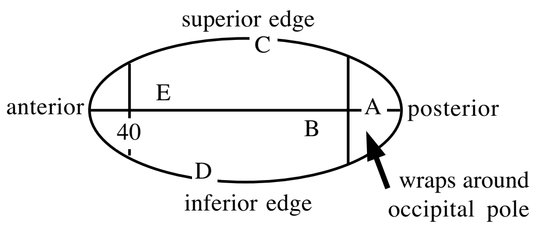
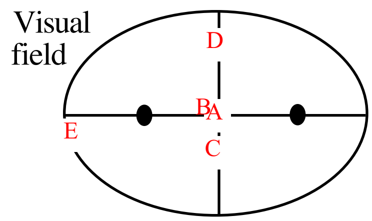
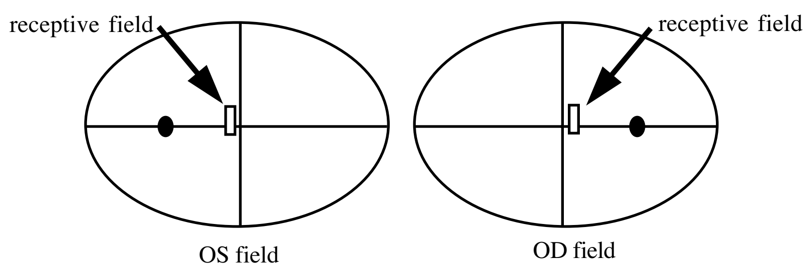
Vision Science IV: Principles of Binocular Vision
Examination 3 - 4/28/99

1. The figure shows a flattened map of the **right** primary visual cortex (calcarine fissure), similar to Fig. 23-6 in Adler's Physiology of the Eye. Assume that electrodes were placed at the five indicated locations, A, B, C, D, E. On the visual field plot, label the approximate location of the receptive fields (A, B, C, D, E) which should elicit a response from each of the respective electrodes. (5)





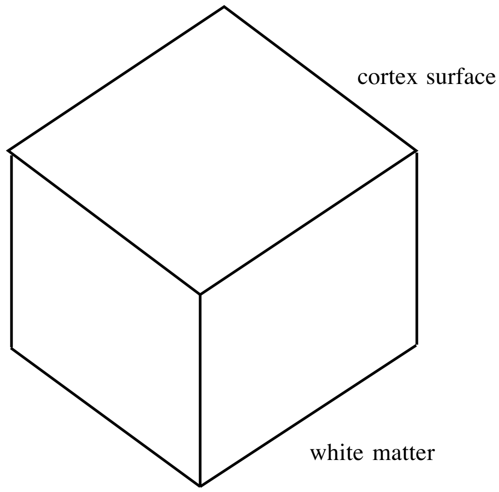
2. A scientist has trained a monkey to maintain straight ahead fixation on a point 60 cm away, while he records from a neuron in the visual cortex. The scientist first scans the right eye visual field at 60 cm (OS occluded) and finds a receptive field. He then scans the left eye visual field, also at 60 cm (OD occluded) and finds another receptive field for the same neuron. The location of the receptive fields for the right and left eye are shown below. Which answer below best describes the neuron? (2)



A. The neuron is binocular, but when stimulated by identical objects in each receptive field, the animal should perceive diplopia since the receptive fields are located in non-corresponding retinal locations.
B. The neuron is a monocular neuron since it is sensitive to a stimulus in either the right or left eye, but they are in non-corresponding locations.
C. The neuron is binocular and specifically tuned to detect an object in space with a certain amount of crossed disparity (located nearer than the fixation point).
D. The neuron is binocular and specifically tuned to detect an object in space with a certain amount of uncrossed disparity (located beyond the fixation point).
E. The response shown in the figure cannot be correct since it is impossible for a single neuron to have receptive fields in non-corresponding locations.

3. Complete the figure which follows, **showing and labeling** the following features of the three-dimensional organization of the primary visual cortex (area V1). (10)

- Layers I-VI, including layers IVB, IVCα and IVCβ
- A right and left ocular dominance slab (column)
- Several regions sensitive to specific orientations
- A hypercolumn
- Blob and interblob regions



(See Adler's Fig. 23-22)

4. Beside each of the following aspects of vision, write a P for parvo or M for magno to indicate which pathway is most closely associated with that aspect of vision. (9)

Aspect of vision	Parvo (P) or Magno (M)
Central vision	P
Peripheral vision	M
Large ganglion dendritic fields	M
Color perception	P
Motion perception	M
High spatial frequency (high resolution)	P
High temporal frequency (rapid flicker)	M
Coarse stereopsis	M
Fine stereopsis	P

5. Complete the following table to show the correct pathway and neurological junctions which eventually terminate in the cortical motion and color centers (right column) . (14)

Pathway (parvo/magno)	Ganglion cell type	LGN layer	V1 1st synapse (layer)	V1 2nd synapse (layer)	V2 region	Higher centers
magno	alpha	Ventral 2	IVCalpha	IVB	Thick (dark) stripes	motion
parvo	beta	Dorsal 4	IVCbeta	II, III blob	Thin (gray) stripe	color
				II, III interblob	interstripe	

6. Hubel and Wiesel suggested that cells in the visual cortex maybe organized in a hierarchal manner with both simple and complex cells. List four important characteristics of simple cells. (4)

Receptive fields are elongated, sensitive to bars or edges
Orientation specific
Spatial antagonism (inhibitory and excitatory regions)
Appear to be based on receptive field organization of connect LGN cells

7. It appears that the visual system processes stereopsis by two subsystems which specialize in fine and coarse stereopsis. Using a F for fine and C for coarse, indicate which type of stereopsis is associate with the following characteristics or structures. (11)

Characteristic	**Fine (F) or Coarse (C) stereopsis**
TN, TF, T0, TI neurons sensitive to small disparities	F
NE, FA neurons sensitive to large disparities	C
Static targets	F
Moving targets	C
Latency about 130 msec (faster)	C
Latency about 250 msec (slower)	F
More sensitive to high spatial frequencies	F
More sensitive to low spatial frequencies	C
Parvo system	F
Magno system	C
Color sensitive	F

8. What level of binocular function (motor fusion, sensory fusion, smooth pursuits) would be normal for a 2 month old infant? (3)

Occasional intermittent strabismus, usually exotropic
no stereopsis, but ability to simultaneously see and superimpose images
Difficulty following target moving from nasal to temporal. Better in opposite direction.

9. What level of binocular function (motor fusion, stereopsis, smooth pursuits) would you normally expect in an 8 month old infant? (3)

Eye should be aligned correctly all the time
At least 60” of stereopsis
Symmetric smooth pursuits in either nasal-to-temporal or opposite direction.

10. According to Held's two stage model for the development of binocular vision, which of the following statements **DOES NOT** correctly describe normal binocular development in the visual cortex? (3)

A. At birth layer IVC of the primary visual cortex is clearly delineated into right and left ocular dominance columns, but as the system matures, afferents from the LGN increasingly overlap, thereby allowing development of binocular neurons at this level.

B. At birth there is considerable overlap of afferent from the LGN in the primary visual cortex, but over the next several months, neurons receiving input from the right and left eyes begin to segregate into distinct binocular dominance columns.

C. At birth there may be a primitive sort of binocularity among first order neurons in layer IVC of the primary visual cortex, but with maturity neurons at this level become monocular.

D. Nearly equal and good quality input from both eyes is required to stimulate the development of normal ocular dominance columns in layer IVC. These monocular neurons then compete for synaptic sites on binocular neurons at higher levels in the primary visual cortex.

E. Monocular deprivation can cause abnormal development of the ocular dominance columns such that those for one eye atrophy while those for the other eye expand.

11. What is the "critical period" and why is it so important? (4)

This is a very important time period in the early development of the visual system, when it is particularly vulnerable to permanent damage caused by visual deprivation. Once the visual system has matured, visual deprivation has no significant effect on binocular vision, but even relatively short periods of monocular deprivation within the critical period can cause an irreversible amblyopia. Treatment for amblyopia includes reverse occlusion, but this must be instituted within the critical period to be effective. The critical period in human may last up until about age 9.

12. What kind of deprivation would lead to the following ocular dominance histogram? (2)

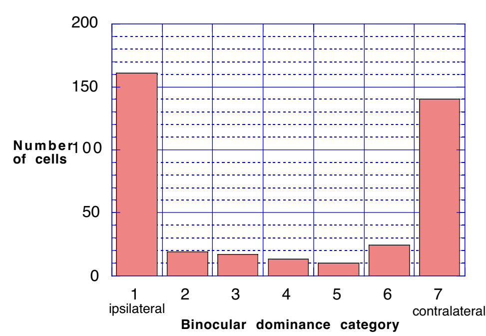
A. Pattern deprivation

B. Optical defocus

C. Strabismus

D. Aniseikonia

E. Anomalous correspondence



13. Consider a case of amblyopia caused by anisometropia. Why would you expect to see more severe developmental anomalies in neurons of the parvocellular rather than magnocellular tract? (2)

Anisometropia will lead to defocus in one eye and the effect is to attenuate high spatial frequencies. The parvocellular system is primarily responsible for processing high spatial frequencies and this kind of deprivation would stunt it's development. Low spatial frequencies would still be available to both eyes and input to the magnocellular system would essentially be normal, therefore development of this system would also be normal.

14. What are some important differences between infantile and accommodative esotropia? (4)

Infantile esotropia: earlier onset (before certain binocular functions have had a chance to develop); usually no refractive error; anomalous pursuits and motion perception; difficult to treat.

Accommodative esotropia: later onset (after some binocular functions have had more time to develop); usually hyperopic; normal pursuits and motion perception; good response to refractive and surgical correction.

15. Name three important principles of effective amblyopia therapy. (3)

Begin treatment as early as possible within the critical period
Provide best possible retinal image quality to the amblyopic eye
Use reverse occlusion to give the weaker eye a competitive advantage against the better eye.

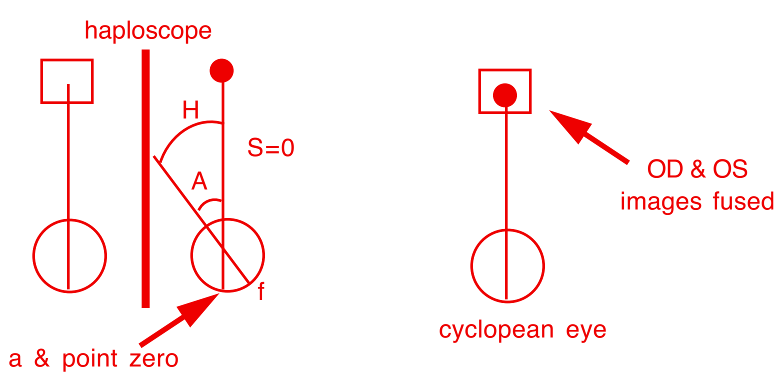
16. What is eccentric fixation? (4)

It is an abnormal adaptation to amblyopia or strabismus in which the poorer eye begins to fixate with some non-foveal part of the retina. It is usually most easily diagnosed by forcing the poorer eye to fixate monocularly.

17. What is anomalous correspondence? (5)

It is a sensory adaptation to strabismus which allows the person to fuse very disparate retinal images and avoid diplopia and confusion without suppressing. The visual cortex reorients the visual directions of the deviating eye so that some non-foveal point is made to correspond with the fovea of the good eye.

18. Draw a figure (similar to those in your notes) of haploscopic fixation for a right esotrope with harmonious anomalous correspondence. Be sure to label point zero, point a (anomalous point) and the fovea of the strabismic eye, along with angles H, S and A. Include the view seen by the cyclopean eye. (6)



19. Draw a figure (similar to those in your notes) of haploscopic fixation for a right esotrope with typical unharmonious anomalous correspondence. Be sure to label point zero, point a (anomalous point) and the fovea of the strabismic eye, along with angles H, S and A. Include the view seen by the cyclopean eye. (6)