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RIVALRY & SUPPRESSION

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RIVALRY

Thus far we have been discussing normal binocular vision, in which the visual system fuses two images into one percept. Normal binocular fusion requires:

- Motor fusion, so the right and left eye images will fall on nearly corresponding retinal locations, and
- Sensory fusion, which combines the two retinal images into one.

Because of Panum's area, it is not necessary for the right and left images to fall on exactly corresponding points; fusion is still possible when the images are on slightly disparate retinal locations, as long as the disparity is not too large.

Retinal disparity naturally occurs for objects that are located off the horopter, i.e. "closer or farther than the fixation distance". The visual system correctly interprets the retinal disparity as a difference in depth, and the stereoscopic perception correctly corresponds with reality. In addition to having a slight disparity in retinal directions, the actual shape of the images in the two eyes may be slightly different. This occurs because of binocular parallax—the two eyes are viewing the same object from different positions.

For example, if you hold your hand vertically about 20 cm directly in front of your nose, the right and left eyes will be looking at opposite sides of your hand. Verify this by alternately occluding the two eyes. When binocularly viewing your hand, both sides are simultaneously visible in a single fused image. (**See Steinman Fig. 1-3**).

This demonstrates that in some natural situations the image presented to the right and left eyes may be different. An acute oculomotor paresis can create a situation in which the image seen by each eye is completely different. When attempting to fuse dissimilar images, the visual system is faced with conflicting data from the two eyes—a situation known as rivalry. The Dictionary of Visual Science defines rivalry as, "*a competition or antagonism; a vying for supremacy.*" The rivalry between the two eyes is sometimes called **binocular rivalry**, **retinal rivalry**, **rivalry of the visual fields**, or **strife rivalry**. Sub-categories include colour rivalry, contour rivalry or border rivalry. When the eyes are pointing in different directions, and they receive different images on corresponding retinal locations, the person may experience both **diplopia** and **confusion**. You should understand the difference between these two terms. Quoting from Reading (Reading R.W. (1983) Binocular Vision Butterworth Publishers, Woburn, MA, p. 36):

"With a deviating eye, two different objects are imaged on the two foveae, and the patient usually sees these in the same visual direction. This is known as confusion. The figure also shows that the object fixated by the left eye, called the fixating eye, is imaged extrafoveally in the right eye, so the patient sees any given object as appearing to be in two locations. This constitutes diplopia."

During rivalry, the person may see **diplopia** (one object, two images), but rivalry is more commonly associated with confusion (two different objects in the same visual direction).

SUPPRESSION

The visual system normally cannot tolerate rivalry for long. It usually reconciles the dissimilar images by suppressing one. Reading defines suppression as, “the failure of one of the two monocular visual systems to perceive a normally visible object in all or part of the visual field.”

The entire image from one retina may be suppressed (**gross suppression**), but in some cases, parts of the right eye’s visual field will be suppressed while other parts of the left eye’s visual field are suppressed. Fig. 5-4 in Steinman illustrates this. You may experience rivalry and intermittent suppression by viewing Fig. 29.1 below.

Figure 29.2 also shows that in some cases, only a small part of one image is suppressed. Suppression of the fovea in one eye by the image in the other eye is called central suppression.

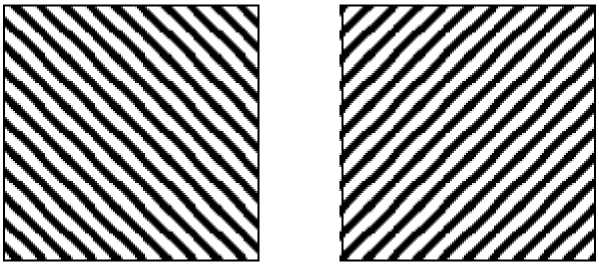

Figure 29.*1 When free-fusing these two images, look for a composite perception caused by the rivalry of dissimilar features. (See* ***Steinman Fig. 5-4****.)*

Figure 29.2 *Free-fuse the two left images and see if you notice that the center of the horizontal line is missing in the fused image.*

PRINCIPLES OF RIVALRY AND SUPPRESSION

Suppression and rivalry are closely related. Rivalry suggests that, in the competition between the two images, one eye’s image may dominate part of the time (or in part of the visual field) while at other times the other dominates. Suppression is a long-term dominance by one image over the other.

Rivalry and suppression are not usually noticed in normal binocular viewing conditions, but these can become clinical problems in some circumstances, such as in an acute oculomotor nerve paresis. The patient will likely experience diplopia and confusion. If the person cannot learn to reconcile the rivalry by suppressing either image, the only solution may be to occlude one eye. In a situation of binocular rivalry, which image, or which feature will be suppressed?
That is, in the competition between two images, which one will win? The manner in which the visual system deals with disparate retinal images depends, to some degree, on the nature of the images.

CONTOURS VERSUS HOMOGENOUS FIELDS

Contours in one image tend to dominate or suppress homogenous fields in the other image. Figure 29.3 illustrates this: A black dot (contour) on a yellow field is presented to one eye, while the other eye sees a homogenous gray field. The binocular percept (right) is of the black dot, surrounded with a slightly brighter yellow corona on the yellow-gray field. The contour takes precedence over the empty field, and the corona shows that the zone of suppression extends beyond the contour itself.

Figure 29.3 *Contours tend to dominate homogenous fields in binocular rivalry. When free-fusing the two left frames, you should notice an image similar to that shown on the right. (See* ***Steinman Fig. 5-7****)*

Similar, but unfusable images

When two similar, though unfusable contours are presented to either eye, the binocular percept includes a fused image with a combined local zone of suppression contributed by each image. If neither image dominates the other, the percept will combine parts from both. Fig. 29.4 illustrates this.

Figure 29.4 *Rivalry between similar contours of equal dominance produces a composite with areas of local suppression from both images. (****See Steinman Fig. 5-8****.)*

When two identical images have opposite black versus white contours, the fused image contains a combination of both percepts. The image may appear to have depth, and the dark background displays lustre or a shiny appearance. This is illustrated by Fig. 29.5 and **Steinman Fig. 5-9**, **10**. Steinman says that:

It has been proposed that the shimmering appearance of lustre mimics the shiny appearance of chrome because when viewing chrome, one eye tends to receive a bright reflection off the metal surface while the other does not, yielding the same type of luminance based rivalry. (p. 134)

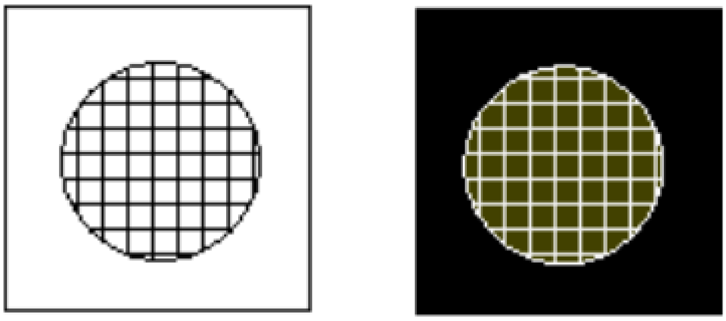

***Figure 29.5** Images designed to illustrate lustre, which results from the binocular rivalry between white and black contours. (See **Steinman Fig. 5-9, 5-10**)*

BINOCULAR LUSTRE AND COLOUR FUSION

When different colours are presented to each eye, the result may be binocular colour fusion - the colour appears to be a mixture of the monocular hues. This delicate percept may be difficult to maintain, and the binocular image may alternate between the two original colours, or portions of the binocular image may contain a mixed colour, while other portions may contain one colour or the other. This may be tested using the green box (left) and the red box (right) in Fig. 29.6. The same effect can be demonstrated by viewing a white field with anaglyph (red/green) glasses.

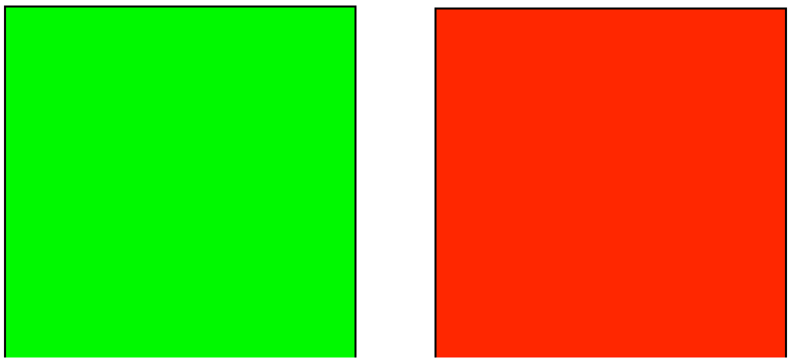

***Figure 29.6** Free-fusion colour rivalry targets designed to demonstrate binocular colour fusion.*

Suppression can be complicated, depending on the nature of the stimulus presented to each eye and the way the images are processed by the visual system. In general, the following trends are expected:

- Bright features tend to suppress darker features
- High contrast features tend to suppress low contrast features
- Clear images tend to suppress blurry images
- Foveal images tend to suppress peripheral images
- Moving images tend to suppress stationary images
- Images on the nasal retina of one eye tend to suppress images on the temporal retina of the other eye. (**See Steinman Fig. 5-11**.)

CLINICAL MEASUREMENT OF SUPPRESSION

Occasionally you may encounter suppression during a routine eye examination. During the von Graefe phoria test or when measuring the BI and BO fusional limits, you expect the patient to perceive diplopia. If, during BI or BO testing, the patient never sees the break, but says the chart appears to be moving to one side, you know that he/she is suppressing one eye.

Some patients may be unable to do a von Graefe test because they never see double, and the target may always appear to be moving to the side as prism is added. If they see single, but the target moves with increasing prism, you know that they are seeing with only one eye. You may then want to test for suppression. The Stereo Fly test includes a suppression check. Another simple test for suppression (as well as diplopia or fusion) is the **Worth Four Dot test** (**Steinman Fig. 5-12**).

It is possible that some patients may suppress one eye only during artificial viewing conditions (such as when looking through a phoropter in a dark room) but not during natural conditions. Although neither eye is suppressed most of the time, a person with a fragile binocular system may tend to suppress one eye some of the time. This may lead to more permanent suppression, so it is useful to have a clinical test to grade suppression proneness in the two eyes.

One technique illustrated by **Figure 3-8 in Reading** (p. 35) uses **Bagolini lenses** and a set of neutral density filters. The Bagolini lenses have fine (http://www.indiana.edu/~v755/cor/cordx.htm - bago), barely visible striations, oriented at 135 degrees before the right eye and 45 degrees before the left eye. During normal binocular fusion the patient wearing the lenses will see a cross, while viewing a point source of light. If either eye is suppressed, only a single line will be seen. Also see **Steinman Fig. 5-15**.

If asymmetric suppression proneness is suspected, it can be graded by the following procedure. Start with normal fusion and the binocular perception of a cross. Gradually add neutral density (ND) lenses before one eye until it is suppressed. For example, the right eye image may be suppressed when a 2.5 ND filter is used. Repeat the procedure for the other eye. For example, the left eye may be suppressed with the addition of a 1.0 ND filter. Such an asymmetric result indicates that the left eye is more prone to suppression.

You could also test suppression proneness by increasing dioptric blur before either eye, although this usually yields more variable and less reliable results than if you use ND filters.

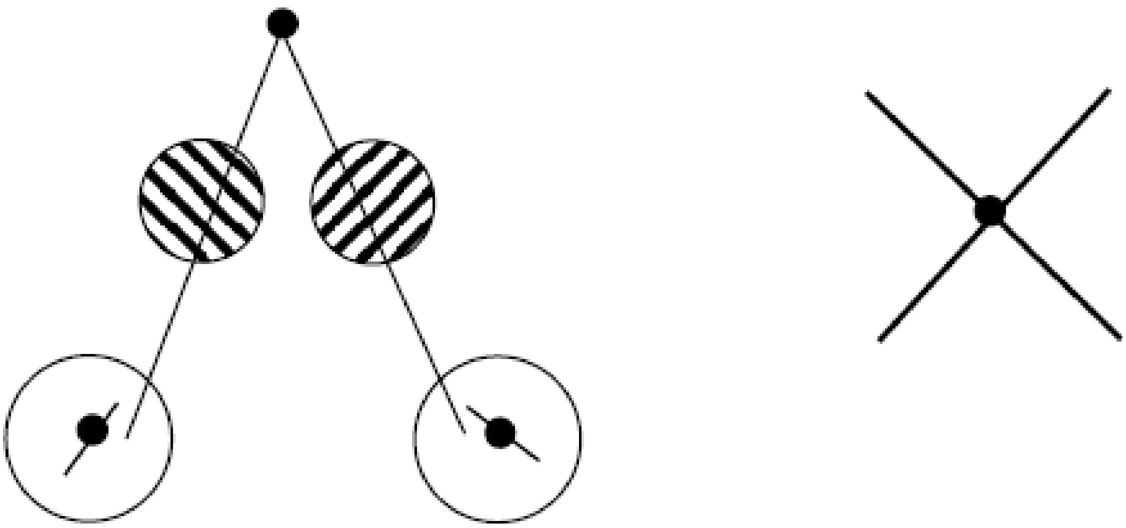

Figure 29.7 *Bagolini lenses may be used to grade suppression. The binocularly fused view is shown on the right.*

SUPPRESSION FIELDS AND STEROCAMPIMETRY

When one eye is suppressed, only certain portions of its visual field are usually suppressed. For example, in order to eliminate confusion caused by different images on the two foveas, the area near the fovea of one eye may be suppressed. In addition, to eliminate diplopia, the retinal location receiving the diplopic image may also be suppressed. This is illustrated in Fig. 29.8, redrawn after **Reading Fig. 3-9**. Steinman Fig. 5-13 also illustrates the same principle.

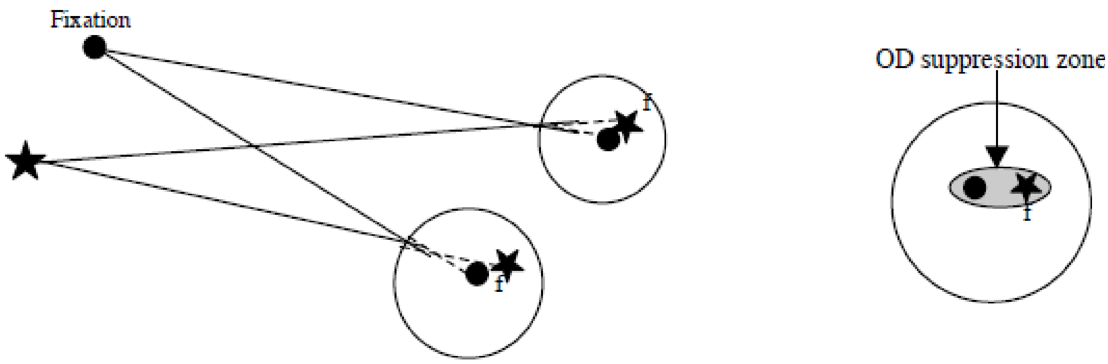

Figure 29.8 *When OS fixates on the dot; the star falls on the fovea of the esotropic OD.*

This leads to confusion and diplopia, which is solved by suppression of a narrow zone on the OD retina. It is possible to measure the extent of local suppression in the visual field of one eye using a technique known as **stereocampimetry**. Figure 29.9 shows how it is possible to plot the zone of suppression in the deviating eye. In this example, the normal right eye observes a fixation target in a mirror, separately from the deviating left eye. Test stimuli are presented to the left eye, which is pointed toward a tangent screen, and the examiner tests for areas of suppression. These will appear as scotomas in that monocular visual field.

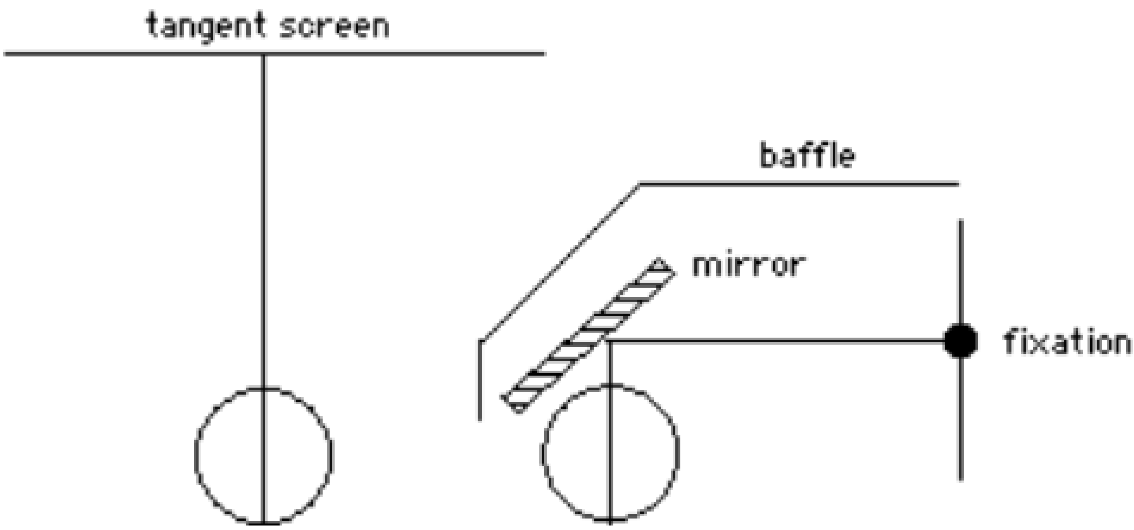

Figure 29.9 *Schematic diagram of one type of stereocampimeter, testing the zones of suppression in the left eye. (Inspired by a graphic from Reading R.W., Binocular Vision, Butterworth Publishers, Woburn, MA, 1983 Fig. 3-10.)*

SUPPRESSION AND VISUAL DEVELOPMENT

Suppression is an important clinical problem in children with strabismus. One eye will be deviated, causing the two foveas to receive different images. The initial perception will be diplopia and confusion. The visual system cannot tolerate this. Usually the eye with the larger refractive error or poorer quality retinal image is suppressed. If suppression continues for a long time in a developing visual system, this can become permanent. It will hinder the normal visual development and lead to amblyopia, a condition in which the visual cortex does not develop normal visual acuity. We will discuss strabismus and amblyopia in greater detail later.

In some cases of strabismus, the refractive error may be similar in the two eyes, so neither image is better than the other. In that case, it is difficult for the visual system to give preference to one eye or the other. The developing visual system may solve the rivalry problem by alternately suppressing either eye. Children who develop alternation usually do not develop amblyopia; each eye develops normal visual acuity. However, since the visual system does not learn to fuse the two images, binocular sensory fusion and binocular visual functions such as stereopsis never develop.

Q Would a person with alternating suppression be able to appreciate the Pulfrich phenomenon?

If a person with strabismus has good visual acuity in both eyes, you can assume that he/she has learned to alternately suppress. Figure 29.10 summarizes the ways that visual system may process two retinal images.

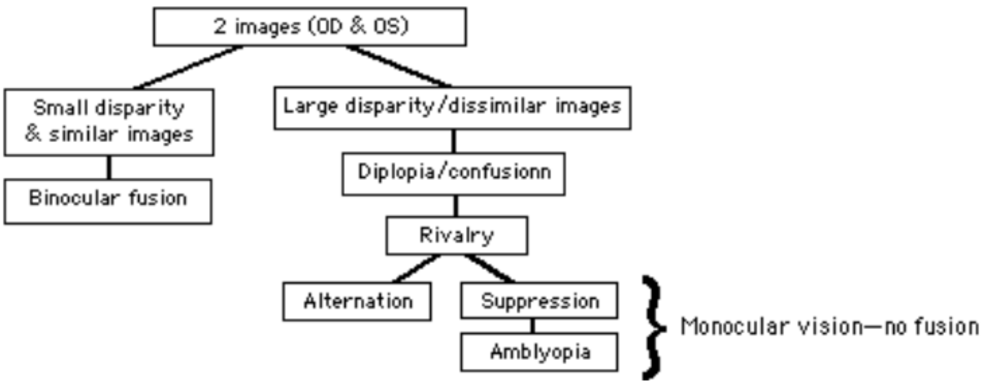

Figure 29.10 *The different ways disparate retinal images may be managed by the developing visual system.*

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