What is the 'correct' human cortical magnification factor?

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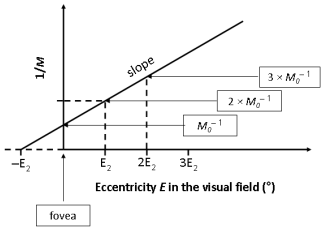
Summary

- Scaling stimulus size by "the" cortical magnification factor (CMF, M) is common practice in psychophysics of peripheral vision
- There is indeed wide agreement that the inverse CMF increases linearly with eccentricity in the visual field
- Yet neither the foveal CMF nor its rate of change with eccentricity is agreed upon
- A re-analysis of 8 studies on the cortical map from 1979 – 2009 reveals a 6-fold variation of the foveal CMF for V1, and even 18-fold variation of cortical E_2
- Parameter d_2 – the location where the central CMF is halved (Strasburger 2022) – and the slope of the CMF function give stable estimates, however

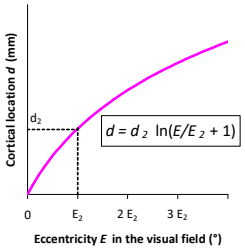
Terms & Definitions

E_2
M_0
slope



CMF Function, local behaviour

d_2



Location Function, global behaviour

E_2 (in ° visual angle) – is the eccentricity where the foveal value is doubled.

d_2 (in mm cortex) – is where the retinotopic centre's value is halved

M_0 (mm/°) is the foveal cortical magnification factor (CMF).

slope refers to the 1/M vs. ecc. Function.

Equations

Location Function

$$d = d_2 \ln(E/E_2 + 1)$$

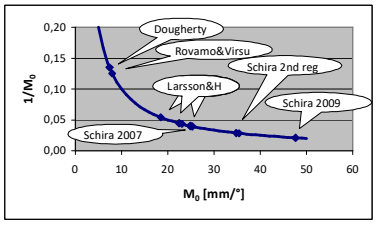
Parameter relationships

$$slope = 1/(M_0 E_2) \quad \rightarrow \quad d_2 \sim 1/slope$$

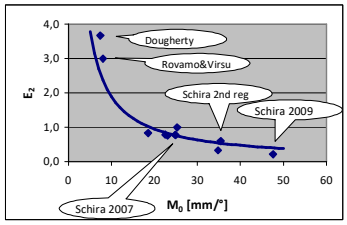
$$d_2 = M_0 E_2 \ln(2) \quad \rightarrow \quad d_2 \sim M_0 E_2$$

Results

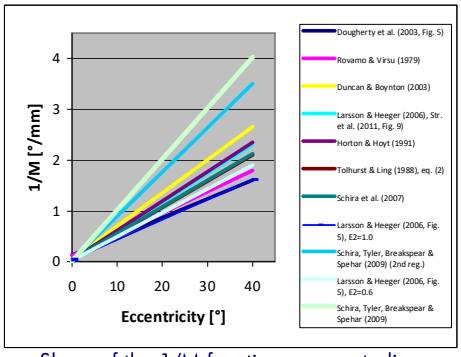
Study	M_0 [mm/°]	E_2 [°]	d_2 [mm]	slope [mm^{-1}] $1/(M_0 E_2)$
Dougherty et al. (2003, Fig. 5)	7.40	3.670	18.82	0.037
Rovamo & Virsu (1979) @40°	7.99	3.00	16.61	0.042
Duncan & Boynton (2003)	18.50	0.831	10.66	0.065
Larsson & Heeger (2006), Str. et al. (2011, Fig. 9)	22.50	0.785	12.24	0.057
Horton & Hoyt (1991)	23.07	0.750	11.99	0.058
Tolhurst & Ling (1988), eq. (2)	24.88	0.780	13.45	0.052
Schira et al. (2007)	24.90	0.770	13.29	0.052
Larsson & Heeger (2006, Fig. 5), E_2=1.0	25.30	1.000	17.54	0.040
Schira, Tyler, Breakspear & Spehar (2009) (2nd reg.)	34.80	0.330	**7.96**	0.087
Larsson & Heeger (2006, Fig. 5), E_2=0.6	35.40	0.600	14.72	0.047
Schira, Tyler, Breakspear & Spehar (2009)	47.60	0.210	6.93	0.100
Variation	**6.4**	**17.5**	**2.7**	**2.7**



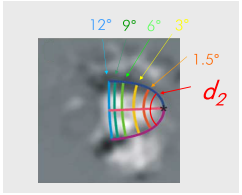
Illustrating the variation of M_0 across studies



E_2 varies inversely with M_0



Slope of the 1/M function across studies



d_2 = 11 mm for illustration (mod. from Duncan & Boynton 2003)

Practical use of d_2
Comparing individuals, species, V1–V3, LGN, anything retinotopic …

Conclusions

- M_0 varies 6-fold across studies. We thus do not yet know the correct foveal CMF
- E_2 varies even 18-fold across studies. It is too variable to characterise the CMF function
- E_2 and M_0 vary inversely across studies so their product is more stable
- Thus d_2 and its inverse, *slope*, are more reliable, varying only 2.7-fold (mean across studies 13 mm). They are thus best suited for describing the CMF function

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