. Patients with low vision also have various amounts of fixation instability. They do not have the same ability to move the eyes to a given target and keep it there as people with healthy eyes do. That's because the mechanism which moves the eyes to fixate on a given target in normal people is set to land incoming images on the fovea - which in low vision patients is lost. If however we present simultaneously the same multiple optotypes then one negates the need for eye movements. An image from one of the optotype targets is bound to hit the eccentric preferred retinal locus (PRL) with best residual vision.

In this respect resolution acuity estimates can be viewed for all intent and purpose as logical estimates of potential visual acuity. Sine wave grating and their equivalent (tumbling E single optotypes) are adequate targets for resolution acuity testing in which the tested subject is required only to confirm the spatial orientation of the target presented. Multiple tumbling single E charts are especially adequate in cases where poor oculomotor functions are present. This allows some of the “flooding Es” to land on retinal areas with best residual vision abilities regardless of cognitive abilities to recognize such opportunities or abilities of the oculomotor system to redirect the eye towards such retinal areas.

The concepts described above were validated and described in a paper published in *Investigative Ophthalmology and Vision Science*.[3] The paper described a computer-based method for assessment of residual resolution acuity which incorporated four features known to improve visual acuity: high contrast; white optotypes (symbols, letters or numbers used in vision testing) on a black background to reduce intraocular scatter; proportional layout to reduce the effects of crowding; and multiple optotypes to minimize the effects of fixation instability and to maximize the likelihood of optotype detection. The study concludes that a multiple-optotype, reversed-polarity test provides the highest estimate of residual visual acuity and the ETDRS charts the lowest.

The Markowitz Potential Visual Acuity Charts (M-PVA) are an adaptation of the concepts presented in the paper quoted above. It involves usage of testing cards instead of computer generated images. Multiple E tumbling optotypes cards at 100% black-and-white contrast are presented to the better seeing eye at 50 cm. Each card can present a different optotype size and orientation. The multitude of optotypes presented concomitantly by the cards floods the vast majority of the retinal surface with identical information, thus assuring perception at the PRL regardless of its location. The patient, wearing the correction for the refractive error and working distance, must correctly identify the orientation of the optotypes on the cards. The card with smallest optotype size identified reflects the level of potential residual resolution acuity present. Optimal testing results are obtained with normal room luminance (9.55-19.1 candella/cm^2) under similar testing conditions used for ETDRS charts.

Detection of potential visual acuity in patients with low vision is a crucial step in the clinical practice of vision rehabilitation. The ability to accurately estimate such potential at baseline before vision rehabilitation interventions or surgery and comparing the results to subsequent evaluations may help assess rehabilitation progress.

The M-PVA Charts address all concerns raised above and can provide estimates of the optimal visual acuity a person with low vision is capable of. The adaptation of the test for use in routine clinical practice is relatively simple and straightforward.

1 Thibos L, Bradley A- New methodologies for discriminating neural and optical losses of vision, Hirsch Memorial Lecture, Annual Meeting of the American Academy of Optometry, Nashville, TN. 1990

2 Markowitz SN – Principles of Modern Low Vision Rehabilitation, Can J Ophthalmol 2006;41(3) :289-312

3. González EG, Tarita-Nistor L, Markowitz SN, Steinbach MJ - Computer-based test to measure optimal visual acuity In Age-Related Macular Degeneration, Invest Ophthal & Vis Sci 2007;48:4838-45

Instructions for administration of the test

The M-PVA test can be administered in regular office setting with the patient seated in the regular examination chair.

The M-PVA test can be administered under regular office illumination conditions used for testing visual acuity with Snellen's and ETDRS charts printed at 100% black-white contrast. This will provide accurate measurements of PVA under normal room lighting (9.55-19.1 can/sq cm) with either fluorescent or incandescent bulbs. For consistent measurements one may use a light meter to measure the luminance of the chart. In some cases additional luminance may be provided with white frosted 60-75 watt incandescent bulbs placed at least one meter or farther away from the chart.

Place the chart at eye level where it receives uniform lighting. Shadows or glare on the chart can adversely affect measurements. The patient should view the chart from a 50 cm distance. The patient should wear best correction for distance adjusted for near vision at 50 cm. Start with better eye while poorer eye is occluded. Present charts in sequential order starting with larger optotypes presented each with a different orientation. The last optotype size identified correctly is the potential visual acuity estimate measured. Switch to measurements for poorer eye under the same guidelines. Additional estimates may be obtained for binocular vision while measuring with both eyes open under the above guidelines.

Maintenance of the charts is minimal. The chart may be wiped clean with a minimally damp cloth to remove fingerprints. Do not scrub or use a wet cloth. The charts are printed on a special paper and will not fade.