pressed as a constant mixing ratio, has been determined by including the C_2H_2 opacity in the synthetic spectrum calculation. The best fit corresponds to a mixing ratio of 10^{-6}, with an uncertainty of half an order of magnitude in either direction; the uncertainty is due to the use of a random band model in the opacity estimate and to the inability to fit the spectrum simultaneously in both Q and R branches of the ν_5 band. This abundance is essentially consistent with Strobel's photochemical models (*18*), but lower than Ridgway's (*4*) earlier estimate of 8×10^{-5}. Rigorous analysis awaits a more complete compilation of line positions and strengths in this band and comparison with detailed laboratory results. While Ridgway (*4*) also identified the ν_9 fundamental band of C_2H_6 near 820 cm^{-1}, we do not expect to be able to discriminate such an emission feature from our internal noise at a resolution of 4 cm^{-1}.

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Abnormal Visual Resolution in the Siamese Cat

Abstract. *When tested behaviorally, Siamese cats display marked differences in contrast sensitivity compared to ordinary cats. Overall sensitivity is depressed, the high-frequency cutoff point is lower, and there is less falloff in sensitivity at low spatial frequencies. Optical factors may contribute to these differences, or they may be attributable to the well-established anatomical abnormalities within the visual system of the Siamese cat.*

In the Siamese cat, optic fibers originating from about the first 20° of the temporal retina, just beyond the vertical midline, cross over to the contralateral side of the brain rather than remaining uncrossed as do most temporal fibers in the ordinary cat (*1*). As the result, subsequent stages in the visual pathways are confronted with an abnormally large contralateral input which the nervous system apparently deals with in one of several alternative ways (*2*). Because this congenital abnormality may disrupt the neuroanatomical substrate for normal vision, we and others have been interested in exploring behaviorally the possible visual consequences of this abnormality (*3*). During our work we unexpectedly discovered that Siamese cats suffer gross deficits in contrast sensitivity, a behavioral result which may reflect the existence of additional anamolies in the visual system of this albino mammal.

In our experiments, contrast thresholds were determined behaviorally with a conditioned suppression technique, the details of which are described elsewhere (*4, 5*). Cats were trained to lick a tube in order to obtain a small quantity of pureed beef, which was delivered on the average of once every ten licks. While licking, the cat faced an oscilloscope screen located 75 cm from its eyes. Conventional techniques (*6*) were used to generate on the screen either an uncontoured field of uniform luminance or vertical grating patterns of sinusoidal luminance profile; spatial frequency and contrast could be varied independently, and the grating and uncontoured display interchanged instantaneously, without altering the average luminance, which was 60 cd/m². The oscilloscope display and a restraining box which housed the cat were enclosed in a light-tight chamber; the cat was unobtrusively observed on a television monitor. During preliminary training, while the cat learned to lick, the oscilloscope display always was uncontoured. Once a stable lick rate was achieved, conditioned suppression trials were introduced. On these trials the uncontoured display was replaced for 15 seconds by a 0.5 cycle-per-degree grating of 0.45 contrast. The grating was turned off and on at the rate of 1.5 hertz, and at the end of the 15-second period a brief, unavoidable shock was delivered through the grid floor of the restraining box. Trials were initiated only when the cat was licking and appeared to be looking at the display. Once the cat was reliably suppressing to presentation of this high-contrast grating, we systematically varied contrast to find the value which produced a 50 percent reduction in lick rate, the conventional definition of threshold with this technique (*4*). Contrast thresholds were measured in this way over a range of spatial frequencies.

The results are shown in Fig. 1, with the open symbols plotting sensitivity (reciprocal of contrast threshold) of a typical ordinary cat and the filled symbols plotting sensitivity for two Siamese cats. Notice that at peak sensitivity (approximately 0.5 cycle per degree) the ordinary cat can detect a contrast of less than 1 percent, and that there is a reduction in sensitivity above and below this peak, with the high-frequency cutoff falling near 6 cycles per degree. This pattern of results is quite representative of ordinary cats: in our laboratory a total of six normal, adult cats have been tested for contrast sensitivity, and the same general curve is always found (cutoff frequency ranges from 4.7 to 6.5 cycles per degree). Using different techniques, others have reported much the same result (*7*). The contrast sensitivity functions for both Siamese cats, however, display several notable departures from the normal function: overall sensitivity is depressed by more than ½ log-unit at most points, the high-frequency cutoff is lower by at least a factor of 2, and there is little, if any, falloff in sensitivity at low spatial frequencies.

Like most Siamese cats, both the animals we tested displayed a noticeable convergent squint, which raises the possibility that the overall reduction in their contrast sensitivity could arise either from improper accommodation at a point nearer than the visual display or from some form of interocular suppression in response to diplopia. To test the first possibility, we reduced the viewing distance to 45 cm, by moving the oscilloscope toward the animal, and remeasured the contrast thresholds on one of the Siamese cats. This maneuver only served to produce a further reduction in contrast sensitivity, on the order of 0.2 log-unit. We conclude, therefore, that misaccommodation is not the primary cause of the depression in Siamese cats' contrast sensitivity. To test the second possibility, we remeasured at the 75-cm viewing distance contrast thresholds for 0.5 cycle per degree while allowing the animal to use only one eye at a time; the nontested eye was occluded with an opaque contact lens. Restricting the Siamese cat to monocular vision produced no change in contrast sensitivity, thus ruling out interocular suppression as the cause.

In considering possible structural and physiological factors that might account for this reduction in visual resolving power in Siamese cats, several plausible explanations come to mind. The deficit could be purely optical in origin, such that the contrast in the image on the retina of the Siamese cat is attenuated. To get a rough idea of the optical quality of the Siamese cat eye, we carefully inspected the fundus ophthalmoscopically through the dilated pupil of a relaxed, awake animal. We were able to visualize the fine capillaries as clearly as in the eye of an ordinary cat, indicating that the dioptrics of the Siamese cat eye can produce a clearly focused image on the retina (*8*). At the same time, however, we did observe an unusually large amount of light scatter within the Siamese eye, which is undoubtedly related to the reduced pigmentation characteristic of this albino mammal. Because stray light produces an appreciable illuminance plateau throughout the extent of an in-focus image (*9*), it is quite plausible that contrast in the image of a grating pattern would be diluted, thus reducing to some extent the contrast sensitivity of the Siamese.

As another possibility, it is conceivable that there exists within the eye of the Siamese cat a deficiency in one class of receptors (for example, cones), or that the receptors are abnormally distributed throughout the retina. While this might account for the reduction in the high-frequency cutoff point, it is not obvious how this would relate to the overall depression in contrast sensitivity or to the virtual absence of a low-frequency falloff in sensitivity.

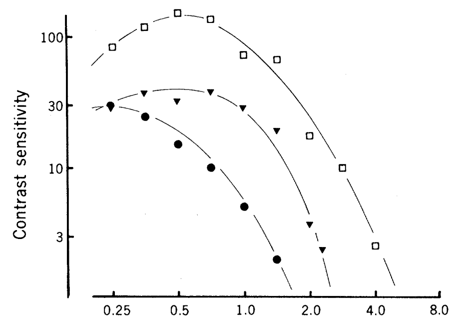

Fig. 1. Contrast sensitivity (reciprocal of threshold contrast) as the function of spatial frequency. Open symbols (□) show the results from an ordinary cat, and the filled symbols (▼, ●) give the results for two Siamese cats. Each point represents the contrast value which produced a 50 percent reduction in response rate at that spatial frequency. The individual curves were fitted by eye. Luminance, 60 cd/m^2; viewing distance, 75 cm; field size, 10° × 8°.

Finally, the abnormal contrast sensitivity exhibited by the Siamese cat could be related to the aberrant visual projections characteristic of this animal. Others have predicted deficits in the visual capacities of the Siamese cat, based on the unusual retinotopic organization in Siamese striate cortex and superior colliculus (*2*). However, because very little is known about the receptive field properties (for example, spatial selectivity) of individual neurons in the visual nervous system of Siamese cats, at present we can only speculate as to the details of the possible neural correlates of the animal's poor visual resolution (*10*).

From our behavioral data we are unable to distinguish between these various hypotheses, and there is no reason to believe they are mutually exclusive. It remains for future work to determine the extent to which optical and neural factors contribute to the abnormal contrast sensitivity of the Siamese cat. This, in turn, could furnish some clues concerning the etiology of amblyopia in human albinos.

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8. This technique of estimating optical resolution is based on the quite reasonable assumption that the optics of the eye are reversible; any degradation in the image of the retinal blood vessels would also occur when the image of an external object was formed on the retina [H. Ikeda and M. J. Wright, *J. Physiol. (London)* **232**, 34P (1973)]. Incidentally, based on ophthalmoscopic examination of the non-atropinized eye of the Siamese cat, we estimate that the animal shown by filled circles in Fig. 1 is slightly myopic. In humans it is hyperopia, not myopia, which can lead to accommodative esotropia (convergent squint).
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10. We find the following hypothesis particularly intriguing. It is well established that the visual pathways of the ordinary cat are functionally segregated into at least two major classes of neurons, termed X-cells and Y-cells, which are distinguishable on the basis of their spatiotemporal response properties [C. Enroth-Cugell and J. G. Robson, *J. Physiol. (London)* **187**, 517 (1966); B. G. Cleland, M. W. Dubin, W. R. Levick, *ibid.* **217**, 423 (19 L. Maffei and A. Fiorentini, *Vision Res.* **13**, 1255 (1973)]. With respect to their sensitivities to flashing or continuously moving grating patterns, Y-cells do not respond to higher spatial frequencies but do display a less pronounced response attenuation at low spatial frequencies, compared to X-cells. The reduced high-frequency cutoff for the Siamese cat contrast function, plus the relatively shallow attenuation at low frequencies, is consistent with the hypothesis that the visual system of the Siamese cat is composed predominantly of Y-cells. Perhaps the disproportionately large contralateral input from the Siamese cat retina to subsequent visual sites (*1*) somehow is biased in favor of the larger-axon Y-cells. While the distribution of X- and Y-cells in the Siamese cat retina has yet to be studied, it may be of significance that in the ordinary cat some Y-cells, but not X-cells, from up to 15° into the temporal retina project contralaterally instead of ipsilaterally [D. L. Kirk, W. R. Levick, B. G. Cleland, H. Wassle, *Vision Res.* **16**, 225 (1976)]. The proportion of misdirected Y-fibers might be exaggerated in the Siamese cat.

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