

Remedial typography: correcting presbyopic defocus by spatial filtering

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Beyond magnification, what can be done typographically to mitigate defocus for presbyopes forced to read without glasses? Ideally, remedial typography would correct defocus for a given visual object $O(x,y)$ (e.g., a printed letter) by transforming it into another object $O'(x,y)$ which yields $O(x,y)$ when convolved with the pointspread function $P(x,y)$ of the defocused eye: $P \square O' = O$. (O , P , and O' are nonnegative real functions representing light intensity.) As an example, this can always be done for P itself, regarded as an object, by replacing it with the point object $\delta(x,y)$, since $P \square \delta = P$. In general an object O can only be completely pre-corrected for defocus in this way if its Fourier transform Fo contains the transform of P as a factor: $Fo = FpFo'$, where Fo' is the transform of some other object. This constraint (together with nonnegativity) implies that an object's spectral contrast $|Fo(u,v)/Fo(0,0)|$ can only be pre-corrected if it does not exceed the eye's modulation transfer function (i.e., only if $|Fo(u,v)/Fo(0,0)| \leq |Fp(u,v)/Fp(0,0)|$). For the levels of defocus routinely created by presbyopia this means only objects that are already severely blurred can be pre-corrected for the contrast-reduction component of defocus—ordinary printed letters need not apply! However the phase component of defocus—*phase reversal* (“spurious resolution”)—can always be pre-corrected by selectively reversing portions of the object's phase spectrum. This can dramatically improve legibility by correcting retinal image shape. The talk will demonstrate how well phase precompensation for defocus works with English letters, and discuss theoretical and experimental questions posed by phase-prefiltering.