active, and as time went on increasingly frenzied, visual exploration of the room, they often bumped into table legs as they scurried around.

There were, moreover, differences between cats reared in horizontal and vertical environments. They were virtually blind for contours perpendicular to the orientation they had experienced. They showed no startle response for an approaching 'Perspex' ('Plexiglas') sheet covered with black stripes, nor would they visually place on such a pattern, if the stripes were of the inappropriate orientation. The differences were most marked when two kittens, one horizontally and the other vertically experienced, were tested simultaneously with a long black or white rod. If this was held vertically and shaken, the one cat would follow it, run to it and play with it. Now if it was held horizontally the other cat was attracted and its fellow completely ignored it.

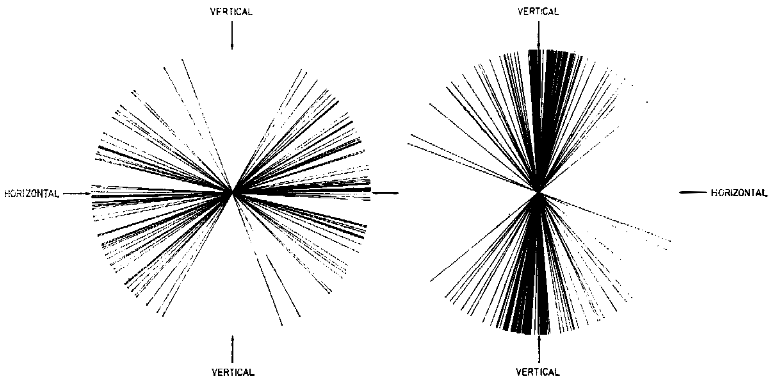

Fig. 2. These polar histograms show the distributions of optimal orientations for fifty-two neurones from a horizontally experienced cat on the left, and seventy-two from a vertically experienced cat on the right. The slight torsion of the eyes, caused by the relaxant drug, was assessed by photographing the pupils before and after anaesthesia and paralysis. A correction has been applied for torsion, so the polar plots are properly orientated for the cats' visual fields. Each line shows the optimal orientation for a single neurone. For each binocular cell the line is drawn at the mean of the estimates of optimal orientation in the two eyes. No units have been disregarded except for one with a concentric receptive field and hence no orientational selectivity.

We moved on from behavioural studies to neurophysiology when the cats were 7·5 months old. They were anaesthetized with nitrous oxide and paralysed with succinyl choline while we recorded from single neurones in the primary visual cortex, using sodium chloride filled micropipettes. The refractive states of the eyes was corrected with contact lenses, spectacle lenses and 3 mm artificial pupils. There was no evidence of severe astigmatism, which might have explained our behavioural findings.

We used thin bright slits or edges to plot receptive fields on a screen 114 cm from the cat. The luminance of the background was about 5 cd. m^{-2} and of the bright target about 17 cd. m^{-2}. Our initial procedure was to make one long penetration deep into the medial edge of the post lateral gyrus, studying every single neurone encountered. We found units on the average about 80 μm apart, so presumably our electrode was not specially selective for the cells from which it recorded. After the long penetration we moved the electrode to other positions in area 17 and sampled just a few neurones at each place. Our exploration thus covered many cortical columns[1] and quite a large area of the visual field around the area centralis.

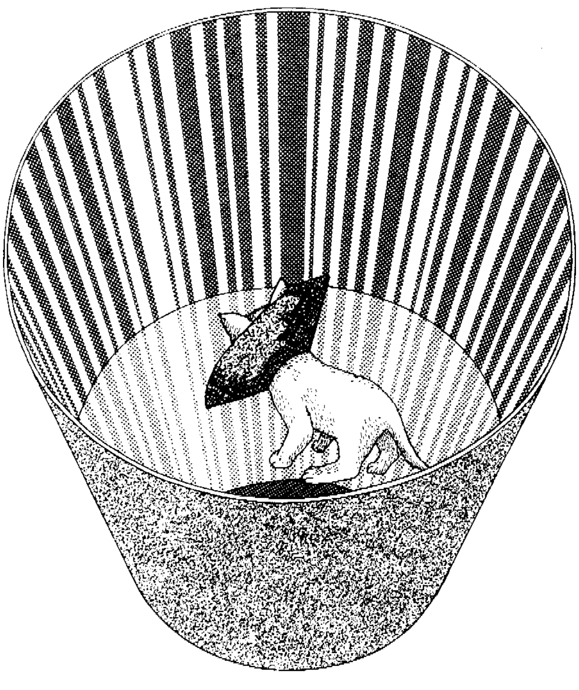

Fig. 1. The visual display consisted of an upright plastic tube, about 2 m high, with an internal diameter of 46 cm. The kitten, wearing a black ruff to mask its body from its eyes, stood on a glass plate supported in the middle of the cylinder. The stripes on the walls were illuminated from above by a spotlight. The luminance of the dark bars was about 10 cd. m^{-2} and of the bright stripes about 130 cd. m^{-2}: they were of several different widths. For this diagram the top cover and the spotlight have been removed from the tube.

So far we have studied 125 neurones from two cats, one horizontally, the other vertically experienced. Of all these units, only one did not have distinct orientation selectivity and it had the action potential waveform and concentric, monocular receptive field of a projection fibre from the lateral geniculate body. About 75 per cent of cells, in both cats, were clearly binocular and in almost every way the responses were like those in a normal animal. The distributions of preferred orientation, however, were totally abnormal (Fig. 2). Not one neurone had its optimal orientation within 20° of the inappropriate axis and there were, *in toto*, only twelve within 45° of it. This anisotropy is highly significant ($P < 0{\cdot}00001$: chi-squared test).

Evidently the visual experience of these animals in early life has modified their brains, and there are profound perceptual consequences. But we do not think that there is merely passive degeneration of certain cortical neurones because of under-activity. For we did not notice any obvious large regions of "silent" cortex, corresponding to the "missing" cortical columns. It seems instead that the visual cortex may adjust itself during maturation to the nature of its visual experience. Cells may even change their preferred orientation towards that of the commonest type of stimulus; so perhaps the nervous system adapts to match the probability of occurrence of features in its visual input.

We thank Patrick Jackson and Ian Creese for building the striped tubes and the MRC for research grants.

COLIN BLAKEMORE
GRAHAME F. COOPER

The Physiological Laboratory,
University of Cambridge,
Cambridge CB2 3EG.

Received July 17, 1970.

[1] Hubel, D. H., and Wiesel, T. N., *J. Physiol.*, **160**, 106 (1962).
[2] Hirsch, H. V. B., and Spinelli, D. N., *Science*, **168**, 869 (1970).
[3] Hein, A., and Held, R., *Science*, **158**, 390 (1967).
[4] Hubel, D. H., and Wiesel, T. N., *J. Physiol.*, **206**, 419 (1970).
[5] Held, R., and Hein, A., *J. Comp. Physiol. Psychol.*, **56**, 872 (1963).