

Myopia and ambient lighting at night

Myopia, or short-sightedness, occurs when the image of distant objects, focused by the cornea and lens, falls in front of the retina. It commonly arises from excessive postnatal eye growth, particularly in the vitreous cavity. Its prevalence is increasing and now reaches 70–90% in some Asian populations^{1,2}. As well as requiring optical correction, myopia is a leading risk factor for acquired blindness in adults because it predisposes individuals to retinal detachment, retinal degeneration and glaucoma. It typically develops in the early school years but can manifest into early adulthood². Its aetiology is poorly understood but may involve genetic and environmental factors^{1,2}, such as viewing close objects, although how this stimulates eye growth is not known³. We have looked at the effects of light exposure on vision, and find a strong association between myopia and night-time ambient light exposure during sleep in children before they reach two years of age.

Research in species as diverse as chicks and monkeys indicates that postnatal eye growth and refractive development are governed by a vision-dependent retinal mechanism acting mainly within the eye, with only limited participation of the brain and extra-ocular neural pathways^{3,4}. The duration of the daily light period has been shown to affect eye growth in chicks⁵, so we investigated whether refractive development in children might associate with any

recognizable pattern of light exposure. Because early neonatal visual experience markedly affects refractive development in animals^{4–6}, we evaluated light exposure both at the child's present age and before the age of two years, a period during which the eye grows rapidly⁷ but before the usual onset of myopia².

Between January and June 1998, parents of children aged 2–16 years (median age 8.0 years; $n = 479$ children, 55% males; 70% Caucasian, 30% African-American, less than 1% Asian-American) that were seen as outpatients in a university paediatric ophthalmology clinic completed a questionnaire on the child's light exposure both at present and before the age of two years. Children with amblyopia, cataract, glaucoma or a history of prematurity were excluded.

The prevalence of myopia and high myopia during childhood was strongly associated with ambient light exposure during sleep at night in the first two years after birth (Fig. 1). The relation between refraction and night-time light was dose dependent, as a greater proportion of children became myopic if they slept at night during their first two years with room lighting rather than with a night light. The increased prevalence of myopia resulted from a smaller proportion of emmetropic children, as light exposure did not relate to the proportion of hyperopic children. We found no other association of refraction with report-

ed light exposure, including no relation with night-time lighting at the child's present age.

An influence of ambient lighting during sleep on refractive development is plausible, because eyelids of human adults and infants transmit some visible light, mostly at longer wavelengths⁸. The scotopic retinal sensitivity of infants is relatively good compared with that of adults, particularly by the age of 18 weeks⁹. Further, sutured eyelids of infant monkeys transmit a degraded image and perturb refractive development⁶.

This study does not indicate whether early visual experience influences ocular anatomy by age two or only later, and does not permit conclusions to be made about the timing of the onset or progression of myopia. It raises the possibility of a 'critical period' for refractive development analogous to that for visual function¹⁰.

Although it does not establish a causal link, the statistical strength of the association of night-time light exposure and childhood myopia does suggest that the absence of a daily period of darkness during early childhood is a potential precipitating factor in the development of myopia. The results are further qualified by the limitations of collecting behavioural data by questionnaire and the lack of information on whether parental lighting preferences independently associate with other factors known to be correlated with myopia, such as parental socio-economic or refraction status^{1,2}. The generalizability of this relationship, observed in a tertiary referral centre, also requires extension to other populations and especially to Asian groups, which are severely affected by myopia¹. Despite these qualifications, it seems prudent that infants and young children sleep at night without artificial lighting in the bedroom, while the present findings are evaluated more comprehensively.

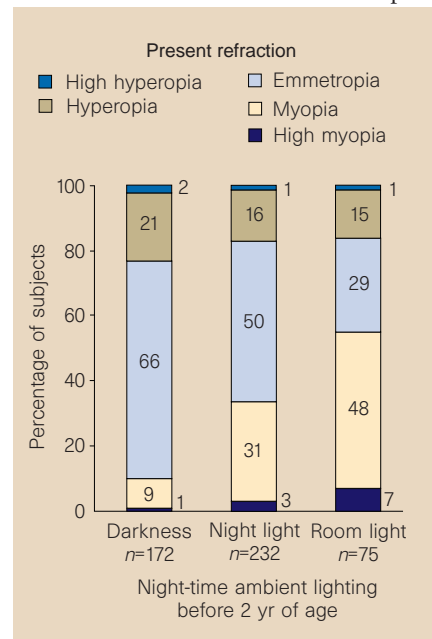
Graham E. Quinn*†, Chai H. Shin*, Maureen G. Maguire†, Richard A. Stone†

*Department of Ophthalmology, Children's Hospital of Philadelphia, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania 19104, USA

†Department of Ophthalmology, Scheie Eye Institute, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania 19104, USA

e-mail: stone2@mail.med.upenn.edu

Figure 1 Present refractions of children of ages 2–16 yr and night-time light exposure before the age of 2 yr. The prevalence of myopia increases markedly with increased levels of night-time ambient lighting during sleep before the age of 2 yr. On a questionnaire approved by an institutional review board, parents were asked, "Under which lighting condition did/does your child sleep at night?" before the age of 2 yr and at present; they chose between 'room lighting', 'a night light' (typically, in the USA, a dim socket-mounted fixture of ~4 W) and 'darkness'. Other questions addressed the lighting in various rooms at home, lighting at day care or school, geographical locations where the child had lived and current use of sunglasses. On the basis of the mean cycloplegic spherical equivalent of both eyes at the child's most recent ophthalmic examination, we separated the refractions into five groups: high hyperopia (long-sightedness), $\geq +5.0$ dioptres (D); hyperopia, $+2$ to $< +5$ D; emmetropia ('normal' childhood refraction), $< +2$ to < -0.5 D; myopia, -0.5 to < -5.0 D; high myopia, ≤ -5.0 D. The percentage of children in the combined myopia and high myopia groups at their present age increased with increasing night-time light exposure before the age of 2 yr (χ^2 with 1 degree of freedom = 55.1, $P < 0.00001$). The strength of the relation was maintained after adjustment for age by logistic regression analysis. The same relation held for separate analyses of the Caucasian and African-American subjects ($P < 0.00001$ for each group; results not shown).



1. Saw, S.-M., Katz, J., Schein, O. D., Chew, S.-J. & Chan, T.-K. *Epidemiol. Rev.* **18**, 175–187 (1996).
2. Zadnik, K. & Mutti, D.O. in *Borish's Clinical Refraction* (ed. Benjamin, W. J.) 30–46 (Saunders, Philadelphia, 1998).
3. Stone, R.A. in *Myopia Updates: Proceedings of the 6th International Conference on Myopia* (ed. Tokoro, T.) 241–254 (Springer, Tokyo, 1997).
4. Wallman, J. *Prog. Retinal Res.* **12**, 133–153 (1993).

- Stone, R. A., Lin, T., Desai, D. & Capehart, C. *Vision Res.* **35**, 1195–1202 (1995).
- Raviola, E. & Wiesel, T. N. *N. Engl. J. Med.* **312**, 1609–1615 (1985).
- Larsen, J. S. *Acta Ophthalmol. (Copenh.)* **49**, 873–886 (1971).
- Robinson, J., Bayliss, S. C. & Fielder, A. R. *Vision Res.* **31**, 1837–1840 (1991).
- Hansen, R. M. & Fulton, A. B. in *Early Visual Development, Normal and Abnormal* (ed. Simons, K.) 130–142 (Oxford Univ. Press, New York, 1993).
- Daw, N. J. *Arch. Ophthalmol.* **116**, 502–505 (1998).

Superconductors under stress

Locquet *et al.*¹ reported a doubling of the critical temperature (T_c) of the superconductor $\text{La}_{1.9}\text{Sr}_{0.1}\text{CuO}_4$, from 25 to 49 K, in compressively strained thin films on a SrLaAlO_4 substrate. This led to speculation that values of T_c close to or even beyond 200 K could be obtained without excessive external pressure, starting from an unstrained cuprate with high T_c (> 100 K). The stress would be applied to the ab (CuO_2) plane of this system of tetragonal symmetry. Such expectations are theoretically unrealistic.

To understand the phenomenon they observed, Locquet *et al.* cited data on uniaxial pressure gradients of T_c on the same compound^{2,3}. In particular, they inferred from the negative sign of the quantity $dT_c/d\epsilon_c$, where ϵ_c is the strain (minus the relative change in distances along the c -axis), that elongation (negative strain) of the c -axis increases the critical temperature, if atomic coordinates in the ab plane are kept constant.

Without questioning the validity of their experimental results, we disagree with Locquet *et al.* on two points. First, the higher the critical temperature in the unstrained state, the closer is the system with respect to optimum density in coordinate space, or to the optimum level of the Fermi energy. Quenching will then lead to a much weaker effect than at low T_c , and may even lower the critical temperature. This conclusion reflects *a priori* on results selecting the Hg-cuprate with the present record T_c of 134 K (three CuO_2 layers per molecular unit).

Second, the cuprates $\text{La}_{2-x}\text{M}_x\text{CuO}_4$ (where M is Sr or Ba) are unsuited as a reliable source of microscopic information via stress-strain relations because of observed structural distortions, phase transitions, non-rigid tilting of CuO_6 octahedra, and so on³, under external parameters and doping. As a result, conventional stress-strain relations, which are macroscopic and phenomenological, are not applicable to these systems on an atomic scale. This implies that the usual equalities (all derivatives are partial), $dT_c/d\epsilon_i = \sum_j (dT_c/dP)C_{ij}$, where ϵ_i is

the strain along the i th axis and C_{ij} are elastic moduli, cannot provide the information desired. With i denoting the c -axis direction, the right-hand side is large and negative^{3,4} for $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$, but its indicated relation to a quantity which presupposes that all coordinates except those along the c -axis remain unchanged does not hold.

Locquet *et al.* incorrectly conclude that these negative values imply an increase of T_c brought about solely by enlarging the c -axis. In particular, their criticism of the interlayer tunnelling model proposed by Anderson *et al.*⁴ is irrelevant, although this model has been criticized on other grounds⁵.

Laurens Jansen*, Ruud Block†

*c/o Institute of Theoretical Physics, ETH-Hönggerberg HPZ 8093, Zürich, Switzerland

e-mail: jansen@itp.phys.ethz.ch

†J. H. van't Hoff Institute,

University of Amsterdam,

1018 WV Amsterdam, The Netherlands

- Locquet, J.-P. *et al. Nature* **394**, 453–456 (1998).
- Gugenberger, F. *et al. Phys. Rev. B* **49**, 13137–13142 (1994).
- Nohara, M. *et al. Phys. Rev. B* **52**, 570–580 (1995).
- Chakravarty, S., Sudbo, A., Anderson, P. W. & Strong, S. *Science* **261**, 337–340 (1993).
- Tsvetkov, A. A. *et al. Nature* **395**, 360–362 (1998).

Polar gigantism dictated by oxygen availability

The tendency of some animals to be larger at higher latitudes ('polar gigantism') has not been explained, although it has often been attributed to low temperature and metabolism¹. Investigation of gigantism requires widely distributed taxa with extensive species representation at many well-studied sites. We have analysed length data for 1,853 species of benthic amphipod crustaceans from 12 sites worldwide, from polar to tropical and marine (continental shelf) to freshwater environments. We find that maximum potential size (MPS) is limited by oxygen availability.

Size spectra are right-skewed at all sites, but skewedness increases as temperature decreases (Fig. 1). Analysing gigantism needs emphasis on right-hand extremes of distributions. However, potential sampling bias at some sites precludes using absolute maximum size, so we used the threshold size separating the smallest 95% of species from the largest 5% (which we refer to as $\text{TS}_{95/5}$). For marine sites, $\text{TS}_{95/5}$ increases as water temperature decreases. Sites with low salinity, such as Lake Baikal (0 practical salinity units, p.s.u.), Caspian (13 p.s.u.) and the Black Sea (17 p.s.u.) lie above the marine relationship, and the discrepancy increases as salinity decreases (Fig. 2a), with the Lake Baikal $\text{TS}_{95/5}$, for example, being 1.8 times the marine value at the same tem-

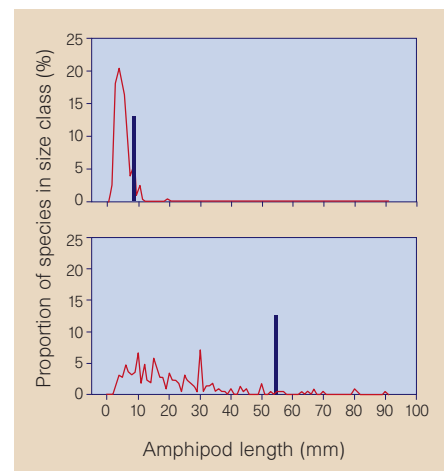


Figure 1 Amphipod size spectra for the two sites (Madagascar¹, top; Lake Baikal², bottom) for which the maximum and minimum $\text{TS}_{95/5}$ values, indicated by bars, were obtained. In total, data were obtained from 12 sites worldwide: Madagascar, mean annual water temperature (T) = 25 °C, $\text{TS}_{95/5}$ = 8.3, number of species at each site (n) = 314; Mediterranean Sea, T = 19 °C, $\text{TS}_{95/5}$ = 12.6, n = 350; Black Sea, T = 16.5 °C, $\text{TS}_{95/5}$ = 20.3, n = 93; Caspian Sea, T = 15 °C, $\text{TS}_{95/5}$ = 25.4, n = 69; British Isles, T = 11 °C, $\text{TS}_{95/5}$ = 23.2, n = 172; Magellanic region, T = 9.75 °C, $\text{TS}_{95/5}$ = 23.4, n = 164; subantarctic islands, T = 9.5 °C, $\text{TS}_{95/5}$ = 21.9, n = 181; Lake Baikal, T = 6 °C, $\text{TS}_{95/5}$ = 54.4, n = 226; Barents Sea, T = 4 °C, $\text{TS}_{95/5}$ = 35.4, n = 134; South Georgia, T = 1.5 °C, $\text{TS}_{95/5}$ = 40.5, n = 150; West Antarctica, T = 0.75 °C, $\text{TS}_{95/5}$ = 41.5, n = 297; East Antarctica, T = 0.0 °C, $\text{TS}_{95/5}$ = 43.6, n = 195). Analyses were restricted to a depth of 250 m (continental shelf depth), except for Antarctica, which included species to 500 m because of continental shelf depression by the Antarctic icecap. Sites that had fewer than 50 species described were not analysed.

perature. But oxygen solubility increases as salinity decreases, and replotting $\text{TS}_{95/5}$ against water-dissolved oxygen content removes this discrepancy and produces a linear relation: $\text{TS}_{95/5} = -42.6 + 0.252 \text{ O}_2$ (n = 12; r^2 = 0.98; F = 51.69; P < 0.0001) (Fig. 2b).

Thus, oxygen availability controls $\text{TS}_{95/5}$. The fit of regressions (not shown) relating lower threshold size values (such as $\text{TS}_{90/10}$ and $\text{TS}_{50/50}$) with oxygen improves with increasing threshold size value, indicating that oxygen becomes more important relative to other ecological factors as size increases. Furthermore, the relation between $\text{TS}_{95/5}$ and temperature for marine sites is curvilinear (Fig. 2a), reflecting the nonlinear relation between seawater oxygen content and temperature.

$\text{TS}_{95/5}$ reaches zero when mean environmental oxygen is 183 μmol per kg of water. This should indicate an environmental limit for amphipods. A variety of hot and/or highly saline conditions would produce 183 μmol O_2 per kg, but these areas are inhabited by brine shrimp and ostra-