Optimizing Contrast Sensitivity Perimetry for Clinical Use

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Perimetric testing is used clinically to detect visual field abnormalities and to monitor changes during the course of management. Conventional automated perimetry (CAP), which employs small (0.43 degree) targets (Fig. 1), is hampered by high test-retest variability. Consequently, many tests are required in order to determine whether a patient is stable or progressing. Decreasing test-retest variability would enable clinicians to detect progression with fewer tests.[1]

Test-retest variability for CAP is inversely related to retinal sensitivity, which varies as a function of distance from fixation and in the presence of disease.[2,3] Test-retest variability is also influenced by the use of high stimulus contrast which can saturate ganglion cell responses and by variations in prereceptoral factors such as refractive status, pupil diameter, and density of the crystalline lens.[4,5] For CAP, there is an inverse relationship between optical blur and sensitivity. Hence, patients require accurate refractive correction prior to testing.[6-11]

Pupillary diameter (area) and density of the crystalline lens are factors that contribute to retinal illuminance (the amount of light originating from a stimulus and background that reaches the sensory retina). For subjects with clear ocular media and pupil diameter of 3 mm or greater, adherence to Weber's law ensures that sensitivity will be relatively unaffected by changes in retinal illuminance in conventional perimetry.

FDT perimetry, a form of contrast sensitivity perimetry, uses larger (5-10 degree), 0.25–0.50 cycle/degree targets with rapid (18/25 Hz) temporal counterphase flicker, for which high mean luminances are required to reach the Weber region. Previous studies have demonstrated that, while variability for FDT perimetry does not increase as a function of sensitivity,[12] results can be dramatically affected by changes in retinal illuminance (e.g., lenticular density or

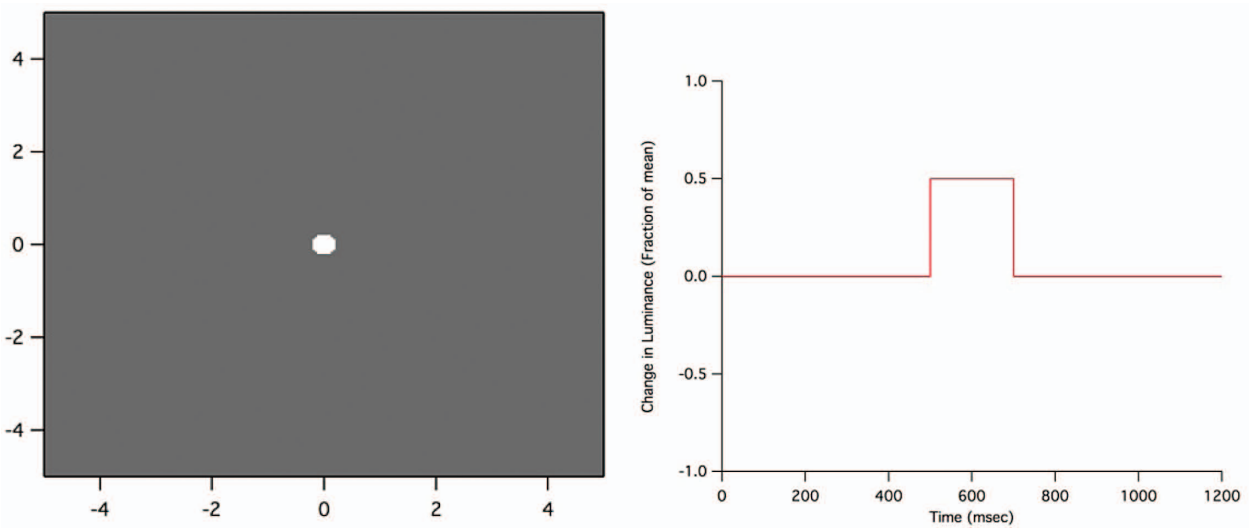

Figure 1. Conventional automated permetry stimulus and luminance profile.

pupil diameter).[13,14] Pupil diameter can be highly variable across subjects; for the 100 cd/m^2 mean luminance of the FDT perimeter, pupil diameter in a normal population varies from less than 2 to 8 mm.[15] FDT perimetry is less influenced by the effects of optical blur, i.e. up to 4 diopters of refractive error.[16]

Swanson and colleagues[17] developed a quantitative model of the effects of ganglion cell damage on responses of cortical cells. This model allowed predictions relating ganglion cell damage to perimetric loss for a wide range of stimuli. Pan, Swanson and Dul[18] used this model to develop stimuli designed to have lower test-retest variability than conventional perimetry while retaining good sensitivity to defects. Our conclusion was that stimuli should preferentially stimulate cortical cells tuned to lower spatial frequencies (Fig.2). We then tested this prediction with two stimuli: an achromatic 0.5 cycle/degree sinusoidal grating patch (a Gabor patch, with a circular two-dimensional Gaussian window), and a chromatic incremental stimulus with diameter set to chromatic Ricco's area at each visual field location, found that both stimuli have an advantage over conventional perimetric stimuli and confirmed the prediction.

The use of Gabor stimuli had been termed "contrast sensitivity perimetry" (CSP).[19] We have developed a customized station to introduce this form of perimetry in a clinical setting (Fig. 3).

The present studies evaluated the effects of retinal illuminance and optical blur in control eyes over the range of retinal illuminances expected in clinical populations (normal variations in pupil diameter, refractive error and lenticular density), in an effort to optimize CSP stimuli for clinical use.

Figure 3. Customized testing station of contrast sensitivity perimetry.

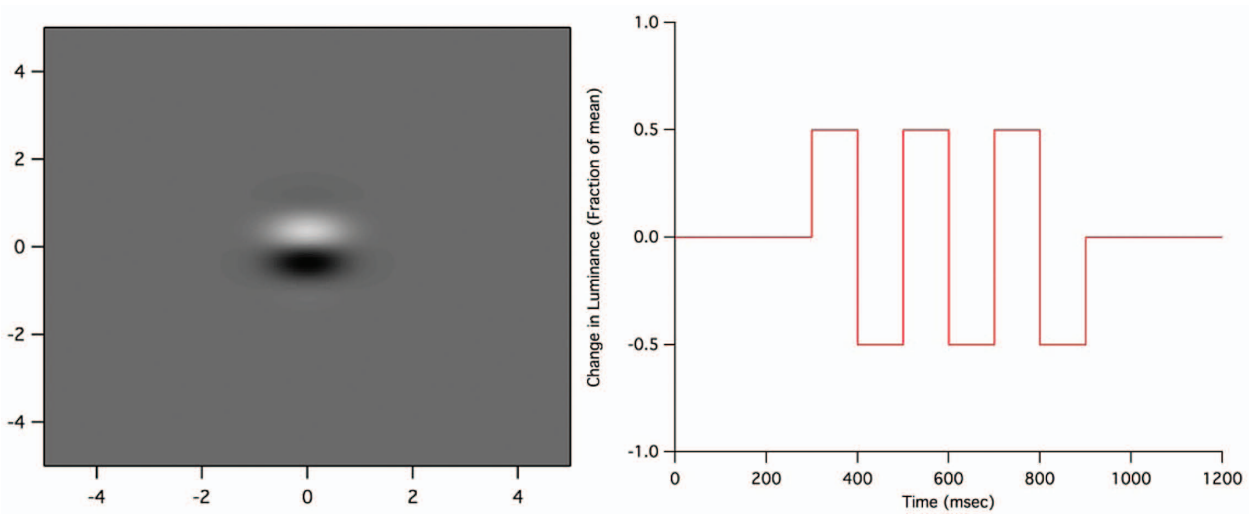

Figure 2. Contrast sensitivity perimetry stimulus and luminance profile.

Conflicts of Interest

None.

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