INTRODUCTION

Retinal images suffer from optical blur, given by the Optical Transfer Function (OTF). Its modulus (the MTF) expresses the loss of contrast and sharpness (cut-off spatial frequency, COF), whereas its phase describes spatial shifts between frequencies (phase shift). These are the main factors affecting optical image quality, and hence they induce a loss of visual acuity and quality of vision.

The aim of this experiment was to evaluate the effects of these three factors (contrast, cut-off frequency and phase) separately by means of an adaptive optics simulator.

METHODS

We calculated the appearance of images on 5-mm pupil diameter, degraded either by a loss of contrast (i.e. 1; 0.5; 0.25; 0.12 and 0.06) or by a lower cut-off spatial frequency (i.e. 50; 25; 12 and 6 c/deg) or by the phase shifts (i.e. 0.05; 0.10; 0.25; 0.5; 0.75; 1; 1.25; 1.5 diopters of pure defocus for 5 mm pupil).

As a reference, these synthetic degradations were compared to that caused by pure defocus (modulus and phase), for the same diopters.

Simulated Images : manipulating the OTF

The COF is a scalar variable, but contrast and phase are 2D functions in general. To somehow convert them to scalar variables, the contrast was assumed constant within the frequency interval 0 < f < COF; the phase of the OTF was that of a pure defocus, given in diopters. In this way a synthetic OTF was obtained combining that phase with a MTF, which was a cylinder with radius COF, and height given by the contrast (plus a delta function at f = 0).

RESULTS

Effects of Defocus, Phase, Contrast and COF on the 5 subjects

The averaged inter-individual standard deviation (SD) was 0.03 logMar and 0.15 grade, the larger difference of SD between subjects and type of degradation was observed with image quality score. The averaged inter-individual SD was 0.03 logMar and 0.27 grade. These SD were largely under clinical significant difference (i.e. 0.1 logMar and a difference of grade of 1).

When reducing the VA by 2 lines, in the same time the subjective score is reduced to 2.3, 0.6, 0.6 and 3 due to respectively a pure defocus, phase shift, a loss of contrast and a lower cutoff spatial frequency.

We normalized the results to obtain respectively the best and worst VA corresponding to the best and worst score for the defocus condition.

CONCLUSION

The cut-off frequency induces a comparable loss of VA and subjective score. However, a loss of contrast or phase shift appeared to have a less detrimental effect on VA than on subjective score. Considering a given loss of VA, we are subjectively more affected by a phase shift or loss of contrast than by a loss of sharpness (lower COF) or a pure defocus error.

REFERENCES


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