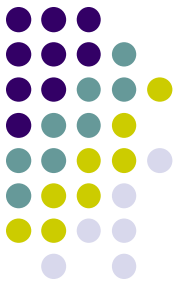
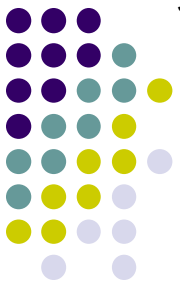


Sensory Adaptations to Strabismus

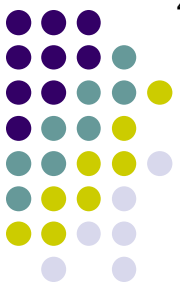
*Hol up...Before we start talking about sensory adaptations to strabismus, let's review the basic principles of **binocular vision***



- With respect to abnormalities of binocular vision: What is the difference between *visual confusion* and *diplopia*?

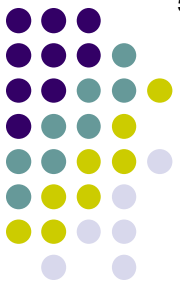


- With respect to abnormalities of binocular vision: What is the difference between **visual confusion** and *diplopia*?
 - *Confusion* occurs when...

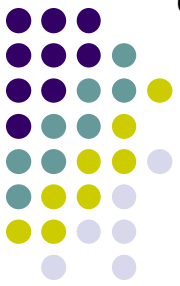


- With respect to abnormalities of binocular vision: What is the difference between **visual confusion** and *diplopia*?
- *Confusion* occurs when...*different* images are projected onto **corresponding** retinal areas

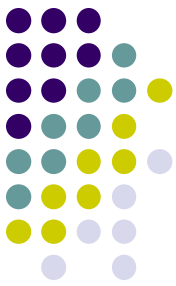
(We'll unpack the notion of 'corresponding retinal areas' shortly)



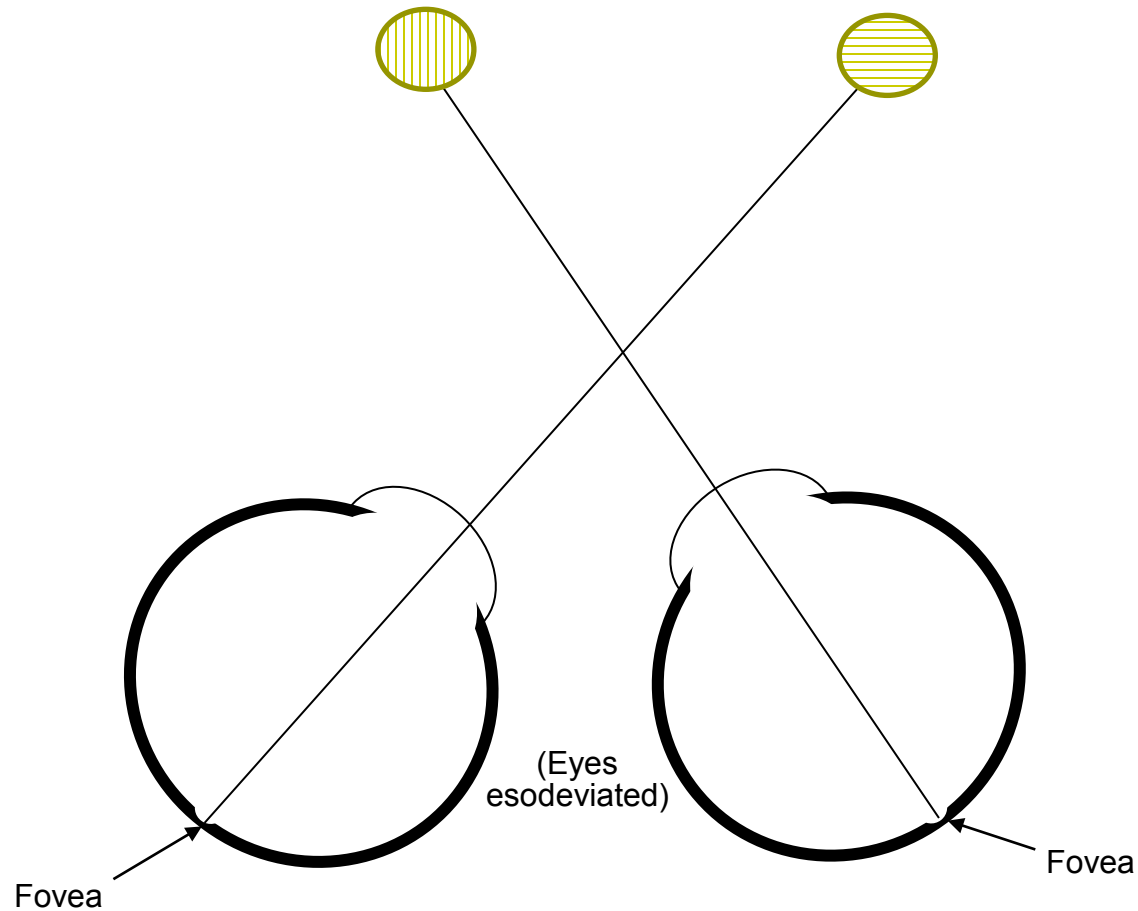
- With respect to abnormalities of binocular vision: What is the difference between **visual confusion** and *diplopia*?
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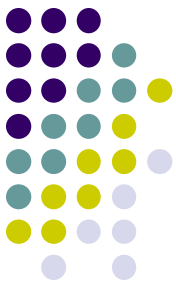
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 - *Confusion* occurs when...*different* images are projected onto **corresponding** retinal areas
 - Visual confusion produces the visual impression of...*two* objects occupying a **single** location in visual space



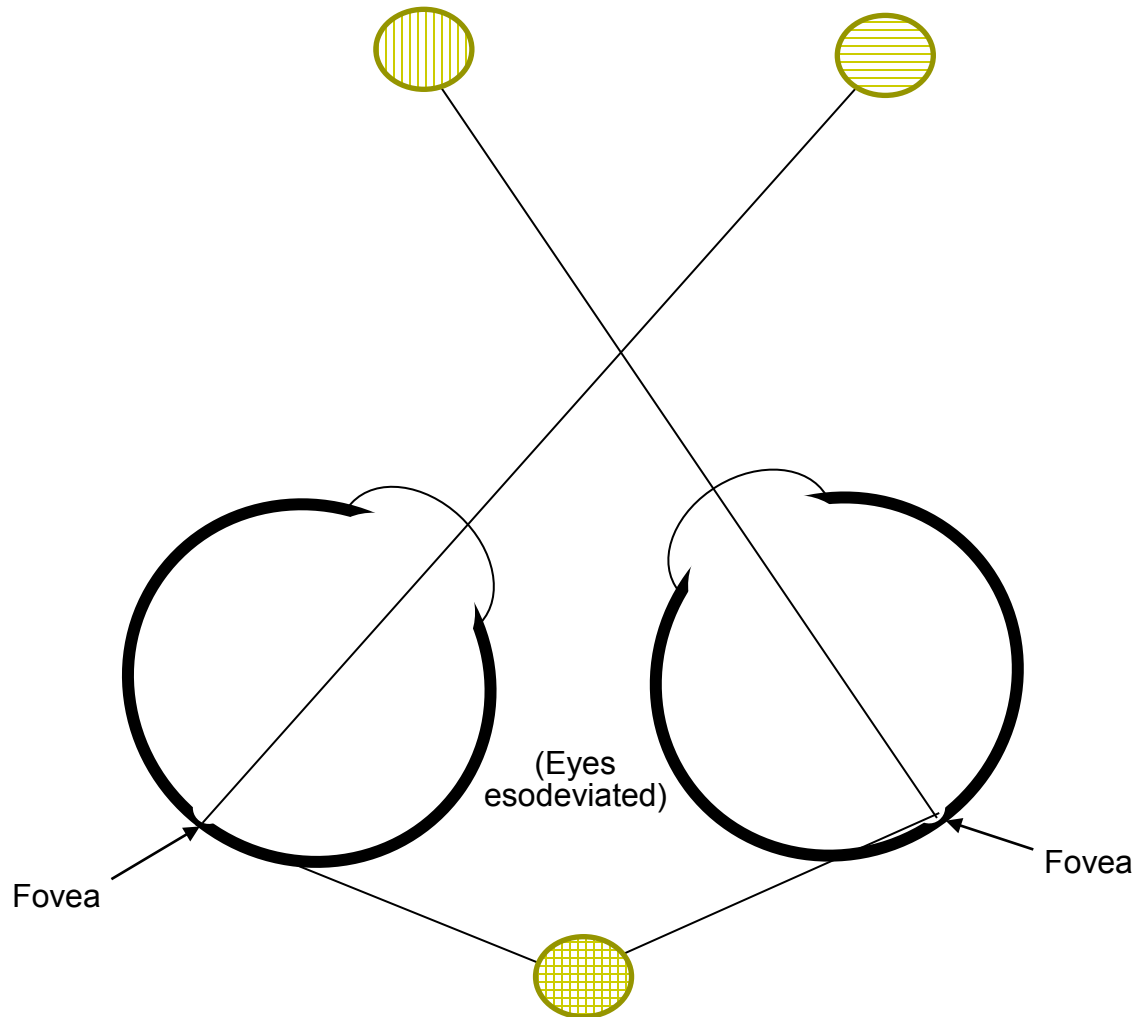
Sensory Adaptations to Strabismus



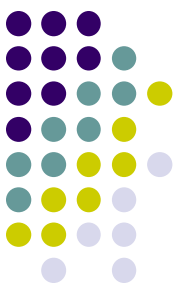
These misaligned eyes are foveating different objects, and thus each is projecting a different image to the visual cortex as being the object of regard.



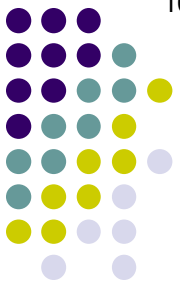
Sensory Adaptations to Strabismus



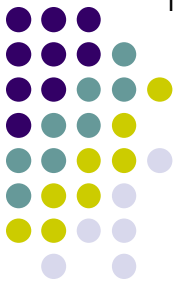
These misaligned eyes are foveating different objects, and thus each is projecting a different image to the visual cortex as being the object of regard. *If the brain deal with this conundrum by creating a percept of the two objects occupying the same space, this would constitute visual confusion.*



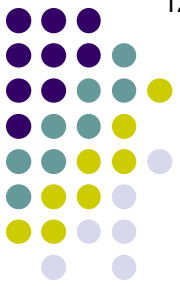
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 - Visual confusion produces the visual impression of...
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 - **Diplopia** occurs when...



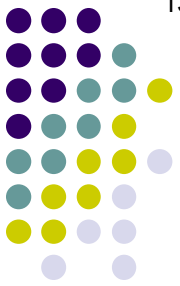
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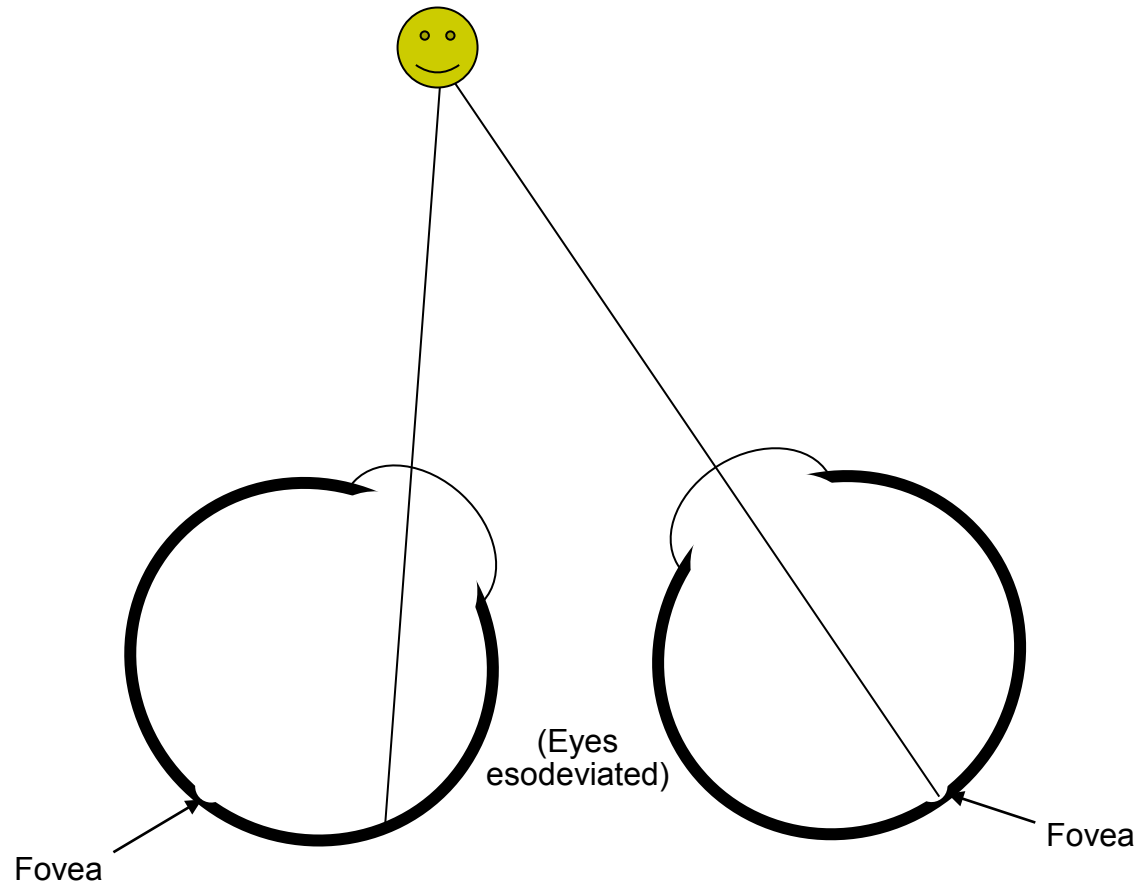
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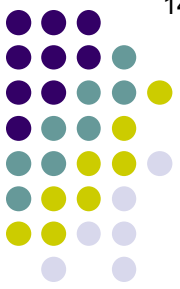
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a single object occupying **two** locations in visual space



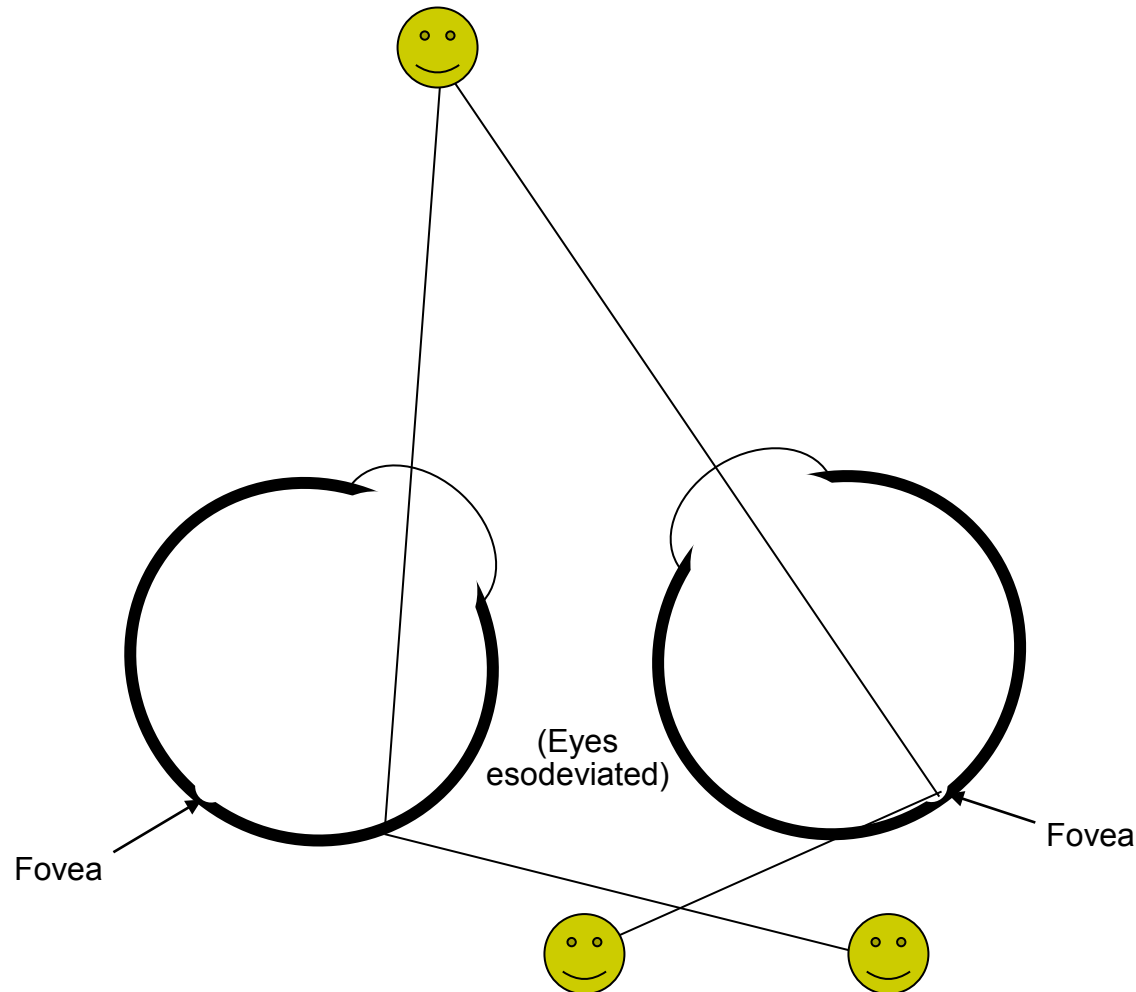
Sensory Adaptations to Strabismus



In these misaligned eyes, the image of a single object is being projected to noncorresponding areas of the retinas.



Sensory Adaptations to Strabismus



In these misaligned eyes, the image of a single object is being projected to noncorresponding areas of the retinas. **If the brain interprets this situation by creating a percept of this one object occupying two separate locations in space, this would constitute diplopia.**

- What does it mean to say retinal locations in the two eyes *correspond*?



- What does it mean to say retinal locations in the two eyes *correspond*? It means the two locations have the same

words 1 and 2 of 3

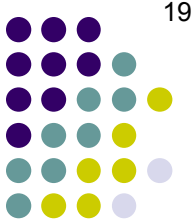
word 3 of 3



- What does it mean to say retinal locations in the two eyes *correspond*? It means the two locations have the same **subjective visual direction**.

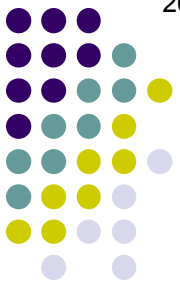


- What does it mean to say retinal locations in the two eyes *correspond*? It means the two locations have the same **subjective visual direction**.
 - If all corresponding retinal areas in the two eyes are symmetrically located (i.e., are the same retinal distances and directions from their respective foveas), the two retinas are said to be in words 1 and 2 of 3 word 3 of 3 (abbreviation of prev 3 words).



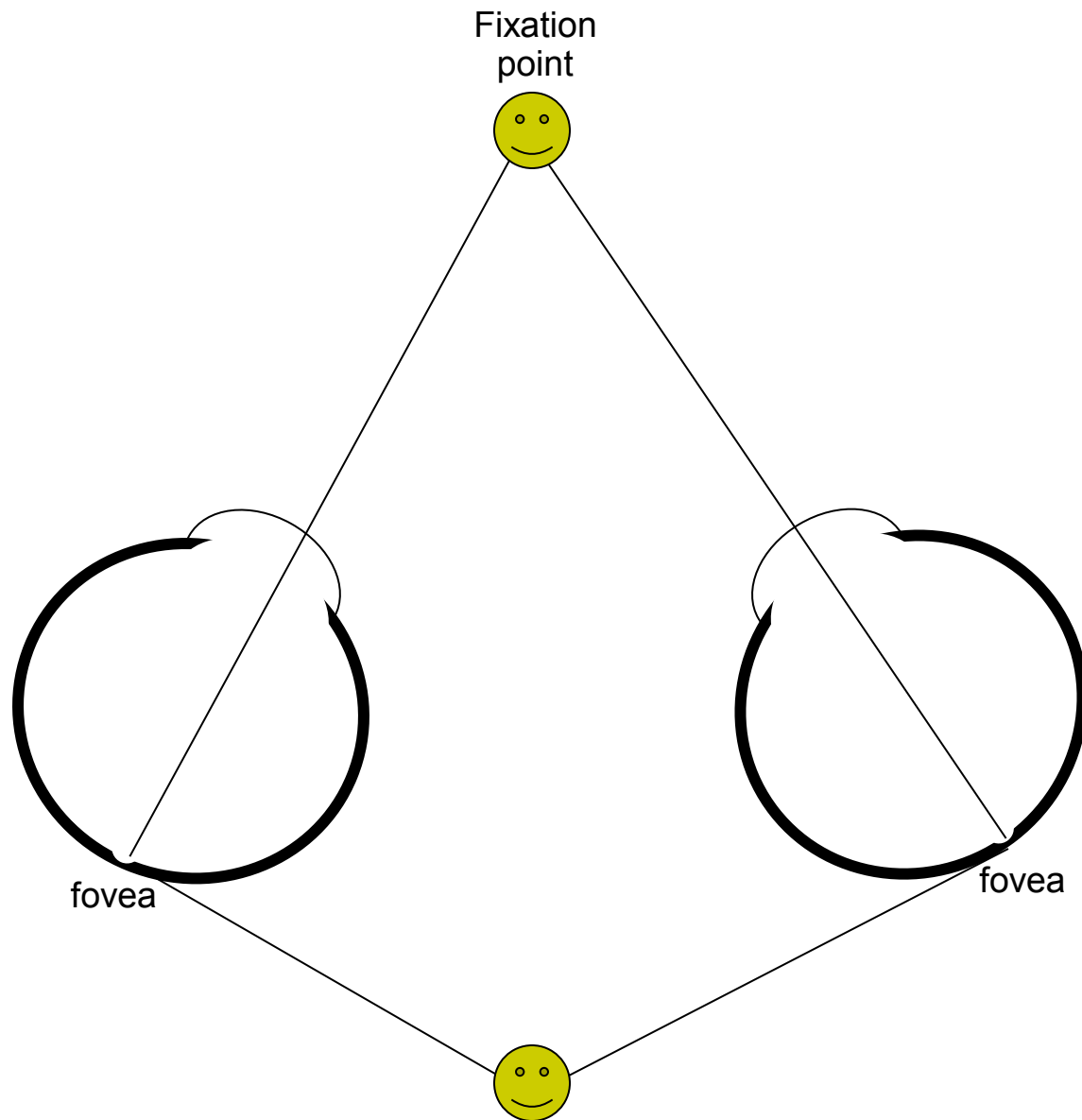
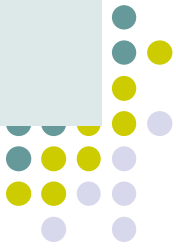
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 - If all corresponding retinal areas in the two eyes are symmetrically located (i.e., are the same retinal distances and directions from their respective foveas), the two retinas are said to be in **normal retinal correspondence** (**NRC**).

Sensory Adaptations to Strabismus

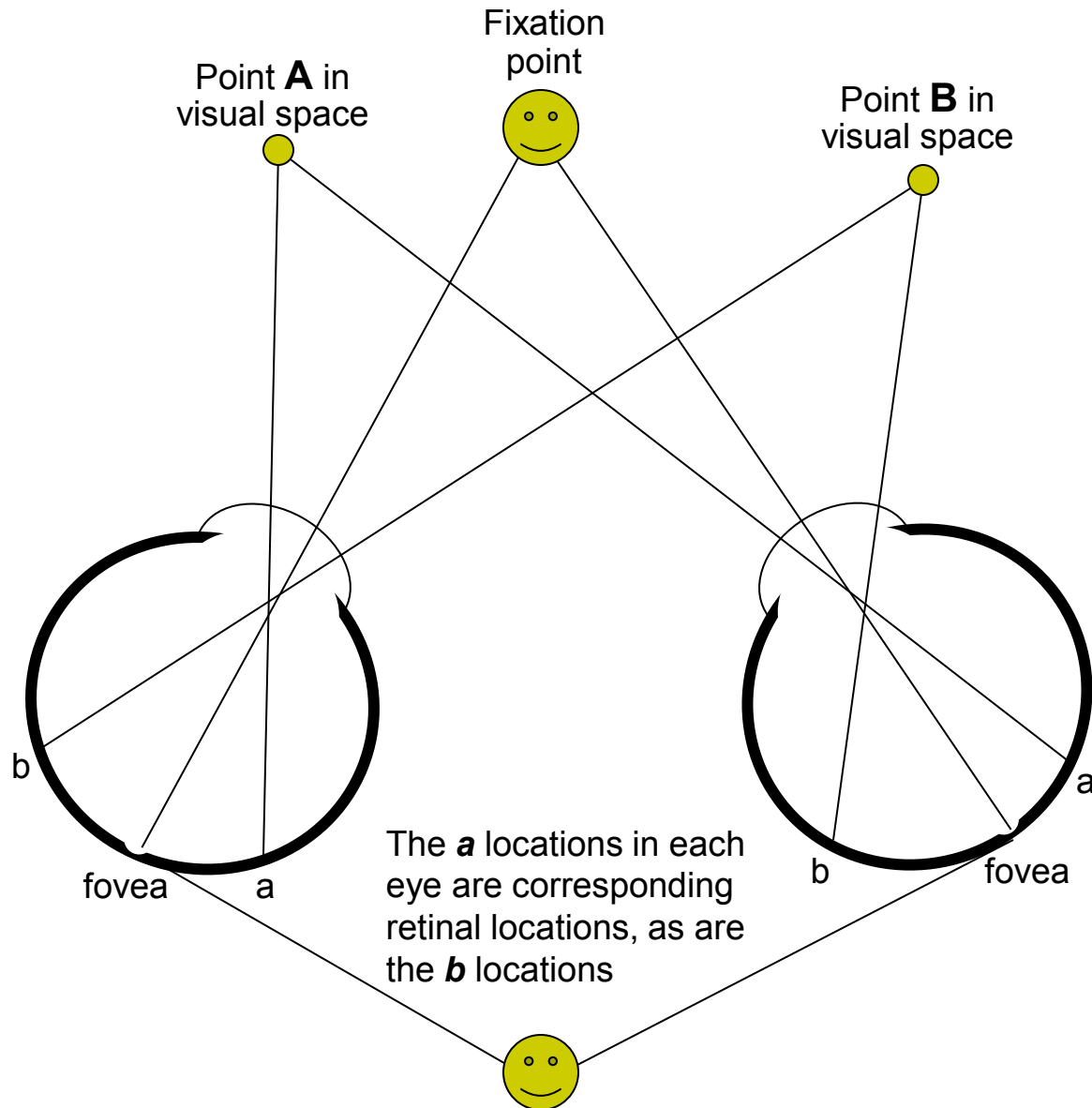


*Continuing on with our review of the principles underlying binocular vision, let's look at those related to **stereopsis***

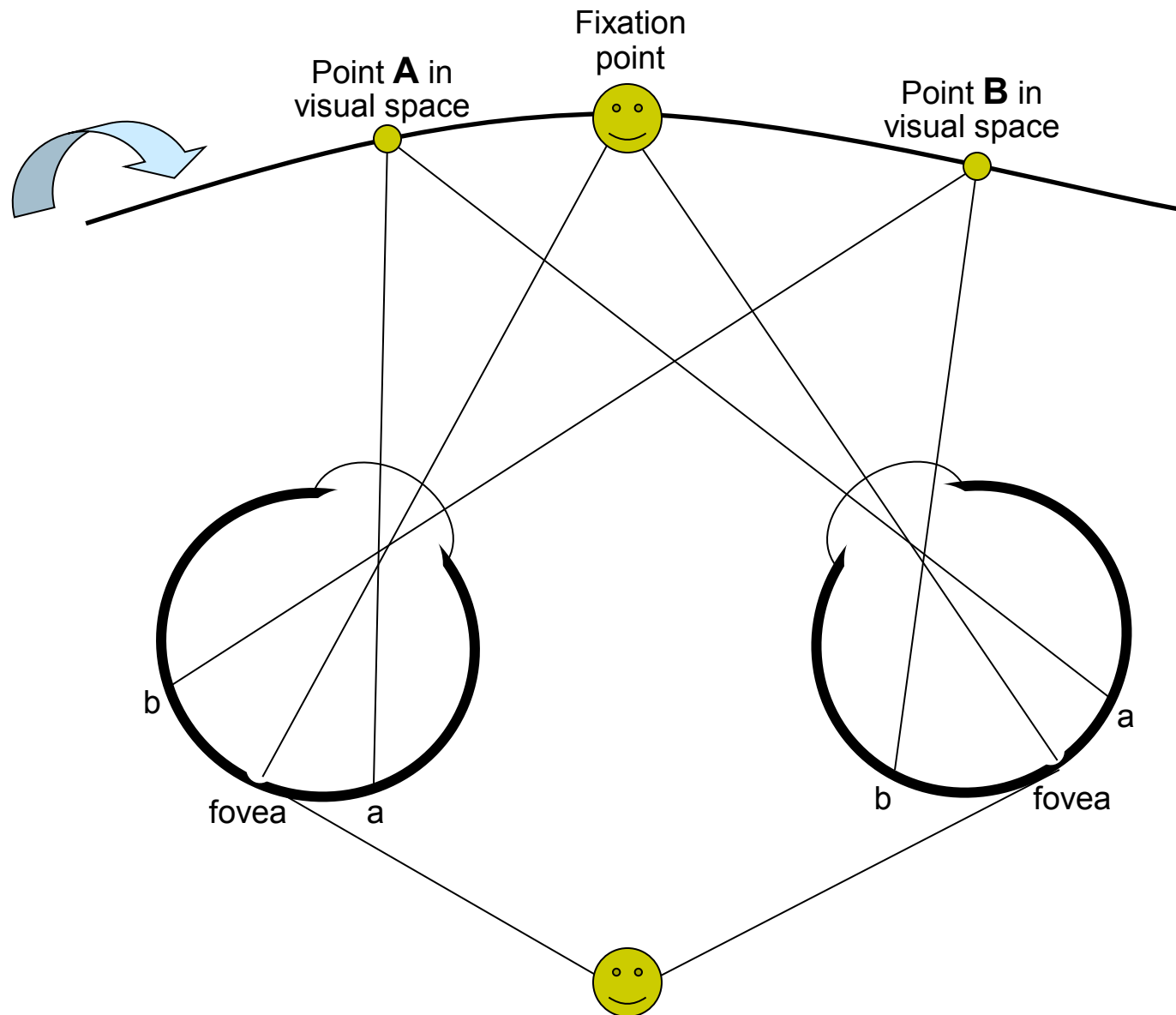
Assume this person has NRC.

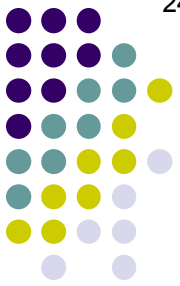


Assume this person has NRC. For a given fixation point, we can identify a set of points in visual space that stimulate corresponding retinal areas.



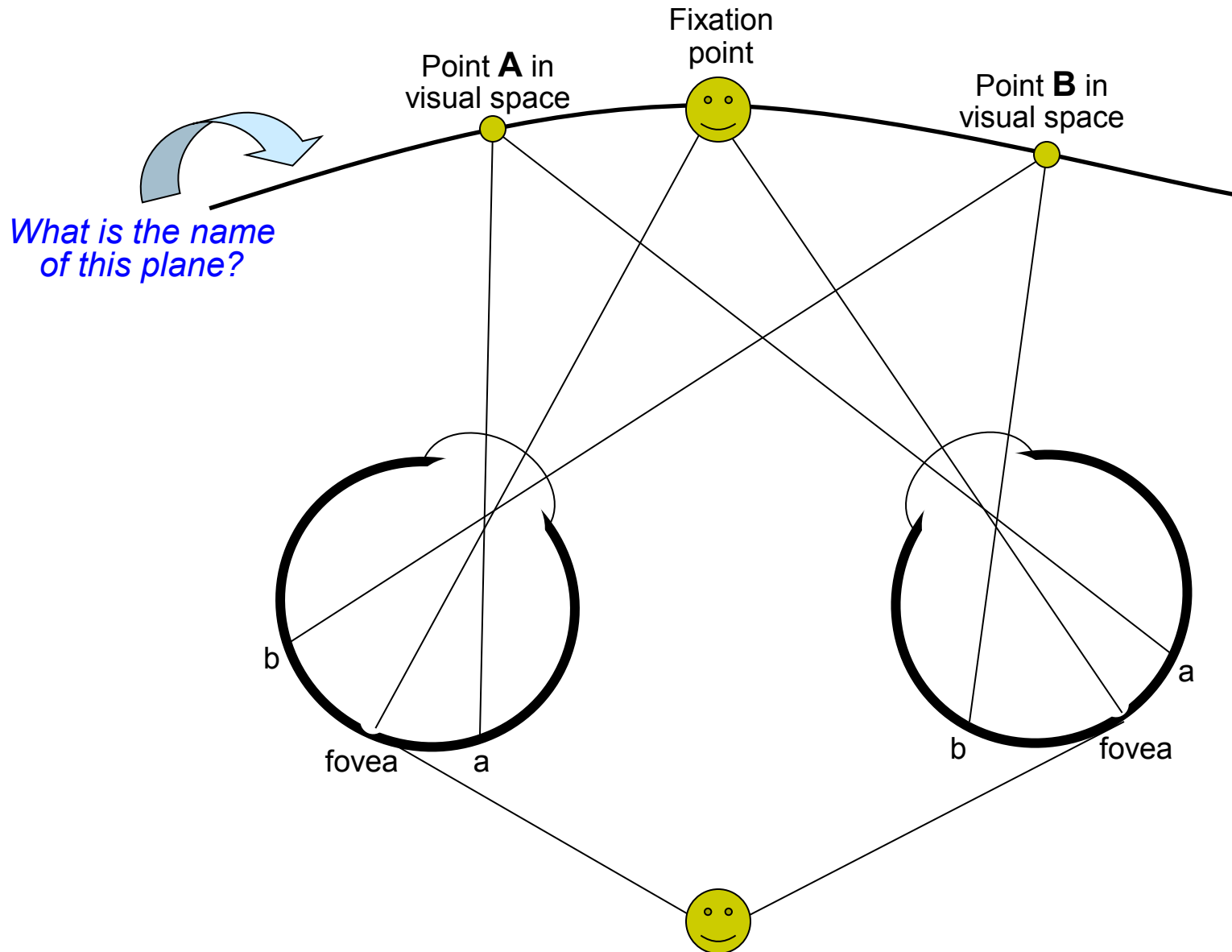
Assume this person has NRC. For a given fixation point, we can identify a set of points in visual space that stimulate corresponding retinal areas. If we mapped them out, we would find these points form a curved plane in front of the pt.

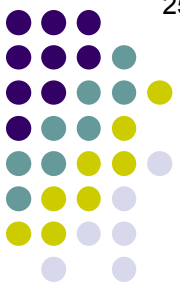




Q

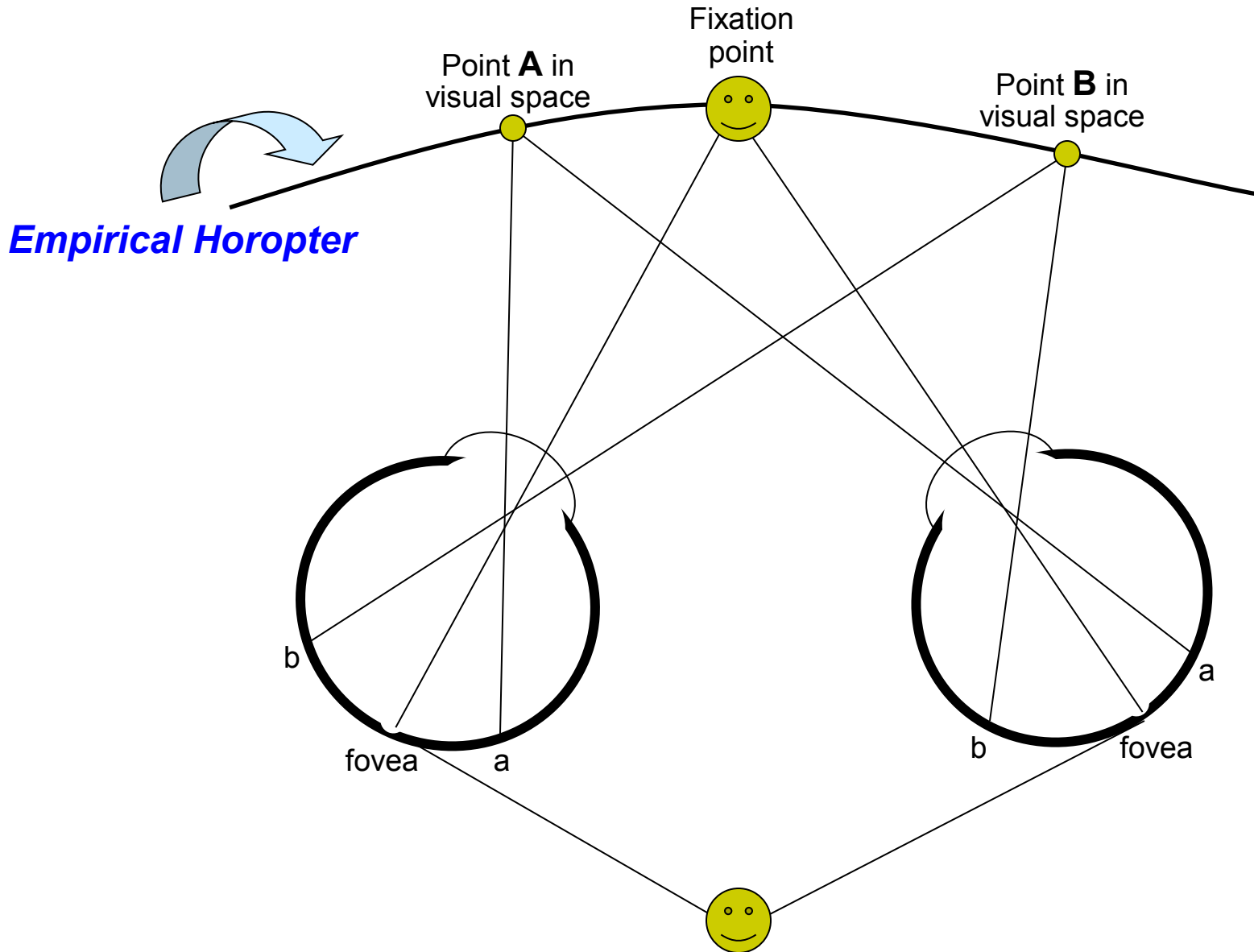
Sensory Adaptations to Strabismus

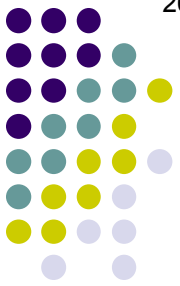




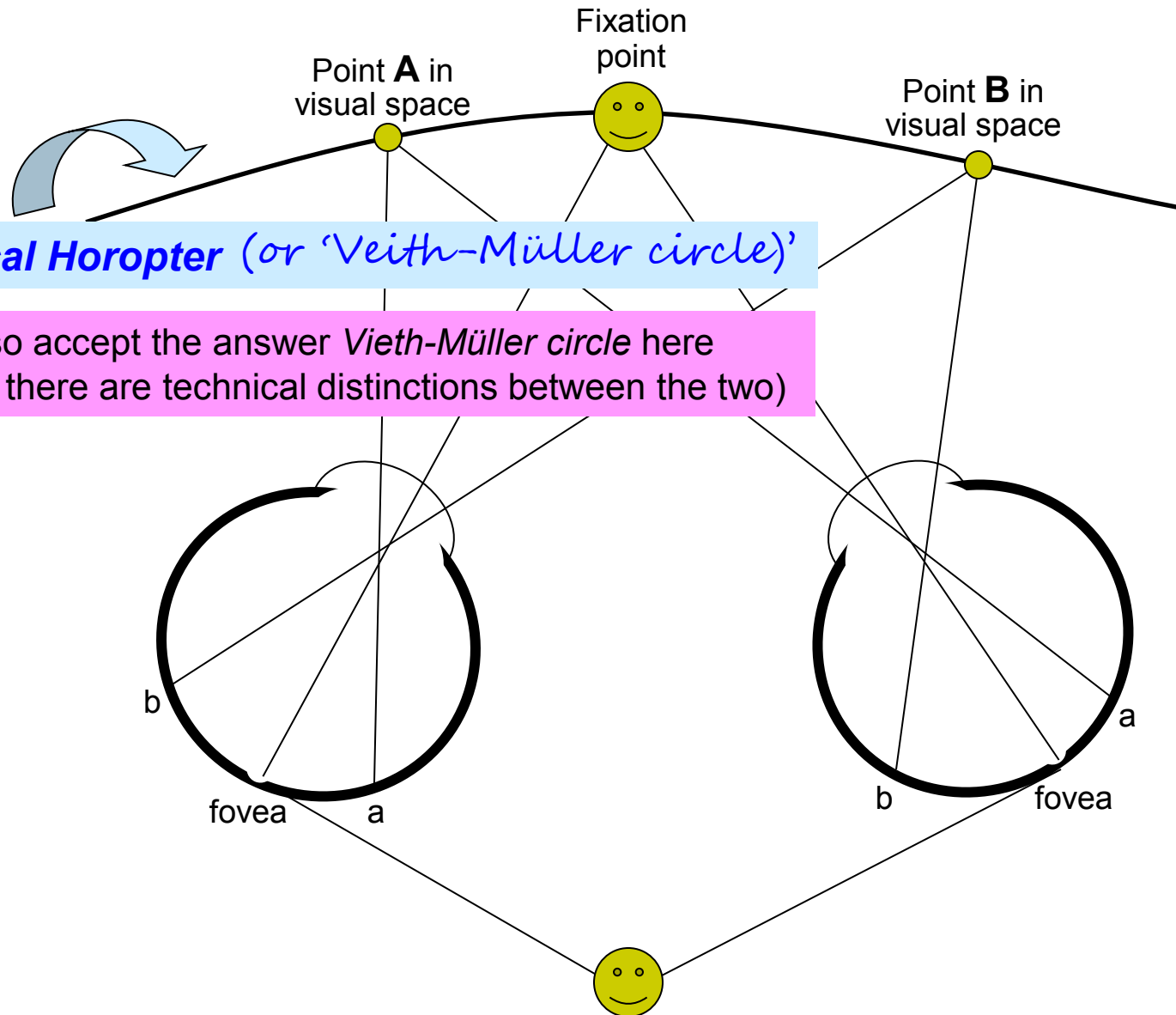
A

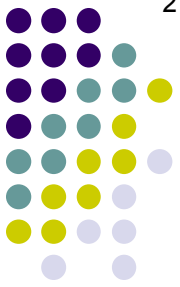
Sensory Adaptations to Strabismus





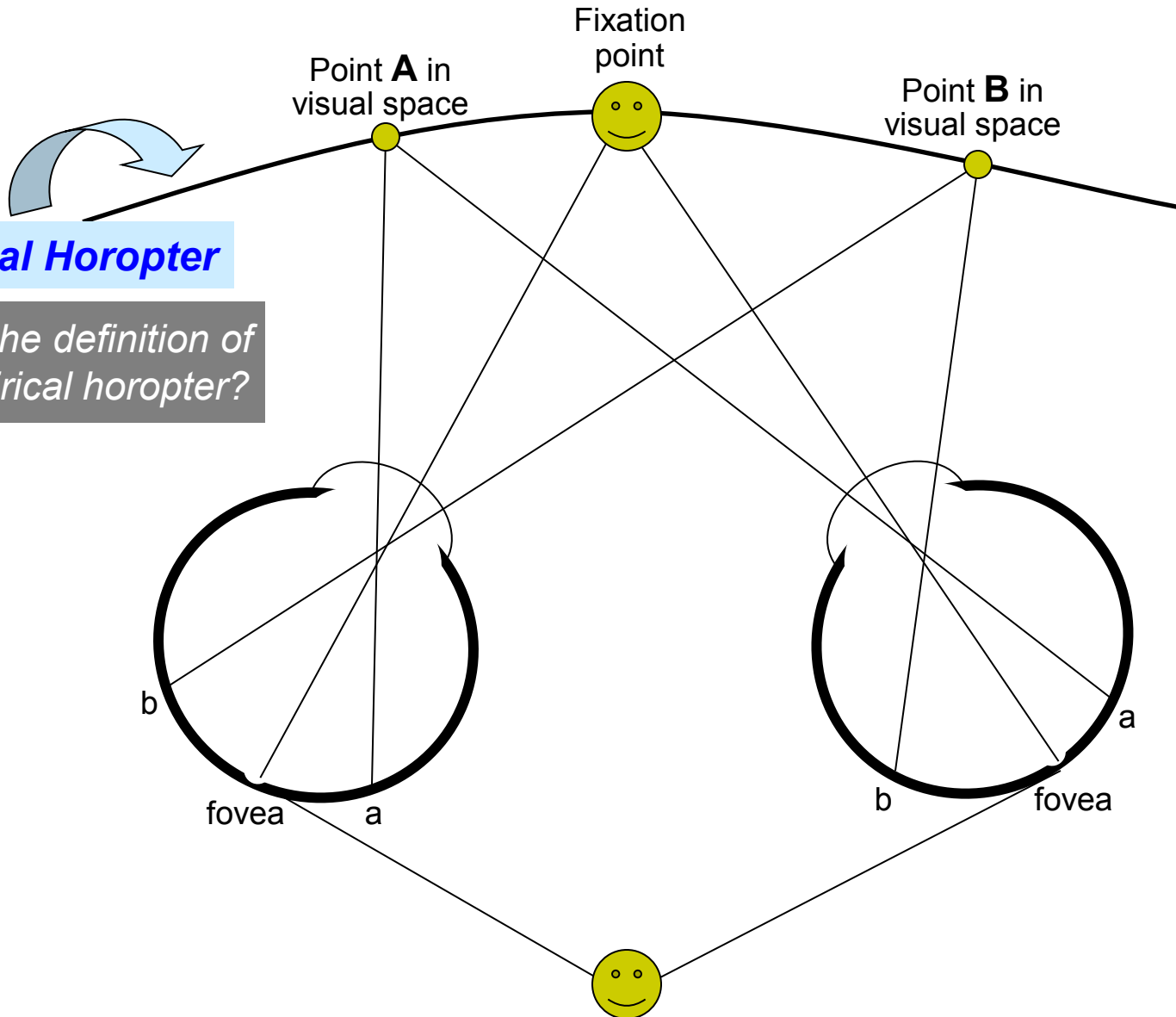
Sensory Adaptations to Strabismus





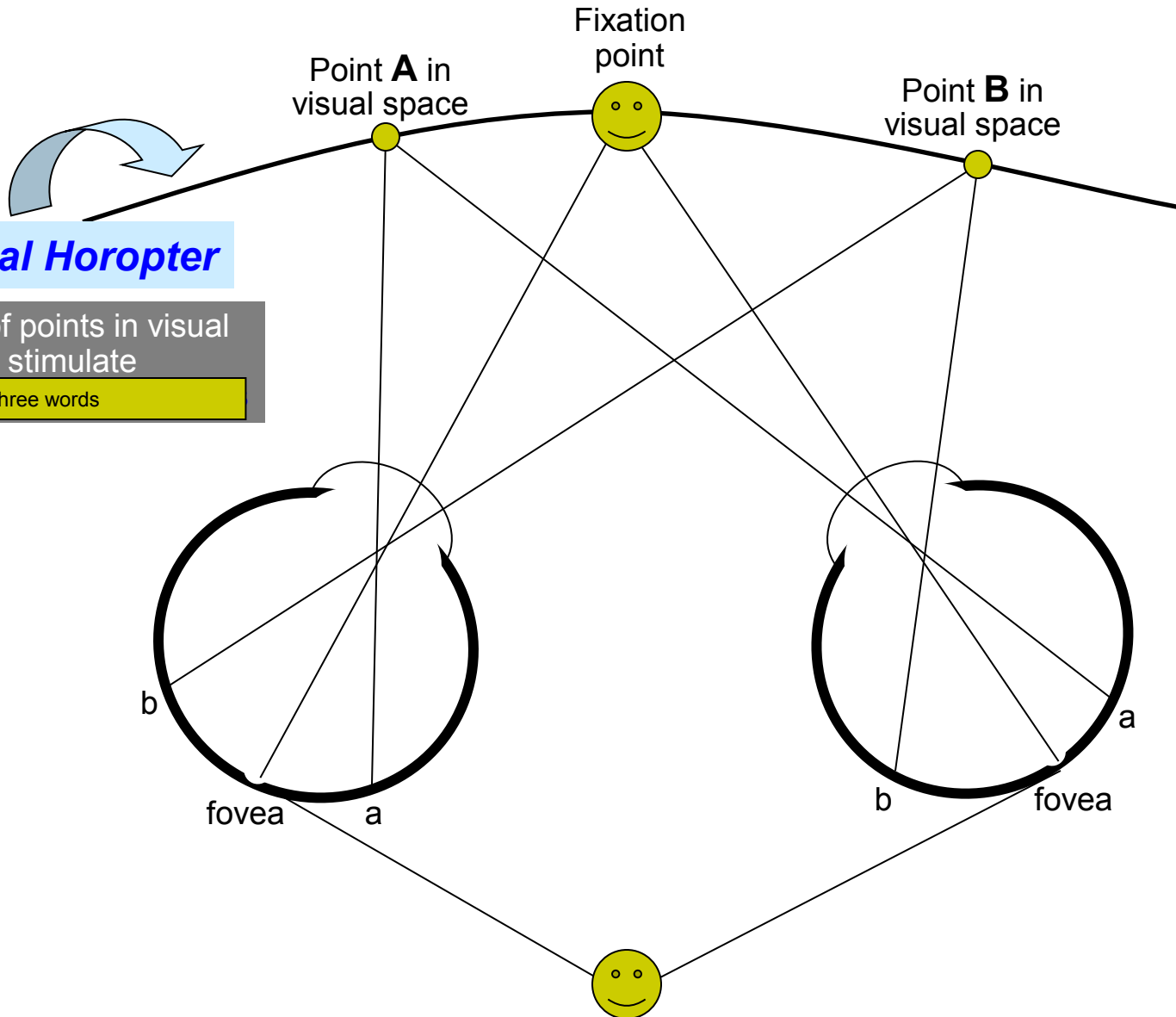
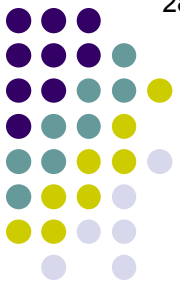
Q

Sensory Adaptations to Strabismus



Empirical Horopter

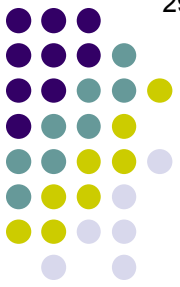
What is the definition of the empirical horopter?



Empirical Horopter

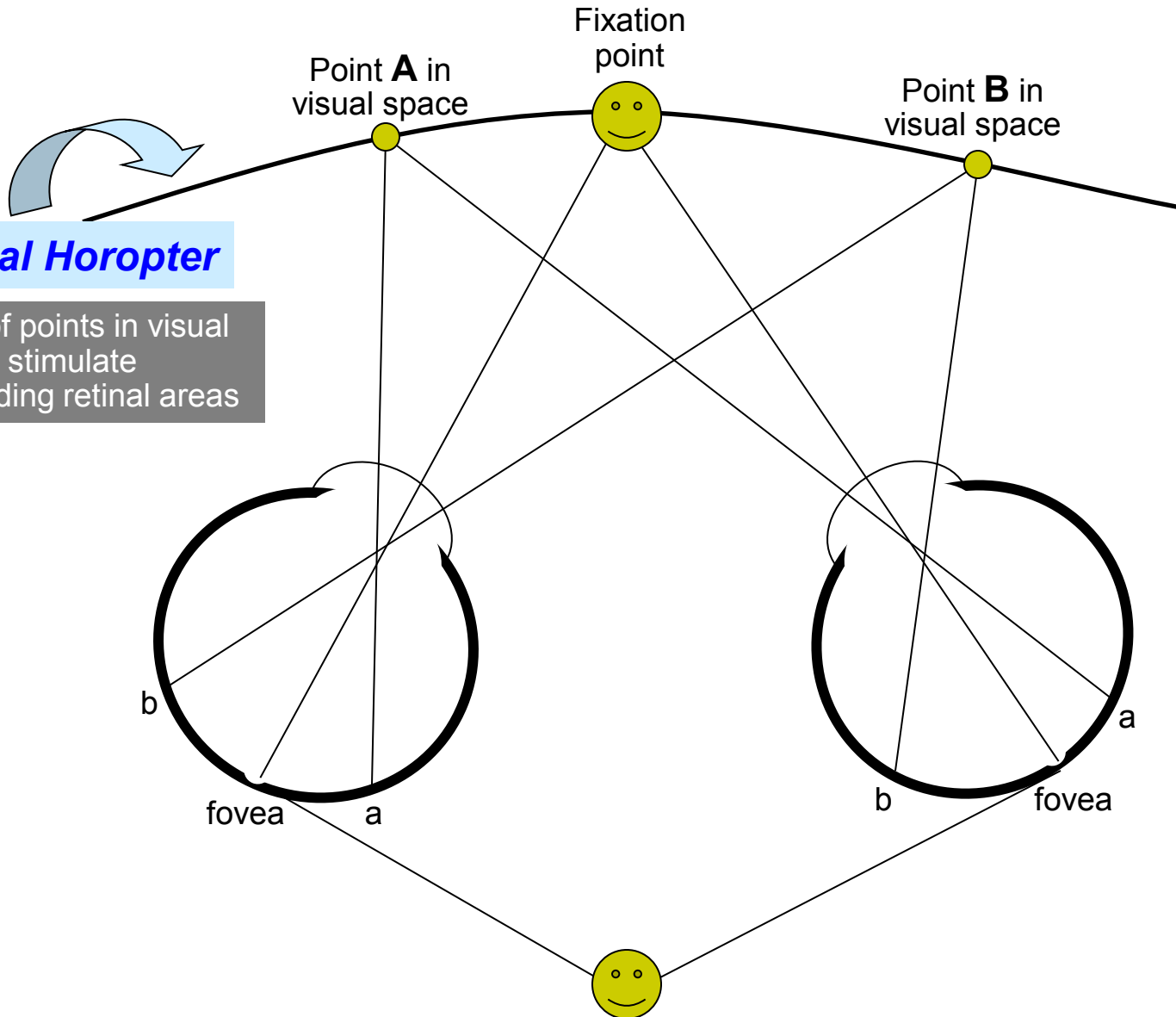
= the set of points in visual space that stimulate

three words



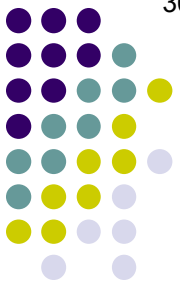
A

Sensory Adaptations to Strabismus



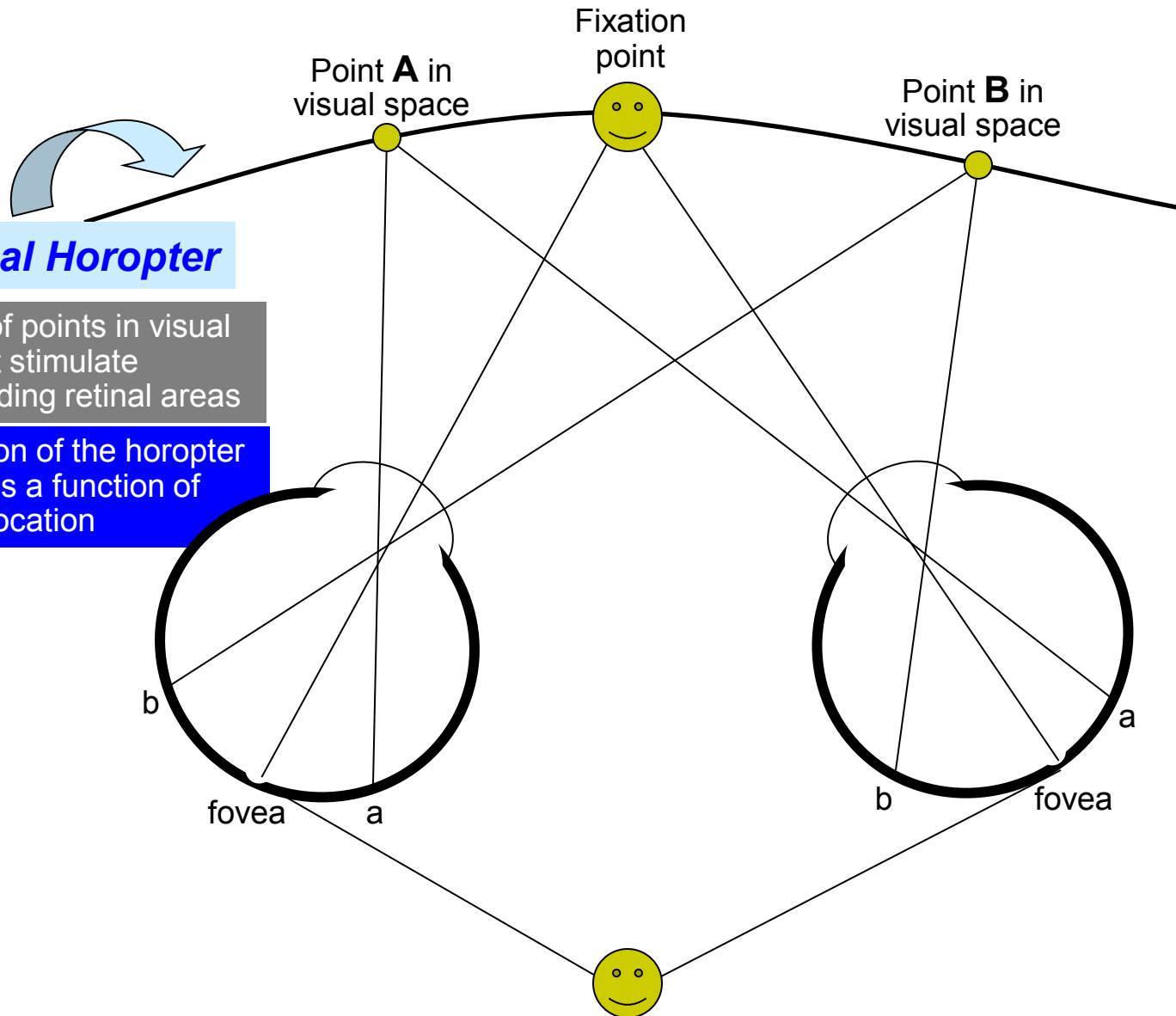
Empirical Horopter

= the set of points in visual space that stimulate corresponding retinal areas



Q

Sensory Adaptations to Strabismus



Empirical Horopter

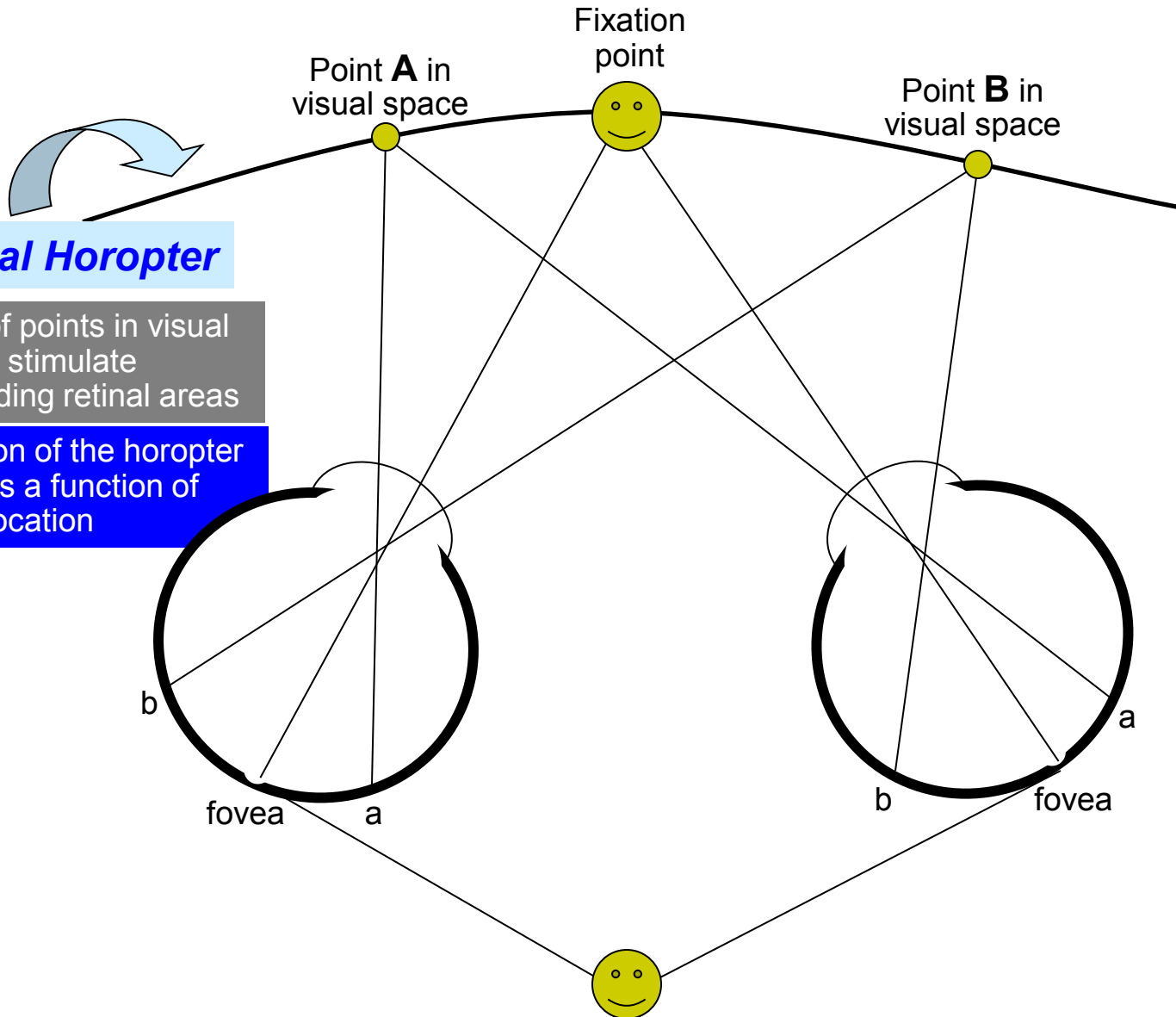
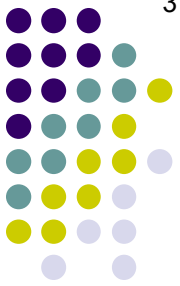
= the set of points in visual space that stimulate corresponding retinal areas

The location of the horopter changes as a function of location

A

Sensory Adaptations to Strabismus

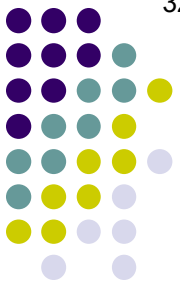
31



Empirical Horopter

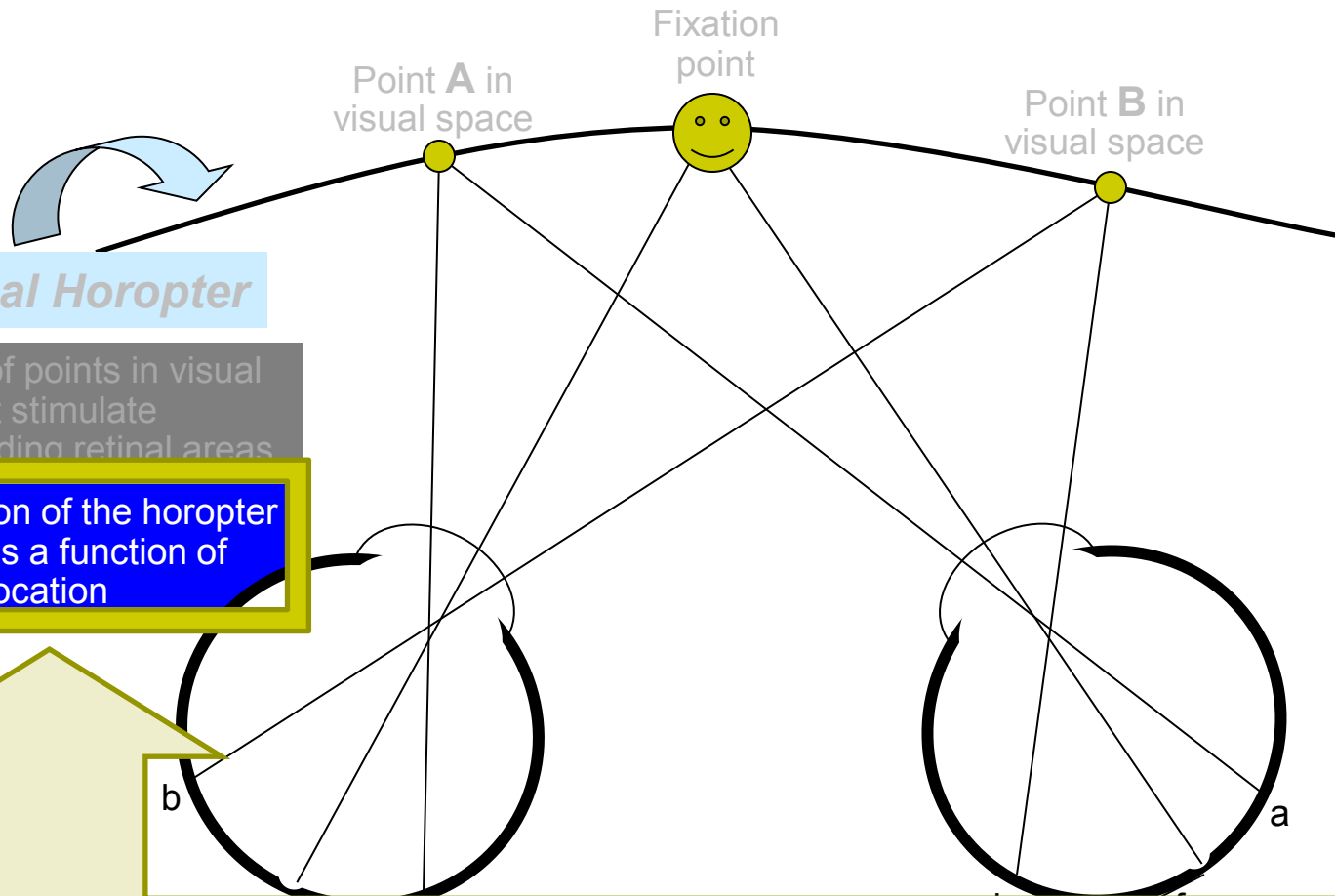
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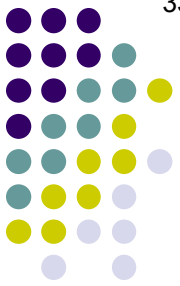
The location of the horopter changes as a function of **fixation** location



A

Sensory Adaptations to Strabismus

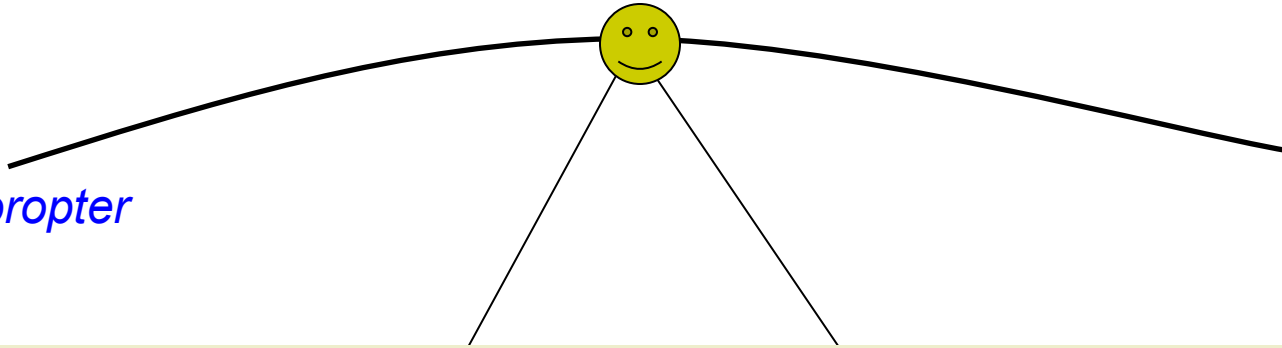




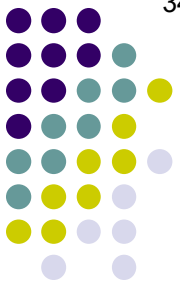
Q

Sensory Adaptations to Strabismus

Empirical Horopter

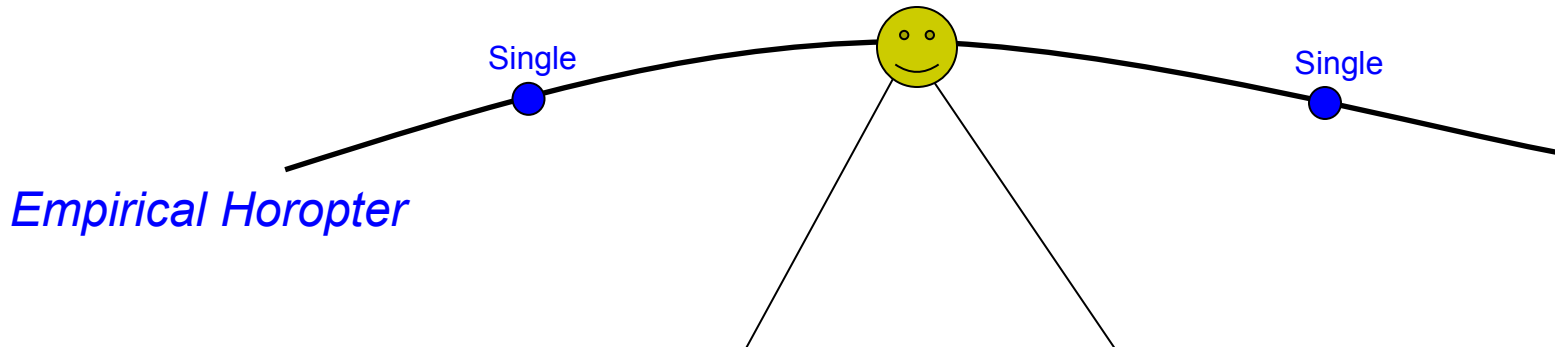


What is the significance of the empirical horopter?



A

Sensory Adaptations to Strabismus



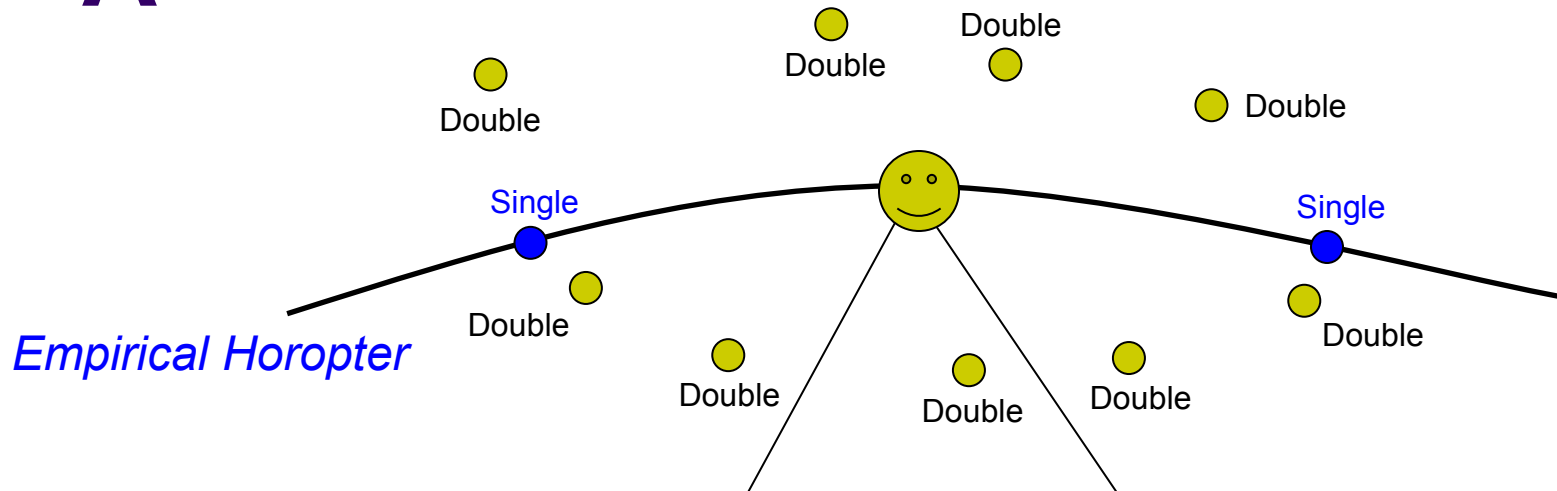
Empirical Horopter

What is the significance of the empirical horopter?

In order to project to corresponding locations on the two retinas, points in visual space must lie on the empirical horopter. Because rays from these points stimulate corresponding retinal locations, the perceptual experience they produce is of a single object at a single location in visual space.

A

Sensory Adaptations to Strabismus



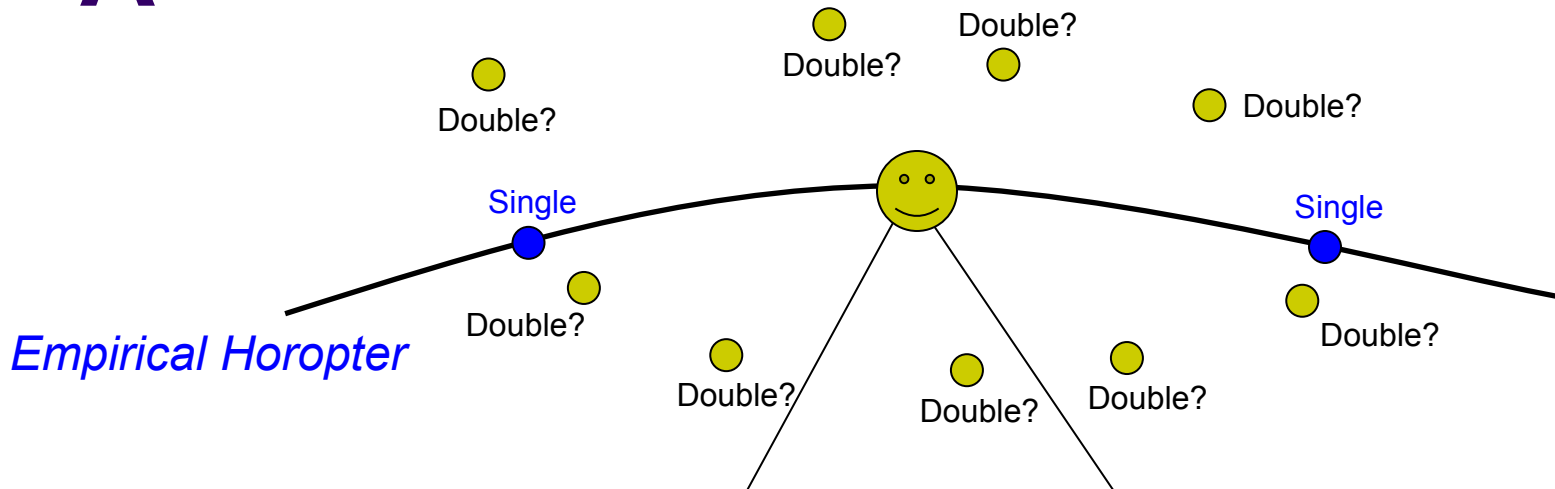
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A

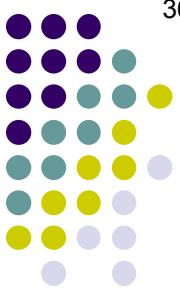
Sensory Adaptations to Strabismus

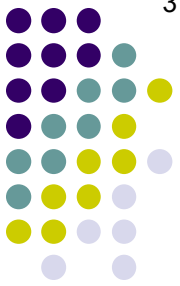


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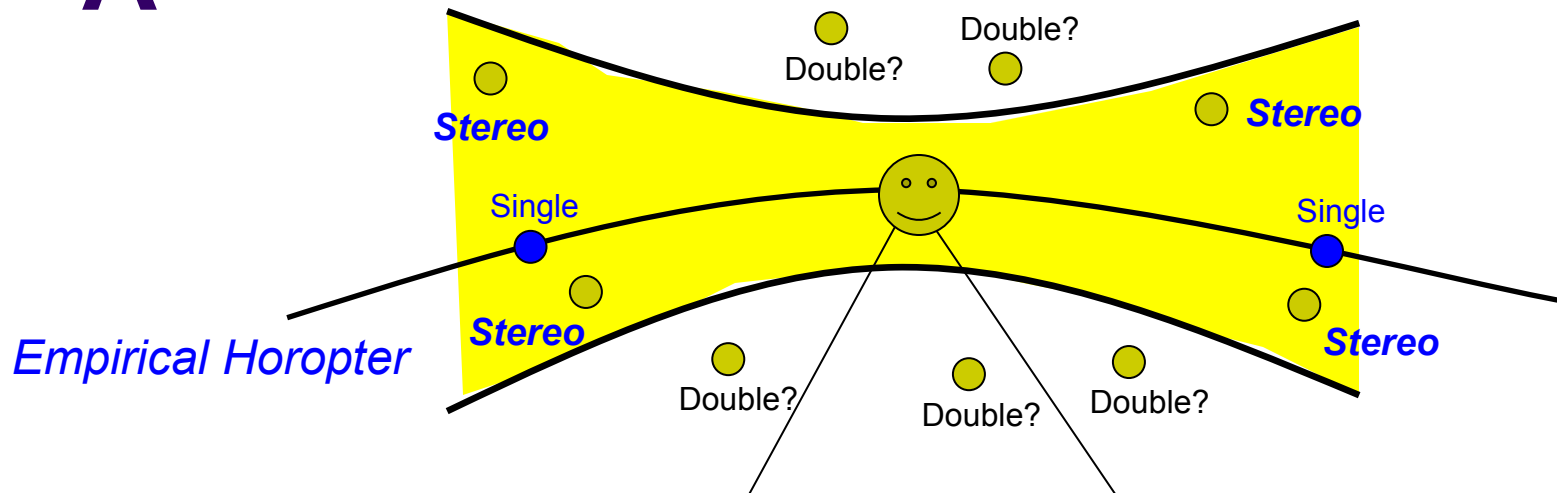
This does **not** occur for all off-horopter locations, however!





A

Sensory Adaptations to Strabismus

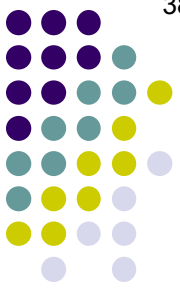


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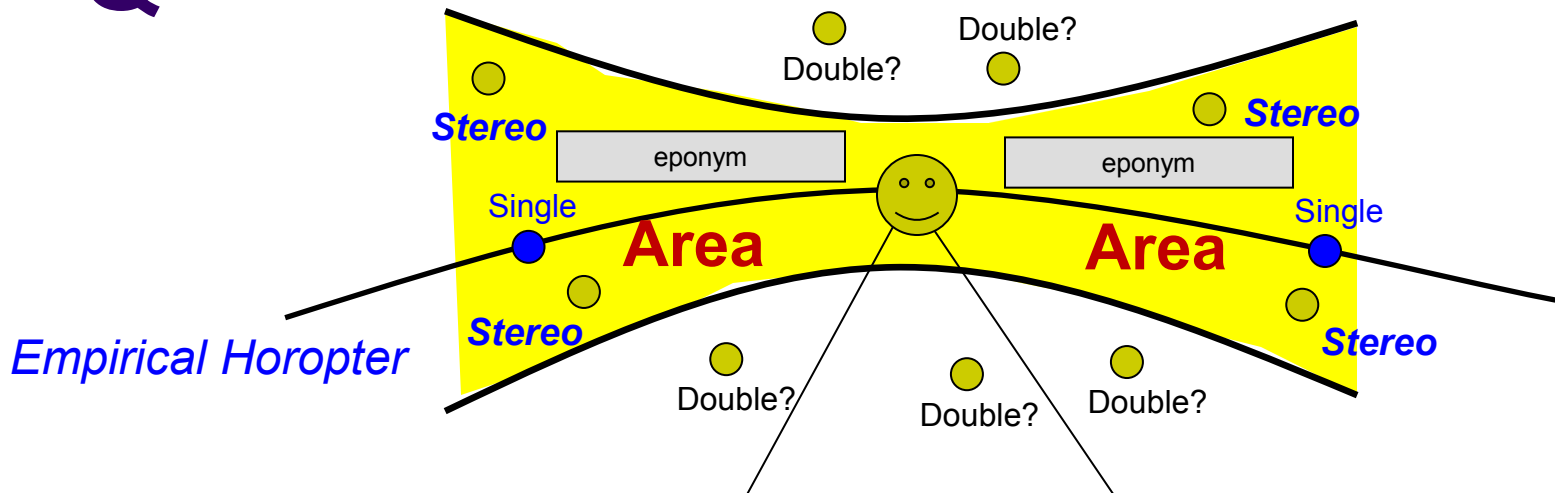
This does **not** occur for all off-horopter locations, however!

There is a set of points around the horopter for which the *slight* retinal noncorrespondence they produce results not in diplopia, but rather an impression of three-dimensionality--that is, **stereopsis**.



Q

Sensory Adaptations to Strabismus



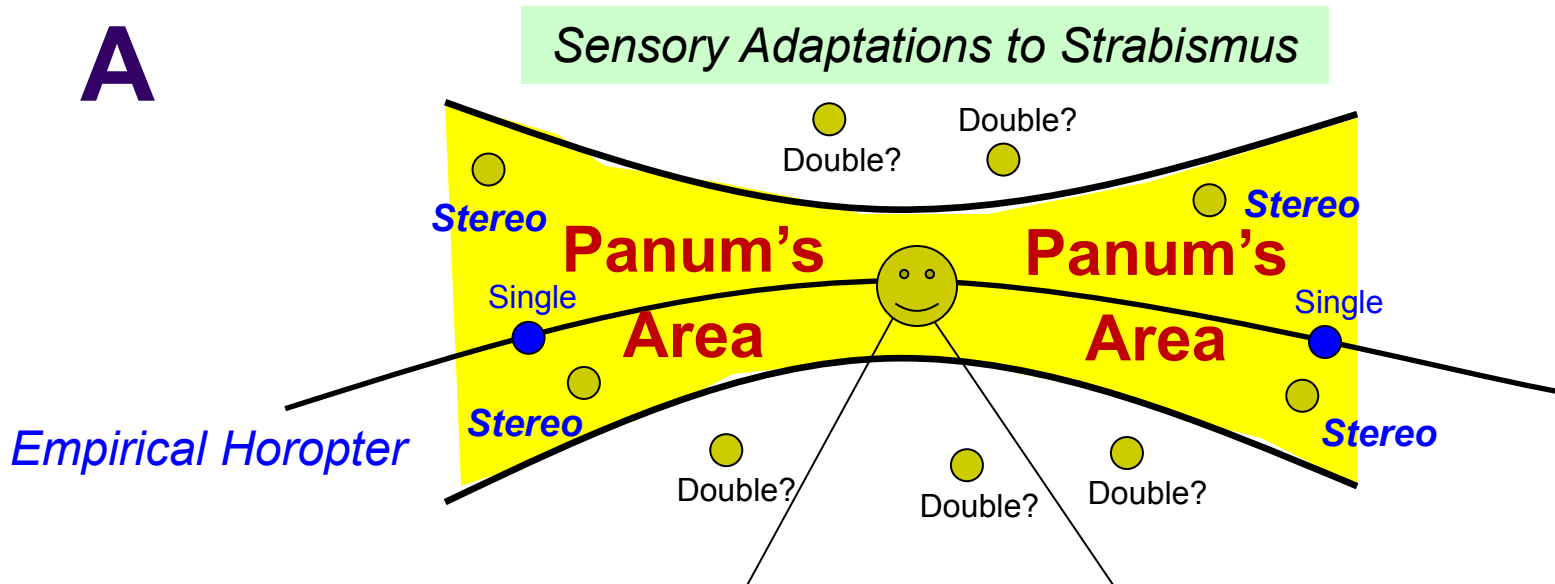
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A



What is the significance of the empirical horopter?

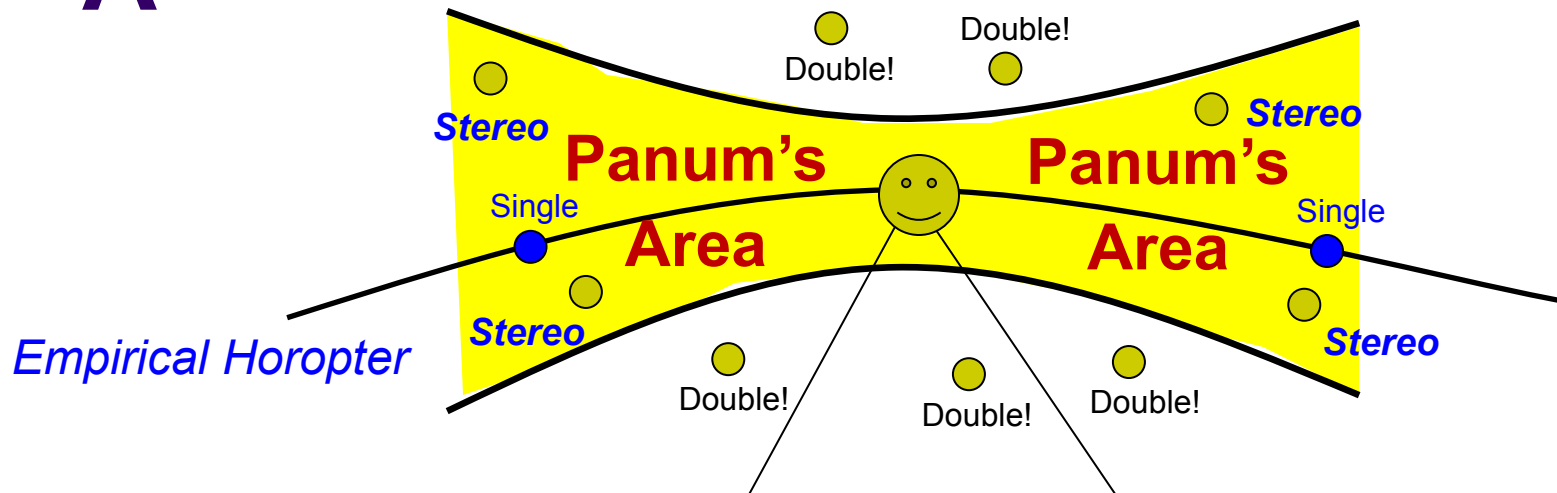
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A

Sensory Adaptations to Strabismus

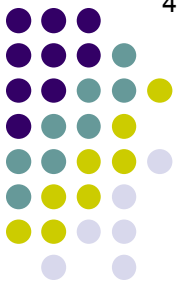


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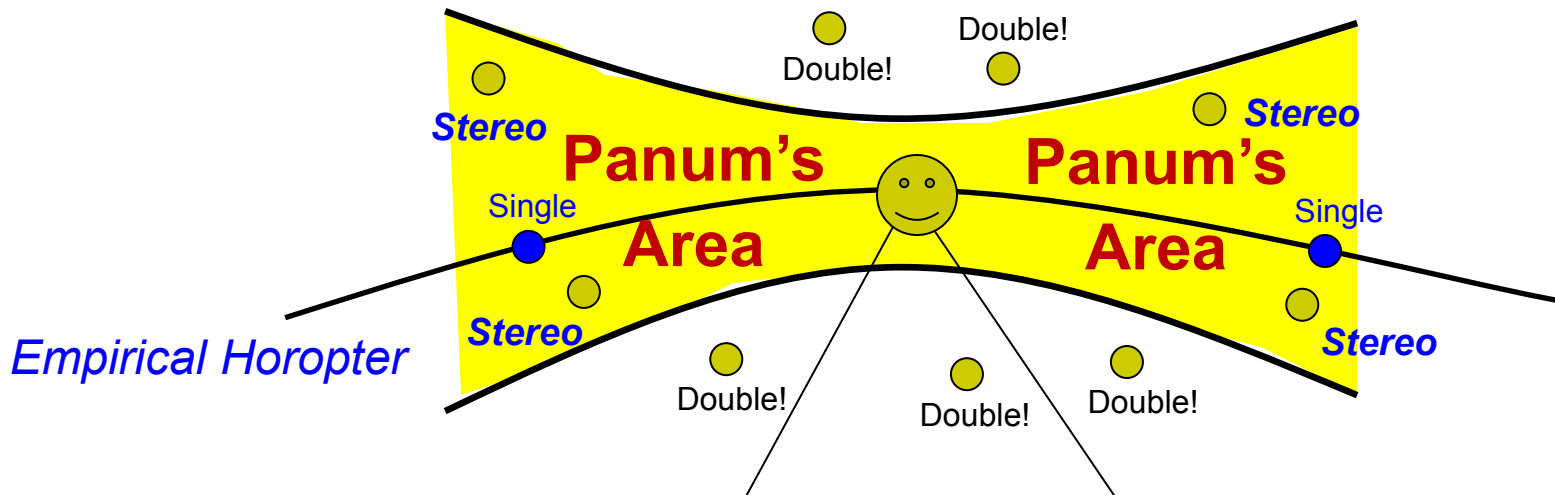
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There is a set of points around the horopter for which the *slight* retinal noncorrespondence they produce results not in diplopia, but rather an impression of three-dimensionality--that is, **stereopsis**. *Taken together, this set of points comprise a space called Panum's area.* Locations in visual space outside of Panum's produce a perceptual experience of *diplopia*, not stereopsis.



Sensory Adaptations to Strabismus



What is the significance of the empirical horopter?

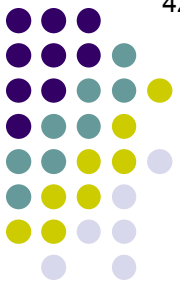
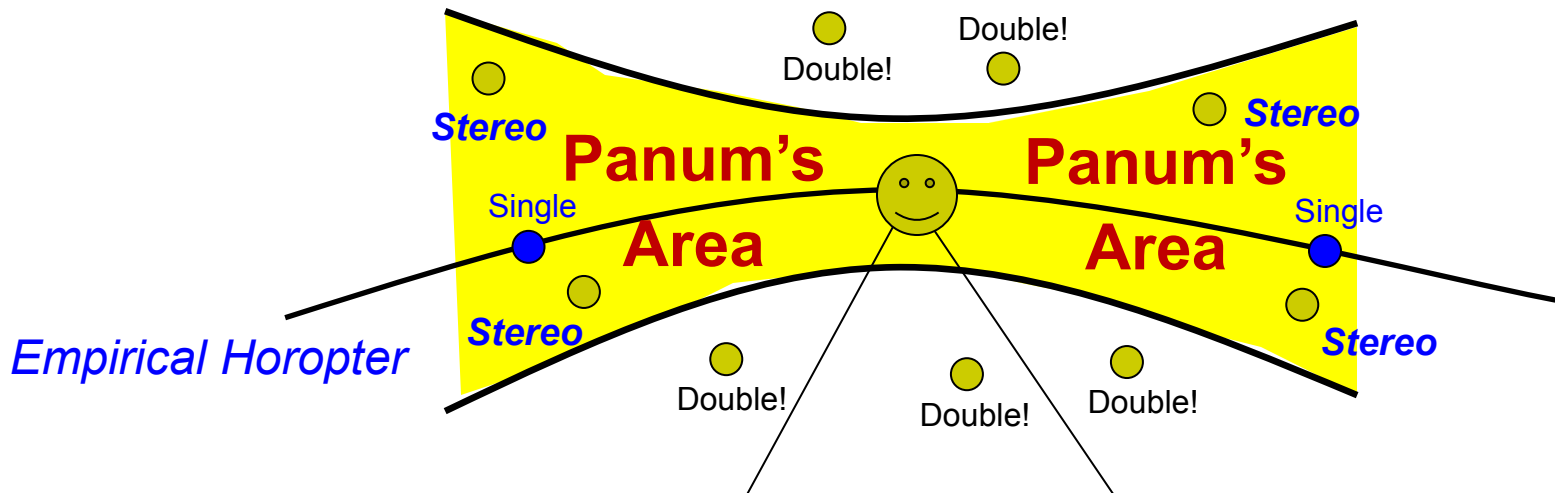
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There is a set of points around the horopter for which the *slight* retinal noncorrespondence they produce results not in diplopia, but rather an impression of three-dimensionality--that is, **stereopsis**. Taken together, this set of points comprise a space called **Panum's area**. Locations in visual space outside of Panum's produce a perceptual experience of *diplopia*, not stereopsis.

TLDR Points in visual space that lie within Panum's area produce an impression of stereopsis; point that lie outside of Panum's area produce diplopia.

Sensory Adaptations to Strabismus



What is the significance of the empirical horopter?

In order to project to corresponding locations on the two retinas, points in visual space must lie on the empirical horopter. Points outside of this area produce a perceptual experience of diplopia, not stereopsis.

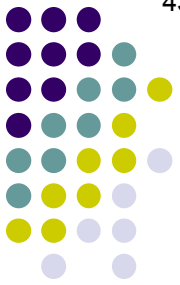
Visualizing Panum's area

Through careful observation, you can demonstrate the existence of Panum's area to yourself. Place yourself in a fairly cluttered environment, ie, give yourself lots of potential visual targets. Pick an object to look at—something 2-3 feet away. While doing so, direct your awareness—not your eyes, your *awareness*—to an object a foot or so closer or farther away, and just off to the side. If you can do this (it's trickier than it sounds), you will find that your visual experience of this not-in-Panum's-area object is diplopic.

Taken together, this set of points comprise a space called **Panum's area**. Locations in visual space outside of Panum's produce a perceptual experience of *diplopia*, not stereopsis.

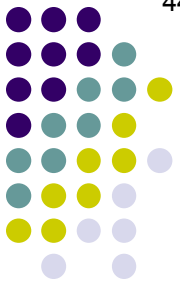
TLDR Points in visual space that lie within Panum's area produce an impression of stereopsis; point that lie outside of Panum's area produce diplopia.

Sensory Adaptations to Strabismus

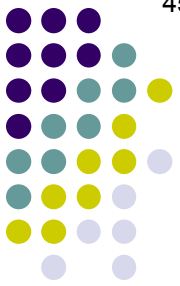


Both visual confusion and diplopia are highly maladaptive if they reach conscious awareness. Unfortunately, ocular misalignment (ie, strabismus) is going to produce both if an individual has NRC and fully-engaged foveas bilaterally.

Sensory Adaptations to Strabismus

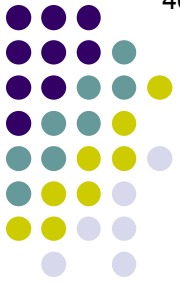


Both visual confusion and diplopia are highly maladaptive if they reach conscious awareness. Unfortunately, ocular misalignment (ie, strabismus) is going to produce both if an individual has NRC and fully-engaged foveas bilaterally. **Fortunately, the visual system has evolved mechanisms for mitigating the visual confusion and diplopia that result from ocular misalignment.**



Sensory Adaptations to Strabismus

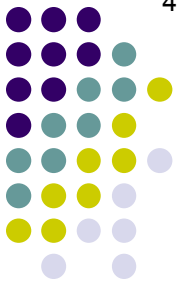
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- What are the three sensory adaptations the visual system employs to avoid confusion and diplopia?

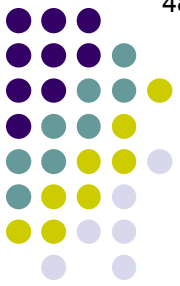


Mnemonic is...



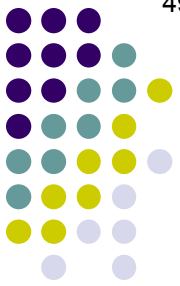
- What are the three sensory adaptations the visual system employs to avoid confusion and diplopia?
 - S
 - A
 - M

Mnemonic is...SAM



- What are the three sensory adaptations the visual system employs to avoid confusion and diplopia?
 - **Suppression**
 - **Anomalous retinal correspondence (ARC)**
 - **Monofixation syndrome**

Mnemonic is...SAM



Sensory Adaptations to Strabismus

- What are the three sensory adaptations the visual system employs to avoid confusion and diplopia?
 - **Suppression**
 - Anomalous retinal correspondence (ARC)
 - Monofixation syndrome

Let's drill down on each adaptation in detail, starting with suppression



Q

Sensory Adaptations to Strabismus: Suppression

- **Sensory adaptations: *Suppression***
- In a nutshell, suppression is...



A

Sensory Adaptations to Strabismus: Suppression

- **Sensory adaptations: *Suppression***
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Q

Sensory Adaptations to Strabismus: Suppression

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Sensory Adaptations to Strabismus: Suppression

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Q

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A

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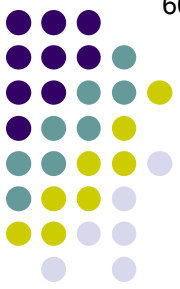
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A

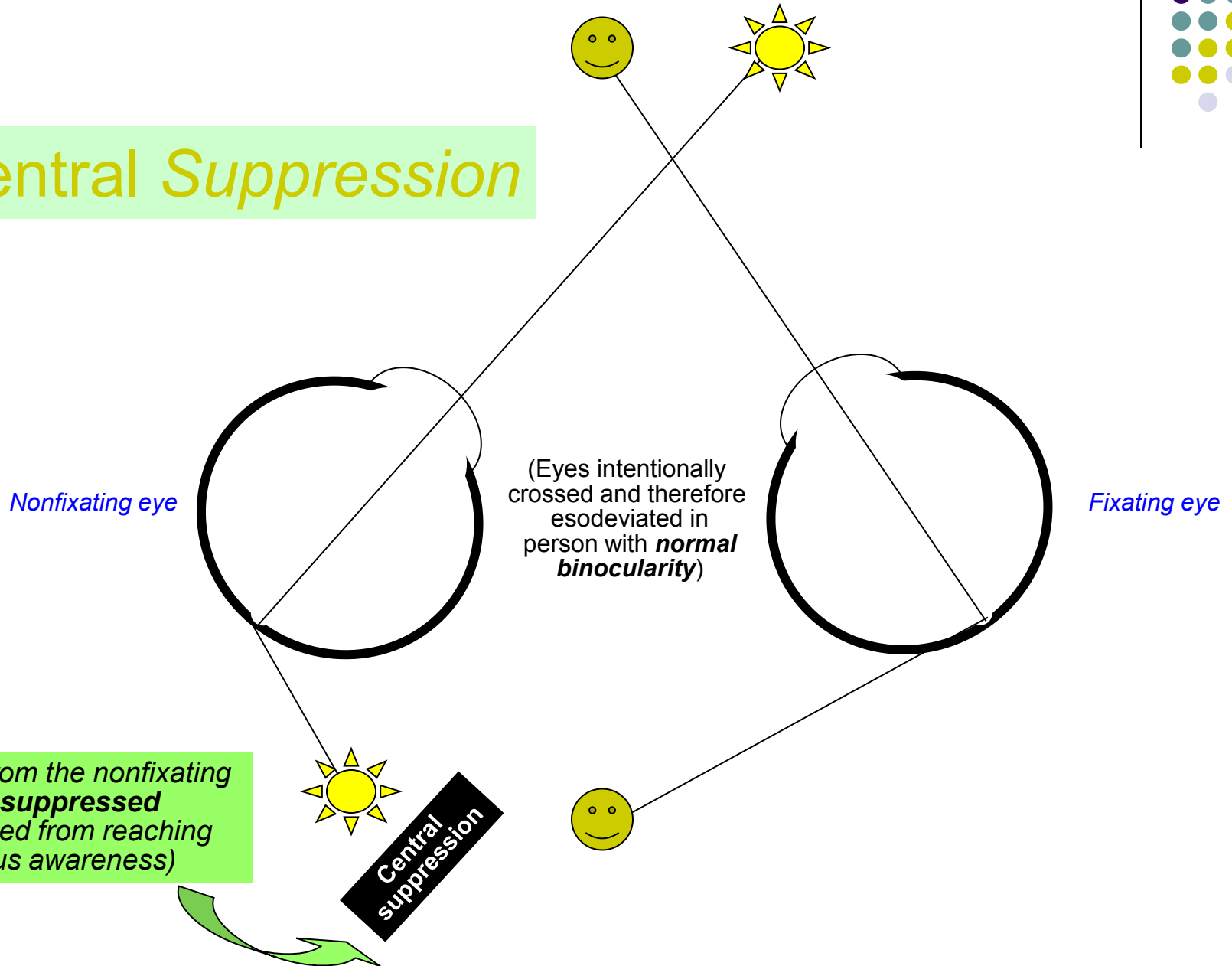
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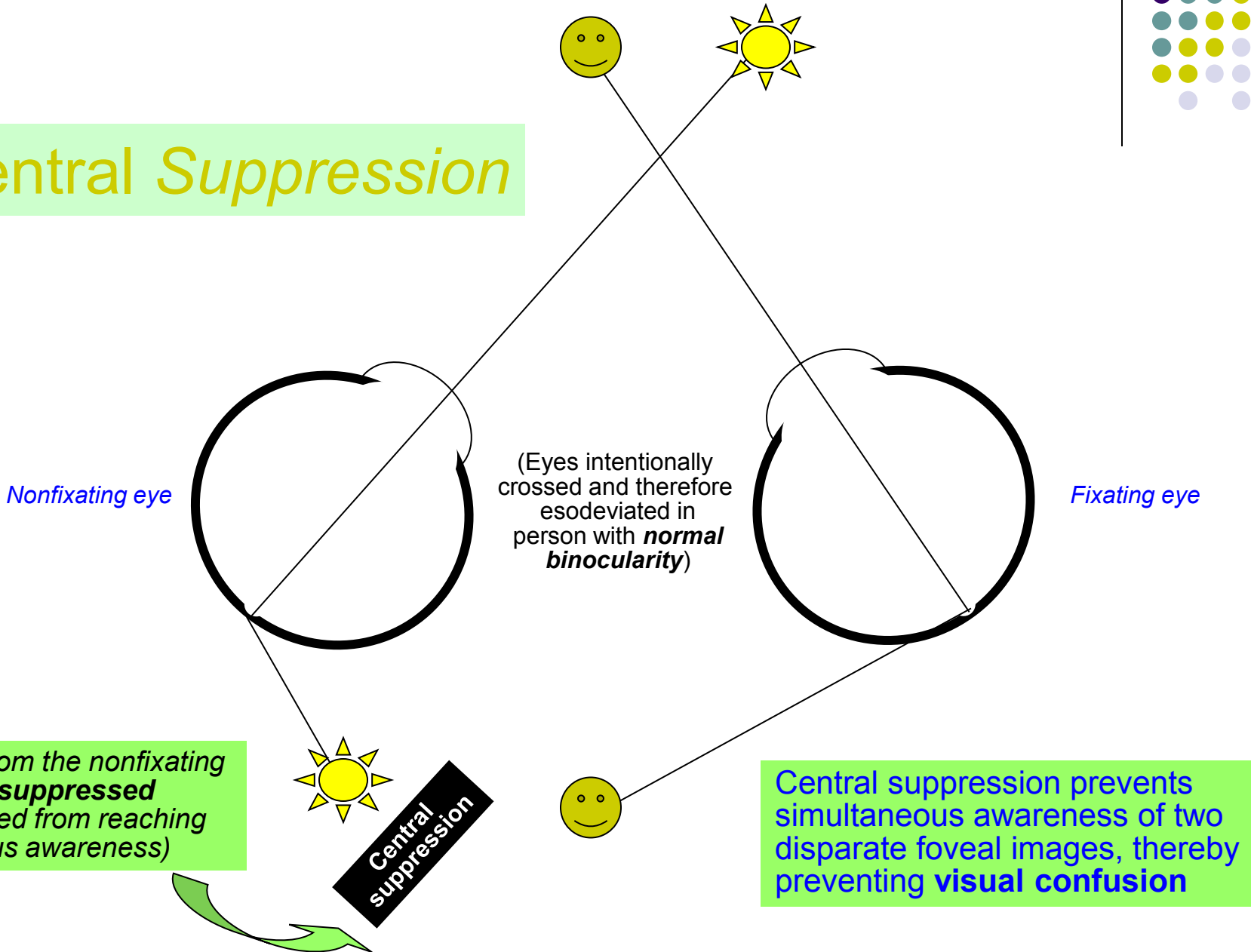
Sensory Adaptations to Strabismus: Suppression

Central Suppression



Sensory Adaptations to Strabismus: Suppression

Central Suppression





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 - Only develops in immature visual system; therefore, is considered Hint: not physiologic suppression



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Q

Sensory Adaptations to Strabismus: Suppression

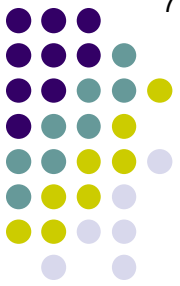
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 - Can be [] (suppression active only when the eye is deviated) or [] (suppression active at all times)



A

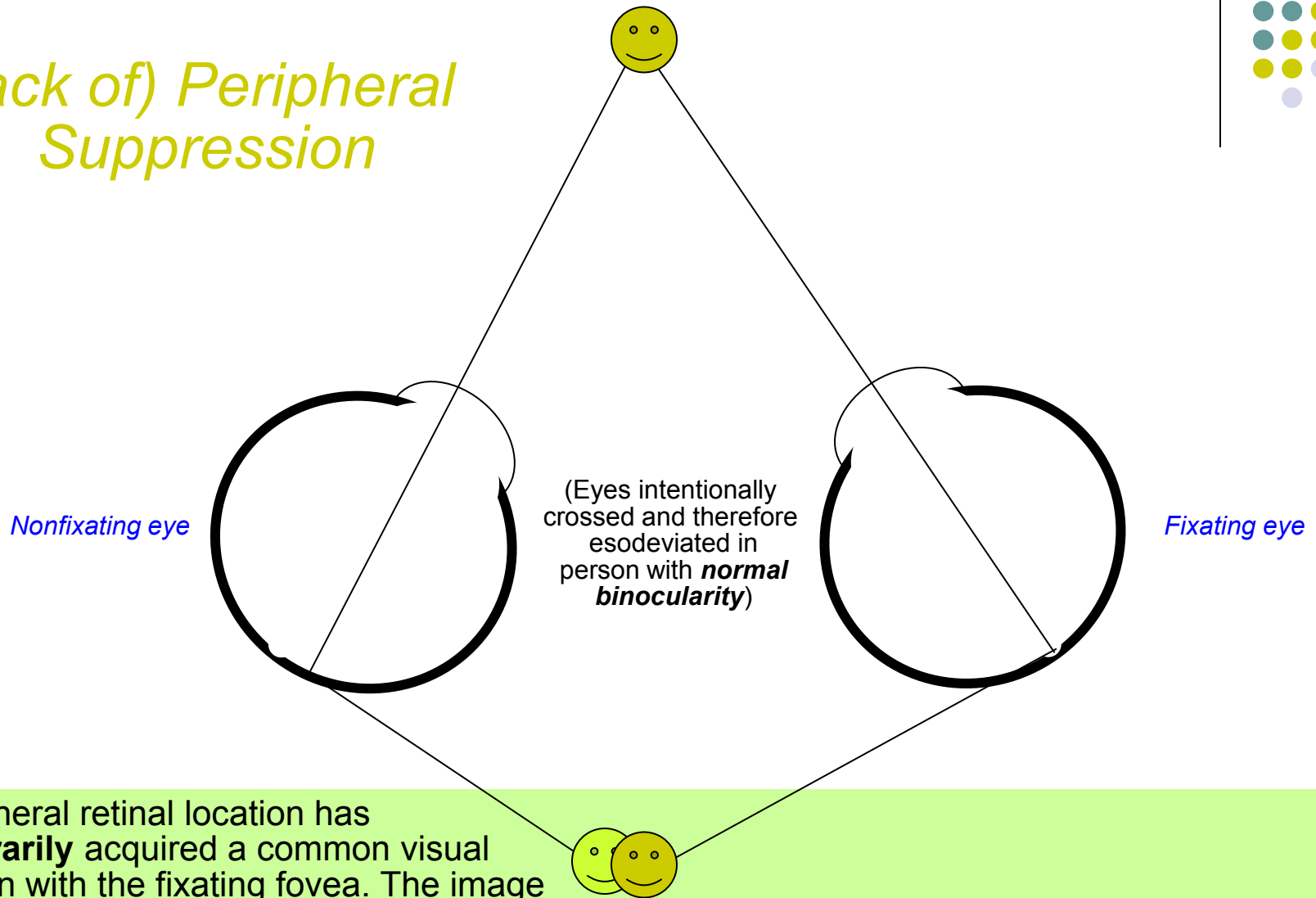
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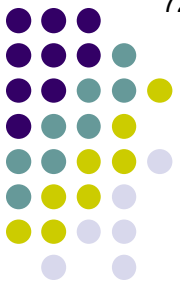


Sensory Adaptations to Strabismus: **Suppression**

(lack of) Peripheral Suppression

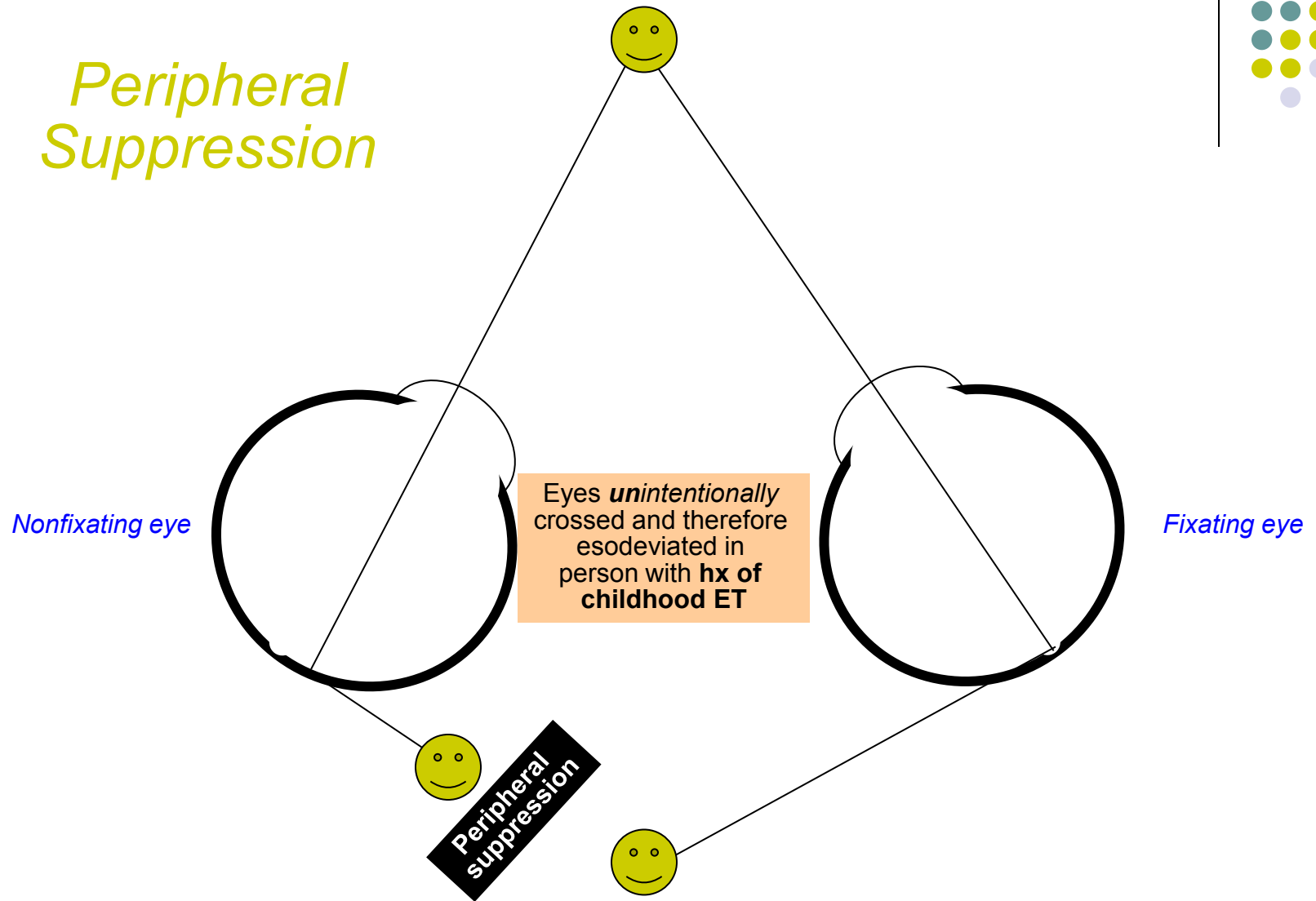


A peripheral retinal location has **temporarily** acquired a common visual direction with the fixating fovea. The image from this location can **not** be suppressed and therefore **does** reach conscious awareness, producing a visual experience of the same object being located at two points in visual space simultaneously (i.e., a visual experience of **diplopia**)



Sensory Adaptations to Strabismus: **Suppression**

Peripheral Suppression



However, in a person with a history of childhood strabismus, **peripheral suppression** prevents conscious awareness of the image from the deviated retina



Sensory Adaptations to Strabismus: **Suppression**

- **Sensory adaptations: *Suppression***

- In a nutshell suppression is prevention of an

Visualizing Suppression

Think about what you see when you cross your eyes. (In fact, go ahead and try it—look at something across the room, then cross your eyes.) The image of regard immediately becomes doubled (and blurred from induced accommodation, but that's a topic for another day). But note what you **don't** see—whatever image is falling on the fovea of your nonfixating eye. The fovea of your nonfixating eye must be pointing at *something*; so why don't you see it?



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You don't see it because this foveal image is prevented from reaching consciousness by the sensory adaptation of *central suppression*. What would you see without central suppression? You would see the two foveal images-of-regard seeming to occupy the same location in visual space—the definition of *visual confusion*. You would see **two** objects in **one** location. But you don't, thanks to central suppression.



Sensory Adaptations to Strabismus: Suppression

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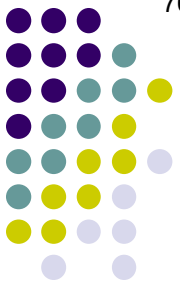
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On the other hand, the image of regard in the fixating eye is also falling on a peripheral retinal area in your nonfixating eye, and suppression of **this** image (*peripheral suppression*) is a sensory adaptation available only on an acquired basis in an immature visual system—it can't be 'conjured up on the fly' during volitional eye-crossing. The result is that crossing one's eyes produces *diplopia*—**one** object seen in **two** locations—but (thanks to central suppression) not visual confusion.

Sensory Adaptations to Strabismus: ARC



- What are the three sensory adaptations the visual system employs to avoid confusion and diplopia?
 - Suppression
 - **Anomalous retinal correspondence (ARC)**
 - Monofixation syndrome

*Next let's look at **anomalous retinal correspondence***

Sensory Adaptations to Strabismus: **ARC**



- What are the three sensory adaptations the visual system employs to avoid confusion and diplopia?
 - Suppression
 - **Anomalous retinal correspondence (ARC)**
 - Monofixation syndrome

*Next let's look at **anomalous retinal correspondence**. But first, we will recapitulate the slides we saw earlier concerning NRC.*



- What does it mean to say retinal locations in the two eyes *correspond*?



- What does it mean to say retinal locations in the two eyes *correspond*? It means the two locations have the same

words 1 and 2 of 3

word 3 of 3



- What does it mean to say retinal locations in the two eyes *correspond*? It means the two locations have the same **subjective visual direction**.



- What does it mean to say retinal locations in the two eyes *correspond*? It means the two locations have the same **subjective visual direction**.
 - If all corresponding retinal areas in the two eyes are symmetrically located (i.e., are the same retinal distances and directions from their respective foveas), the two retinas are said to be in words 1 and 2 of 3 word 3 of 3 (abbreviation of prev 3 words).



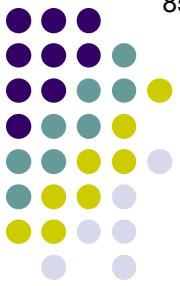
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 - Likewise, if a symmetrical relationship does *not* hold, the retinas are said to be in **not normal** *retinal correspondence* (abbreviation of prev 3 words).



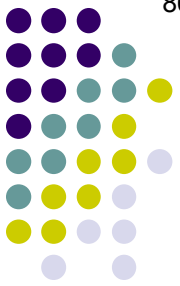
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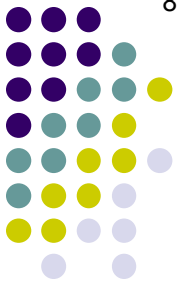
Q

Sensory Adaptations to Strabismus: ARC

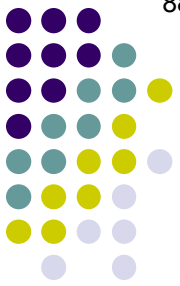
- **Sensory adaptations: *Anomalous retinal correspondence (ARC)***
 - ARC occurs when a peripheral vs central area of the deviating eye acquires a three words with the fovea vs periphery of the fixating eye



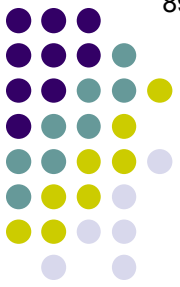
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 - Restores some sense of two words

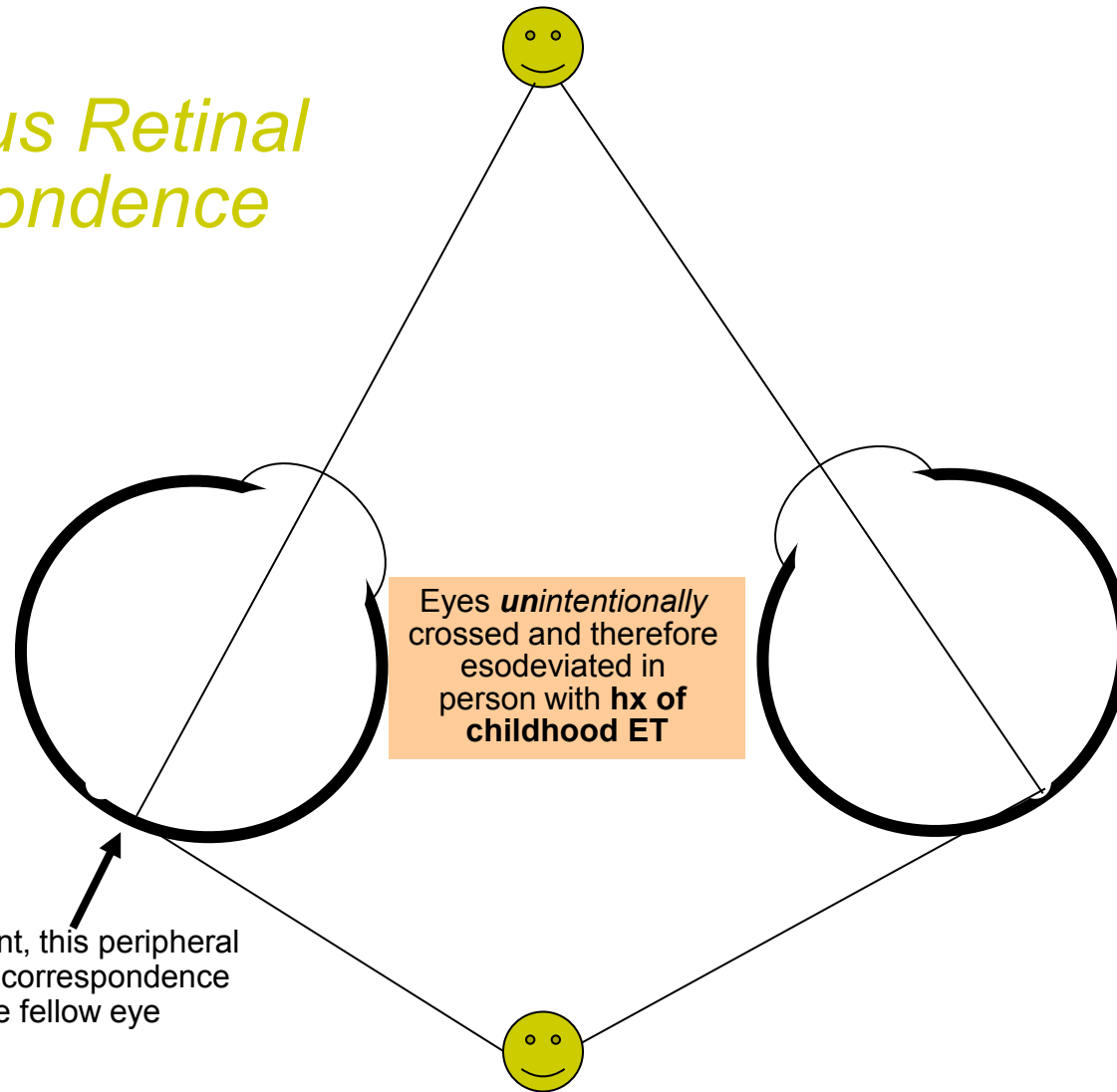


- **Sensory adaptations: *Anomalous retinal correspondence (ARC)***
 - ARC occurs when a **peripheral** area of the deviating eye acquires a **common visual direction** with the **fovea** of the fixating eye
 - Restores some sense of **binocular cooperation**



Sensory Adaptations to Strabismus: **ARC**

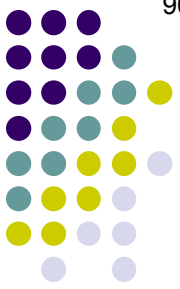
Anomalous Retinal Correspondence



During visual development, this peripheral retinal location acquired correspondence with the fovea of the fellow eye

In a person with a history of childhood strabismus, **ARC** often develops, facilitating binocular coordination by allowing fusion

Sensory Adaptations to Strabismus: Monofixation syndrome



- What are the three sensory adaptations the visual system employs to avoid confusion and diplopia?
 - Suppression
 - Anomalous retinal correspondence (ARC)
 - **Monofixation syndrome**

Finally, we will take a deep dive into monofixation syndrome



Q

Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral fusion but no central

*(BTW, this section is **T/F**)*

A

Sensory Adaptations to Strabismus: Monofixation syndrome



- Monofixators have peripheral fusion but no central fusion *T*



Q

Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral **fusion** but no central **fusion** *T*

In the context of binocular vision, to what does the term fusion refer?



A

Sensory Adaptations to Strabismus: Monofixation syndrome

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In the context of binocular vision, to what does the term fusion refer?

The visual cortex receives two images (one from each eye) of objects located within the binocular field of view. **Fusion** refers to the cortical process of unifying these *two* images into a percept of *one* object in visual space.



Q

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To what do the terms central and peripheral refer in the context of fusion?



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Central refers to images involving the foveal region, **peripheral** to images farther removed



Q

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Do central and peripheral fusion differ in ways other than their relationship to the foveal region?



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Central refers to images involving the foveal region, **peripheral** to images farther removed

Do central and peripheral fusion differ in ways other than their relationship to the foveal region?

Indeed they do. As a general rule, the central fusional process requires that the images be highly similar in size and shape—very little disparity is tolerated in this regard. In contrast, the act of peripheral fusion is much more forgiving of dissimilarity between the images received from the respective eyes.



Q

Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral fusion but no central fusion **T**
- A small foveal suppression scotomata is present OU

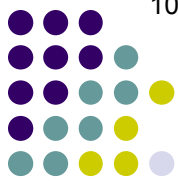
(Note: *Foveal suppression* is a commonly-employed synonym for *central suppression*)



A

Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral fusion but no central fusion ^{*T*}
- A small foveal suppression scotomata is present ^{*unilaterally*} ~~OU~~ ^{*F*}



Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral fusion but no central fusion *T*
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This is the essence of monofixation syndrome: *Peripheral fusion in the absence of central (bifoveal) fusion owing to the presence of a small central suppression scotoma*



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Note: That's degrees, not prism diopters!



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What should be inferred if the scotoma is significantly larger than 4 deg?



Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral fusion but no central fusion *T*
- A small foveal suppression scotomata is present *unilaterally* ~~OU~~ *F*

This is the essence of monofixation syndrome: *Peripheral fusion in the absence of central (bifoveal) fusion owing to the presence of a small central suppression scotoma*

How big (small?) is the suppression scotoma?

Usually about 1-4 degrees

What should be inferred if the scotoma is significantly larger than 4 deg?

That the pt does not have monofixation syndrome



Q

Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral fusion but no central fusion ^{*T*}
- A small foveal suppression scotomata is present ^{*unilaterally*} ~~OU~~ ^{*F*}
- Retinal correspondence = Small angle ARC



A

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Sensory Adaptations to Strabismus: Monofixation syndrome



- Monofixators have peripheral fusion but no central fusion *T*
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- Retinal correspondence = Small angle ARC *T*

In other words: As a rule, monofixation syndrome pts do not develop NRC; instead, they develop ARC. It is a 'small angle' ARC in the sense that the noncorresponding locations in the two eyes that acquire a common visual direction (remember, that is the definition of ARC) tend to be not too far removed from the locations that would have a common visual direction in NRC.

Sensory Adaptations to Strabismus: Monofixation syndrome



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In other words: As a rule, monofixation syndrome pts do not develop NRC; instead, they develop ARC. It is a 'small angle' ARC in the sense that the noncorresponding locations in the two eyes that acquire a common visual direction (remember, that is the definition of ARC) tend to be not too far removed from the locations that would have a common visual direction in NRC. Put another way: Retinal correspondence in monofixation syndrome is anomalous, but not by much.



Q

Sensory Adaptations to Strabismus: Monofixation syndrome

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- Retinal correspondence = Small angle ARC *T*
- Muscle balance is typically a micro (<8 PD) XT



A

Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral fusion but no central fusion T
- A small foveal suppression scotomata is present $\text{OU} \wedge F$ *unilaterally*
- Retinal correspondence = Small angle ARC T_{ET}
- Muscle balance is typically a micro (<8 PD) $\times T \wedge F$



Q

Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral fusion but no central fusion T
- A small foveal suppression scotomata is present $\text{OT}_\wedge F$ *unilaterally*
- Retinal correspondence = Small angle ARC T_{ET}
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Should this be interpreted as indicating monofixation syndrome always involves an ET?



Q/A

Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral fusion but no central fusion T
- A small foveal suppression scotomata is present $\text{unilaterally } \text{OT}_\wedge F$
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Should this be interpreted as indicating monofixation syndrome always involves an ET?

No. Muscle balance in monofixation can be ET, XT, or abb..



A

Sensory Adaptations to Strabismus: Monofixation syndrome

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- A small foveal suppression scotomata is present unilaterally $\text{OT}_\Delta F$
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No. Muscle balance in monofixation can be ET, XT, or HT .



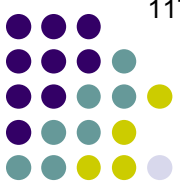
Q

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Should this be interpreted as indicating monofixation syndrome always involves an ET?

No. Muscle balance in monofixation can be ET, XT, or HT . They can even be ortho .

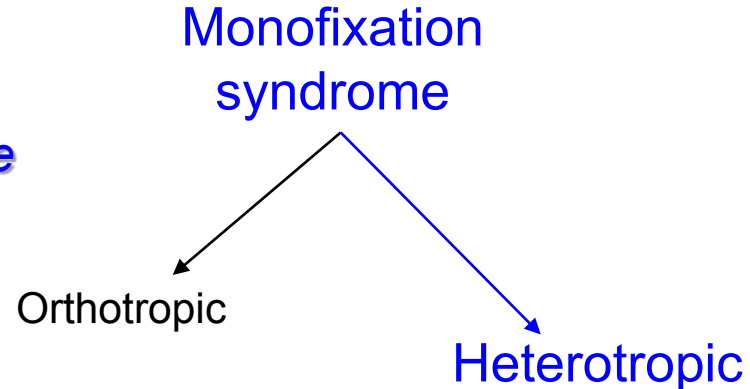
Sensory Adaptations to Strabismus: Monofixation syndrome



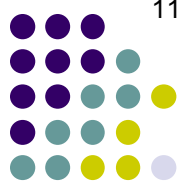
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Monofixation syndrome pts can be ortho, but most are heterotropic



Sensory Adaptations to Strabismus: Monofixation syndrome

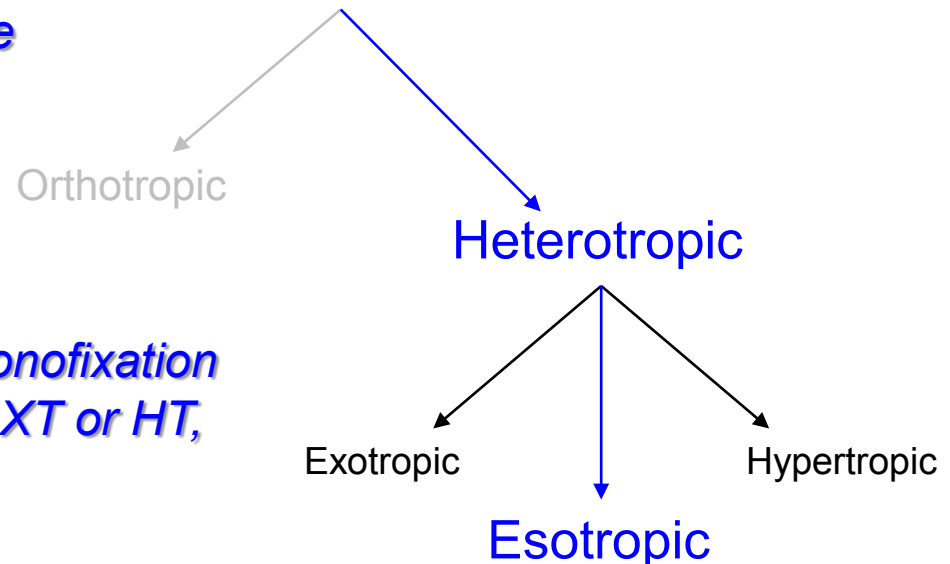


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Monofixation syndrome

Monofixation syndrome pts can be ortho, but most are heterotropic



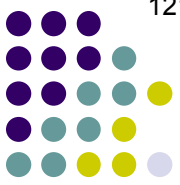
Heterotropia in monofixation syndrome can be XT or HT, but is usually ET



Q

Sensory Adaptations to Strabismus: Monofixation syndrome

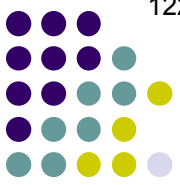
- Monofixators have peripheral fusion but no central fusion T
- A small foveal suppression scotomata is present $\text{OU} \wedge F$ *unilaterally*
- Retinal correspondence = Small angle ARC T_{ET}
- Muscle balance is typically a micro (<8 PD) $\times T \wedge F$
- Amblyopia is uncommon



A

Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral fusion but no central fusion T
- A small foveal suppression scotomata is present ~~OU~~^{unilaterally} F
- Retinal correspondence = Small angle ARC T_{ET}
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Q

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- Amblyopia is ~~uncommon~~^{common} F
- Is an indication for re-op if it develops after ET surgery



A

Sensory Adaptations to Strabismus: Monofixation syndrome

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- A small foveal suppression scotomata is present ^{*unilaterally*} ~~OU~~ _{*^*} ^{*F*}
- Retinal correspondence = Small angle ARC ^{*T*} _{*ET*}
- Muscle balance is typically a micro (<8 PD) ~~XT~~ _{*^*} ^{*F*}
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- Is ^{*not*} _{*^*} an indication for re-op if it develops after ET surgery ^{*F*}



Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral fusion but no central fusion T
- A small foveal suppression scotomata is present ~~OT~~^{unilaterally} F
- Retinal correspondence = Small angle ARC T_{ET}
- Muscle balance is typically a micro (<8 PD) ~~XT~~_A F
- Amblyopia is ~~uncommon~~^{common} F
- Is ^{not}_A an indication for re-op if it develops after ET surgery F

*To the contrary: Monofixation syndrome is a **desirable** outcome after ET surgery!*



Q

Sensory Adaptations to Strabismus: Monofixation syndrome

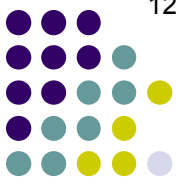
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- Can be diagnosed via the 4Δ BO prism test



A

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- Can be diagnosed via the 4Δ BO prism test *T*



Q

Sensory Adaptations to Strabismus: Monofixation syndrome

- In a nutshell: What does the 4Δ BO prism test, test for?
- /
- /
- /
- /
- /
- Is an indication for re-op if it develops after ET surgery /
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Q/A

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- In a nutshell: What does the 4Δ BO prism test, test for?
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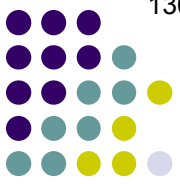
- Is an indication for re-op if it develops after LT surgery
- Can be diagnosed via the 4Δ BO prism test



A

Sensory Adaptations to Strabismus: Monofixation syndrome

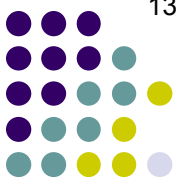
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A

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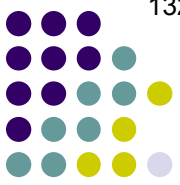
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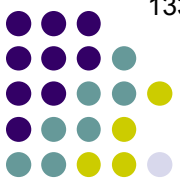
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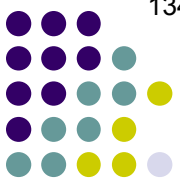
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In a person with **bifixation**:

When the prism is introduced, what will the eyes do first?



A

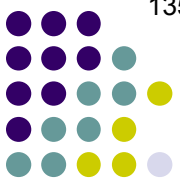
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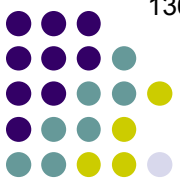
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In a person with **bifixation**:

When the prism is introduced, what will the eyes do first?

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The introduction of the prism yields the impression that the object of regard has suddenly moved, and the eyes turn to refixate it



Q

Sensory Adaptations to Strabismus: Monofixation syndrome

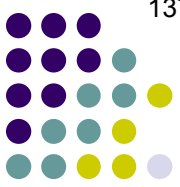
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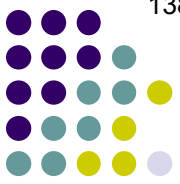
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What will the eyes do next?

The eye without the prism will turn in (ie, will converge)

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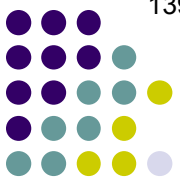
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The presence of the prism produces , which resolves when the fellow eye adducts

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The eye without the prism will turn in (ie, will converge)

The presence of the prism produces diplopia, which resolves when the fellow eye adducts

Q

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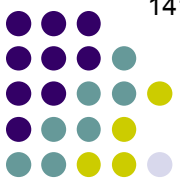
When the prism is introduced, what will the eyes do first?

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What will the eyes do next?

The eye without the prism will turn in (ie, will converge)

Does it matter which eye gets the prism?



A

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Nope



Q

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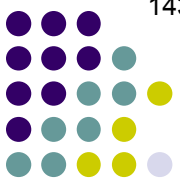
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Nope

In monofixation syndrome, and the prism is over the **fixating** eye:

When the prism is introduced, what will the eyes do first?



A

Sensory Adaptations to Strabismus: Monofixation syndrome

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When the prism is introduced, what will the eyes do first?

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Does it matter which eye gets the prism?

Nope

In monofixation syndrome, and the prism is over the **fixating** eye:

When the prism is introduced, what will the eyes do first?

Both eyes will move in the direction of the prism's apex



Sensory Adaptations to Strabismus: Monofixation syndrome

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When the prism is introduced, what will the eyes do first?

Both eyes will move in the direction of the prism's apex

Just as was the case when prism was placed before the fixating eye of a pt with bifixation (*both* eyes are the 'fixating eye' in a pt who bifixates), introduction of prism before the fixating eye of a monofixation-syndrome pt yields the impression that the object of regard has moved, and so the eyes turn to refixate it



Q

Sensory Adaptations to Strabismus: Monofixation syndrome

- *In a nutshell: What does the 4Δ BO prism test, test for?*
- The presence of a suppression scotoma in a pt who is orthotropic (recall that some monofixation syndrome pts are ortho)
- *How is it performed?*
- As the name implies, it involves a 4Δ prism held in a 'base out' (BO) position.
- The prism is placed in front of either eye, and subsequent movements of the eyes are noted. (Much more below.)
- Is an indication for re-op if it develops after LT surgery
- Can be diagnosed via the **4Δ BO prism test**

In a person with **bifixation**:

When the prism is introduced, what will the eyes do first?

Both eyes will turn in the direction of the prism's apex

What will the eyes do next?

The eye without the prism will turn in (ie, will converge)

Does it matter which eye gets the prism?

Nope

In monofixation syndrome, and the prism is over the **fixating** eye:

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Why doesn't the fellow eye converge?

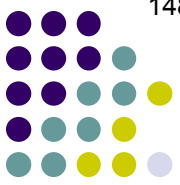
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Why doesn't the fellow eye converge?

Recall that in monofixation syndrome only one eye fixates (hence the name), while the other has a central suppression scotoma. In the present scenario the prism is in front of the fixating eye, meaning the fellow eye is the one with the scotoma.

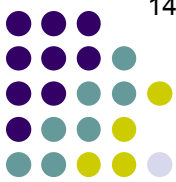
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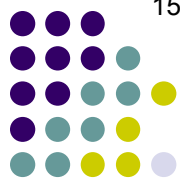
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The eye without the prism will turn in (ie, will converge)

What will the eyes do next?

Nothing (ie, **the fellow eye will not turn in**)

Does it matter which eye gets the prism?

Nope



Q

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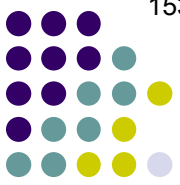
What will the eyes do next?

Nothing (ie, the fellow eye will **not** turn in)

In monofixation syndrome, and the prism is over the **suppressed** eye:

When the prism is introduced, what will the eyes do first?





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In monofixation syndrome, and the prism is over the **suppressed** eye:

When the prism is introduced, what will the eyes do first?

Nothing—they won't move at all



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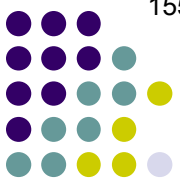
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Why don't the eyes move when the prism is introduced?



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When the prism is introduced, what will the eyes do first?

Nothing — **they won't move at all**

Why don't the eyes move when the prism is introduced?

Again, in monofixation syndrome one eye fixates, while the other is suppressed. In the present scenario, the prism is placed in front of the eye with the scotoma. Because this eye isn't looking at anything (so to speak), introduction of the prism doesn't produce a percept of displacement, and thus there is nothing to compel the eyes to move.

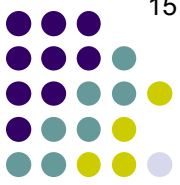


Q

Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral fusion but no central fusion *T*
- A small foveal suppression scotomata is present *unilaterally* ~~OU~~ *F*
- Retinal correspondence = Small angle ARC *T_{ET}*
- Muscle balance is typically a micro (<8 PD) ~~XT~~ *F*
- Amblyopia is *common* ~~uncommon~~ *F*
- Is *not* an indication for re-op if it develops after ET surgery *F*
- Can be diagnosed via the *4Δ BO prism* test *T*
- *Worth 4-dot* testing reveals 4 dots at distance and 2 or 3 at near





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Q

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In a nutshell: What does the Worth 4-dot test, test for?

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Q

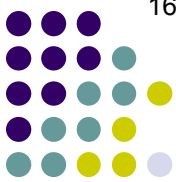
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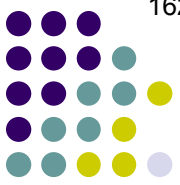
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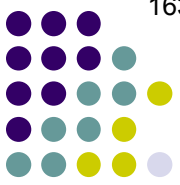
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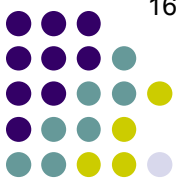
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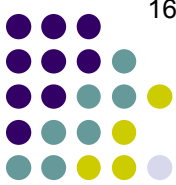
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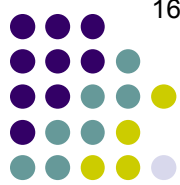
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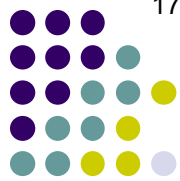
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2)

Q/A

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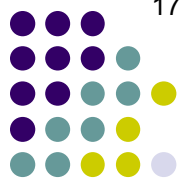
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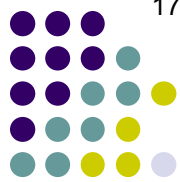
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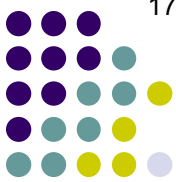
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Before we get to the issue of how the presence of a suppression scotoma affects what the pt sees, what in general is the impact of the colored filters on perceptual experience of the dots?

Two important effects need to be noted:

1) The filters prevent the wearer from seeing the dot that is different from that of the color of the filter. **So the right eye, with its red filter, cannot see the two green dots,** and **the left eye with its green filter cannot see the single red dot.**

2)



Q

Sensory Adaptations to Strabismus: Monofixation syndrome

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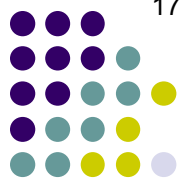
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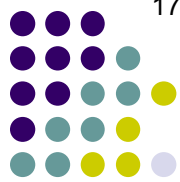
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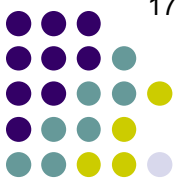
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Two important

Next we will look at different response patterns to the test

1) The filters cause a color shift. The color of the filter. So the right eye, with its red filter, cannot see the two green dots, and the left eye with its green filter cannot see the single red dot.

2) The filters cause the white light to appear to be the same color as that of the filter. So the right eye, with its red filter, sees the **white dot** as red, and the left eye with its green filter sees it as green.



Q

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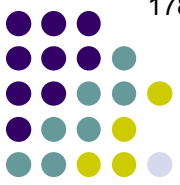
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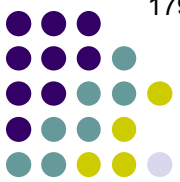
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...she is seeing the red dot along with the white (which appears red because of the filter)



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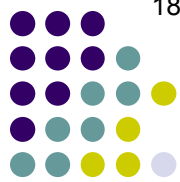
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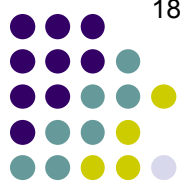
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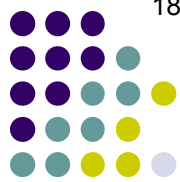
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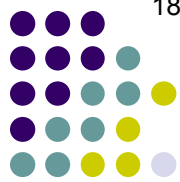
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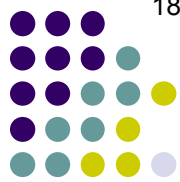
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If the pt sees **four** dots, it means one of two things:

--There is no suppression scotoma in either eye; or

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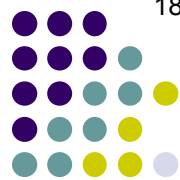
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If the pt sees **four** dots, it means one of two things:

- There is no suppression scotoma in either eye; or
- A suppression scotoma is present, but it is smaller than the angle subtended by the dots at that viewing distance (ie, the images of the dots are falling outside the border of the scotoma)



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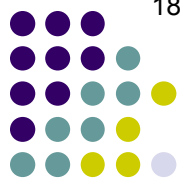
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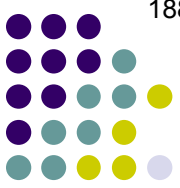
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If the pt sees **four** dots, it means one of two things:

In a pt with NRC and bfixation, what color would the white dot be?

...she is seeing the white dot with her right eye; or
...there is no suppression scotoma in her right eye; or
...there is a suppression scotoma in her right eye, but it is smaller than the subtended by the dots at that distance (ie, the images of the dots are falling outside the border of the scotoma)



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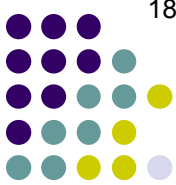
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If the pt sees **four** dots, it means one of two things:

In a pt with NRC and bfixation, what color would the white dot be?
It depends. In pts with a strongly dominant eye, it might appear to be the color of that eye's filter.

...she is seeing the white dot with her right eye; or
...there is no suppression scotoma in her eye; or
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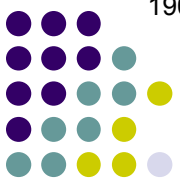
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In a pt with NRC and bfixation, what color would the white dot be?

It depends. In pts with a strongly dominant eye, it might appear to be the color of that eye's filter. Other pts would experience so-called 'rivalry' in which the color of the dot would be seen to switch back and forth between **green** and **red**.

There is no suppression scotoma in either eye; or suppression scotoma is present, but it is smaller than the subtended by the dots at that distance (ie, the images of the dots are falling outside the border of the scotoma)



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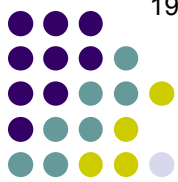
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Are there situations in which a pt would see five dots?



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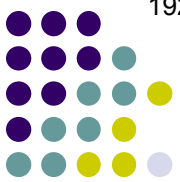
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the left e
and thus
scotoma.

If the pt sees **three** dots, it means...

she is seeing the two green dots

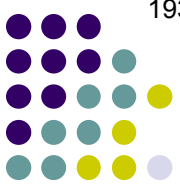
If the pt sees **four** dots, it means
one of two things:

scotoma

s
an the

angle subtended by the dots at that
viewing distance (ie, the images of
the dots are falling outside the
border of the scotoma)

Are there situations in which a pt would see five dots? What would this indicate?
Indeed there are



A

Sensory Adaptations to Strabismus: Monofixation syndrome

In a nutshell: What does the Worth 4-dot test, test for?

Like the 4 Δ BO prism test, it tests for the presence of a suppression scotoma

How is it performed?

The pt wears glasses consisting of a **red** filter over her right eye, and a **green** filter over her left. She then views an image consisting of four small colored lights ('dots') arranged in a diamond. The dot at the top of the diamond is **red**, at the two sides are **green**, and at the bottom is **white**. The pt is then asked how many dots she sees.

Can be diagnosed via the 4 Δ BO prism test *T*

Worth 4-dot testing reveals 4 dots at ^{near}~~distance~~ and 2 or 3 at ^{distance}~~near~~ **F**

If the pt sees **two** dots, it means...

...she is seeing the red dot along

with the v

because

the left e

and thus

scotoma.

If the pt sees **three** dots, it means...

she is seeing the two green dots

If the pt sees **four** dots, it means
one of two things:

scotoma

S

an the

angle subtended by the dots at that

viewing distance (ie, the images of the dots are falling outside the border of the scotoma)

Are there situations in which a pt would see five dots? What would this indicate?

Indeed there are. This would constitute diplopia, and thus would indicate the presence of manifest strabismus absent the 'benefit' of a suppression scotoma and peripheral fusion.



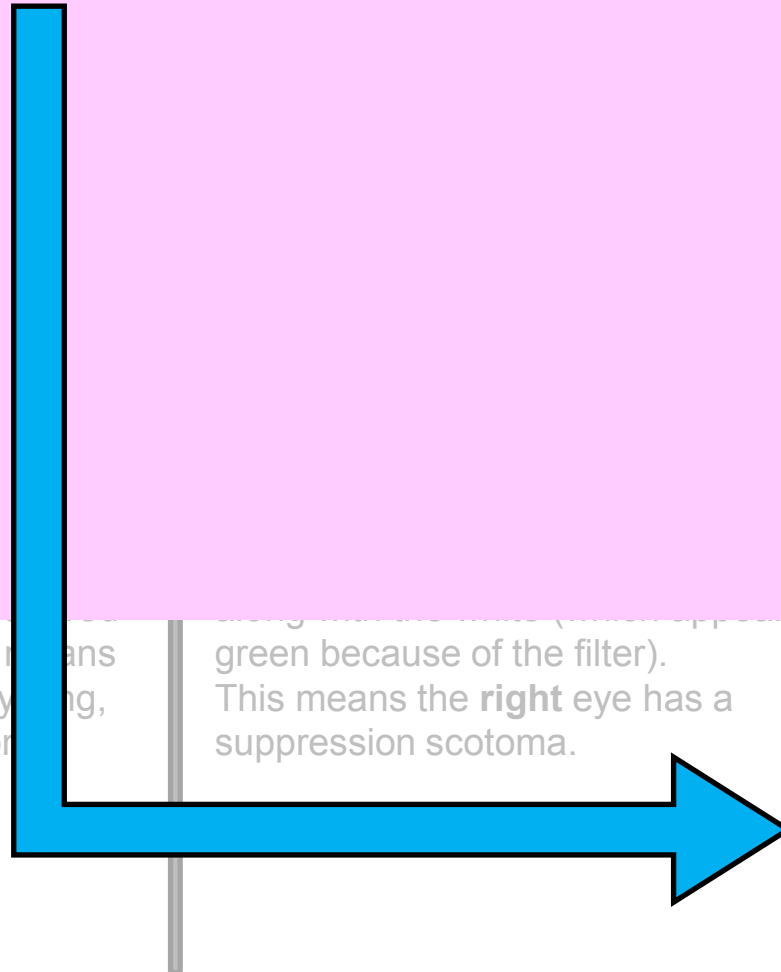
Q

Sensory Adaptations to Strabismus: Monofixation syndrome

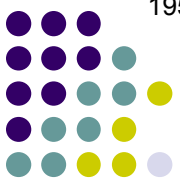
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Let's contemplate this situation in more detail.



--A suppression scotoma is present, but it is smaller than the angle subtended by the dots at that viewing distance (ie, the images of the dots are falling outside the border of the scotoma)



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If th

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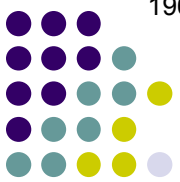
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because of the filter). This means the left eye isn't seeing anything, and thus has a suppression scotoma.

green because of the filter). This means the **right** eye has a suppression scotoma.

in either eye: or

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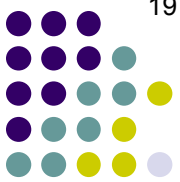
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Given this fact, consider a pt as described in the box, ie, she has a suppression scotoma in one eye, but the image of the dots are falling outside its boundaries; hence, she reports seeing four dots.

(No question yet—proceed when ready)

If th

...S

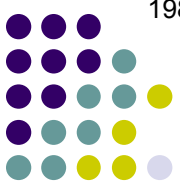
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Eventually, the distance would be great enough that the image of the dots would fall **within** her suppression scotoma. At that point, her perceptual experience would shift from seeing four dots to seeing two or three (depending upon whether her left vs right eye has the scotoma).

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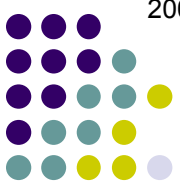
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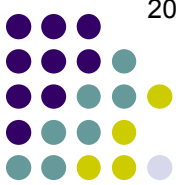
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Eventually, the distance would be great enough that the image of the dots would fall **within** her suppression scotoma. At that point, her perceptual experience would shift from seeing four dots to seeing two or three (depending upon whether her left vs right eye has the scotoma).

This is how monofixation syndrome pts respond during Worth 4-dot testing. When the distance between the display and the pt is short, the dot-images fall outside their scotoma and they report four dots.

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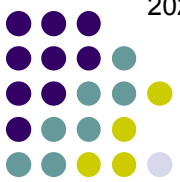
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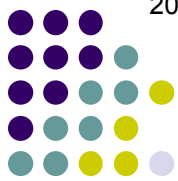
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Q/A

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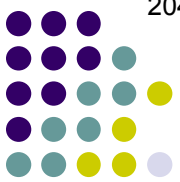
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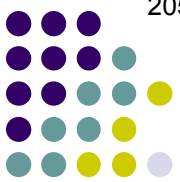
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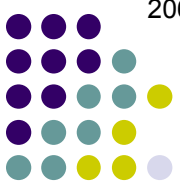
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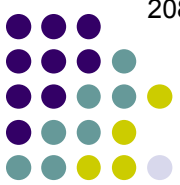
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...fall outside the suppression scotoma? Again assuming the use of a standard display, the angular size of the dot-image will be >4 (and thus be outside the scotoma) at a distance in the # to # meter range.

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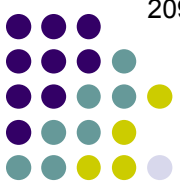
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Q

Sensory Adaptations to Strabismus: Monofixation syndrome

- Monofixators have peripheral fusion but no central fusion *T*
- A small foveal suppression scotomata is present *unilaterally* ~~OU~~ *F*
- Retinal correspondence = Small angle ARC *T_{ET}*
- Muscle balance is typically a micro (<8 PD) ~~XT~~ *F*
- Amblyopia is *common* ~~uncommon~~ *F*
- Is *not* ~~an~~ indication for re-op if it develops after ET surgery *F*
- Can be diagnosed via the *4Δ BO prism* test *T*
- *Worth 4-dot* testing reveals 4 dots at *distance* ~~near~~ and 2 or 3 at *distance* ~~near~~ *F*
- Stereopsis in the 200-3000 arc-s range is usually not achievable





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- A small foveal suppression scotomata is present unilaterally $\text{OT}_\wedge F$
- Retinal correspondence = Small angle ARC T_{ET}
- Muscle balance is typically a micro (<8 PD) $\text{XT}_\wedge F$
- Amblyopia is common +
- Is not an indication $\text{tl;dr slide—no questions}$ $\text{Jery } F$
- Can be diagnosed via the $4\Delta BO$ prism test T
- Worth 4-dot testing reveals 4 dots at distance and 2 or 3 at near distance $\text{near}_\wedge F$
- Stereopsis in the 200-3000 arc-s range is usually not achievable F

Monofixation syndrome is a common entity. These patients have **peripheral fusion without central fusion**; thus they possess **gross stereopsis (200-3000 arc-s)** but not the high-grade stereopsis that requires bifoveation (~40 arc-s). This is because they cannot bifixate an object of regard (hence the term 'monofixation'). Vision in the nonfixating eye is characterized by a small foveal suppression scotoma and minute ARC. **Muscle balance testing usually reveals an ET of about 8PD. Amblyopia is the rule**; it is usually mild but can be profound. Monofixation is considered a desirable outcome in correction of ET with spectacles or surgery. The **$4\Delta BO$ prism test** is very useful in diagnosing a monofixation syndrome. **Worth 4-dot testing** reveals a characteristic pattern: When assessed at a distance of 2-3 feet, the lights fall outside the suppression scotoma and the patient perceives all four dots. However, when the light is held at distance (10+ feet), the lights fall within the suppression scotoma, and only 2 or 3 dots will be appreciated with the non-suppressing eye.