Define Sherrington’s law

Sherrington’s law: Increased innervation to a muscle is accompanied by decreased innervation to its antagonist
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- Sherrington’s law: *Increased* innervation to a muscle is accompanied by *decreased* innervation to its antagonist
Define **Sherrington’s law**

- Sherrington’s law: **Increased** innervation to a muscle is accompanied by **decreased** innervation to its antagonist

*What is the full name of Sherrington’s law?*  
Sherrington’s law of…
Define Sherrington’s law

Sherrington’s law: Increased innervation to a muscle is accompanied by decreased innervation to its antagonist.

What is the full name of Sherrington’s law?
Sherrington’s law of…reciprocal innervation
Define **Sherrington’s law** and **Hering’s law**

- **Sherrington’s law**: Increased innervation to a muscle is accompanied by decreased innervation to its antagonist.

- **Hering’s law**: Innervation to two words is equal.
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- **Sherrington’s law**: Increased innervation to a muscle is accompanied by decreased innervation to its antagonist

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Define Sherrington’s law and Hering’s law.

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*To what does the term yoke muscles refer?*
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Speaking of positions of gaze…How many positions are used in evaluating ocular motility and alignment?

Nine positions are used in evaluating ocular motility and alignment:

- Primary position
- Cardinal positions
- Up and down
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OK, I know what primary gaze is, and ‘up and down’ seem obvious. But as for the so-called cardinal positions…First, how many ‘cardinal positions’ are there? Well, we just said that 9 gaze positions are used in evaluating the EOMs. There’s one primary gaze (duh)…and ‘up’ and ‘down’ make three. This implies (correctly) that there are six cardinal positions of gaze.

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Sherrington’s Law vs Hering’s Law

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What is a cardinal position of gaze?

One

Ok, then what is a field of action?

It refers to the two muscles—one for each eye—that are responsible for putting the eyes into a given position of gaze.
To what does the term yoke muscles refer? It refers to the two muscles—one for each eye—that are responsible for putting the eyes into a given position of gaze.

Define Sherrington’s law and Hering’s law.

- **Sherrington’s law**: Increased innervation to a muscle is accompanied by decreased innervation to its antagonist. Violated in Duane syndrome.

- **Hering’s law**: Innervation to yoke muscles is equal. This defines a cardinal position of gaze: One that corresponds to the field of action for a given extraocular muscle (EOM). It is a gaze direction in which the influence of a given EOM is mostly readily apparent. In essence, it’s the position in which a given EOM ‘cannot hide’

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What is a field of action? It is a gaze direction in which the influence of a given EOM is mostly readily apparent. In essence, it’s the position in which a given EOM ‘cannot hide’—i.e., the gaze direction in which a given muscle will be ‘exposed’ if it is not functioning properly.
Define Sherrington's law and Hering's law, and for each state the classic example of a strabismus-type in which it is violated:

- **Sherrington's law**: Increased innervation to a muscle is accompanied by decreased innervation to its antagonist. Violated in Duane syndrome.
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**Sherrington’s Law vs Hering’s Law**

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**Why aren’t straight up and down cardinal positions?**

The nine gaze positions are divided into three groups—

- **Primary position (1)**
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We just said that 9 gaze positions are used in evaluating the EOMs. There’s one primary gaze (duh)…plus ‘up’ and ‘down’ make three. This implies (correctly) **What are the six cardinal positions of gaze?**

- **Up?**
  - Up and right
  - Up and left

- **Down?**
  - Down and right
  - Down and left

Speaking of positions of gaze…How many positions are used in evaluating ocular motility and alignment?

Nine

The nine positions are divided into three groups—

- **Primary position (1)**
- **Cardinal positions (6)**
- **Up and down (2)**

Why aren’t straight up and down cardinal positions?

Both involve input from multiple EOMs. Because of this, identifying a deficit in these positions is noncontributory in that it doesn’t allow one to attribute that deficit to the dysfunction of a single, unique EOM.
Define Sherrington’s law and Hering’s law, and for each state the classic example of a strabismus-type in which it is violated:

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The nine positions are divided into three groups—what are they?

- Primary position (1)
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OK, let's identify the yoke muscle for the cardinal positions of gaze. Let's start with an easy one. What are the yoke muscle for right gaze? That is, for each eye, which muscle is chiefly responsible for straight-right gaze?
Sherrington’s Law vs Hering’s Law

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So if, say, the right eye cannot turn to the right, the preferred description would be *the right eye has a deficit in the field of action of the lateral rectus.*
Define Sherrington's law and Hering's law, and for each state the classic example of a strabismus-type in which it is violated:

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Speaking of positions of gaze…How many positions are used in evaluating ocular motility and alignment? Nine. The nine positions are divided into three groups—

---Primary position (1)---
---Cardinal positions (6)---
---Up and down (2)---

So if, say, the right eye cannot turn to the right, the preferred description would be the right eye has a deficit in the field of action of the lateral rectus. That seems unnecessarily wordy. If the right eye won’t turn right, why not simply say ‘Yo, the right LR ain’t working’?

Because an inability of the right eye to abduct is not necessarily indicative of LR dysfunction. For example, LR function might be fully intact, but a medial restrictive process—say, entrapment of the MR in a healed medial-wall fracture—could be present.
Define Sherrington's law and Hering's law, and for each state the classic example of a strabismus-type in which it is violated:

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Sherrington's Law vs Hering's Law

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- Primary position (1)
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Nine, we just said that 9 gaze positions are used in evaluating the EOMs. There’s one primary gaze (duh) plus up and down make three. This implies (correctly) what are the six cardinal positions of gaze?

- Not surprisingly, the yoke muscles for left gaze are the mirror image of those for right gaze.
- LR → OD
- MR → OS
- LR → OS
- MR → OD
- Down and right
- Left
- Up and left
- Right
- Up and right

What are the cardinal positions of gaze? The cardinal positions (6) include:

- Primary position (1)
- Up and down (2)
- Cardi

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**Sherrington’s Law vs Hering’s Law**

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**What are the yoke muscles for gaze up and right?**

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**Sherrington’s Law vs Hering’s Law**

- **OD → LR**
- **OS → MR**
- **OD → LR**
- **OS → MR**
- **LR ← OS**
- **MR ← OD**

**Speaking of positions of gaze...** How many positions are used in evaluating ocular motility and alignment? Nine.

The nine positions are divided into:

- **Primary position (1)**
- **Cardinal positions (6)**
- **Up and down (2)**

**What are the six cardinal positions of gaze?**

- **Right**
- **Left**
- **Down and right**
- **Down and left**

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- **Right Left**
- **Up and right**
- **Down and right**
- **Up and left**
- **Down and left**

To what does the term yoke muscles refer?

It refers to the two muscles—one for each eye—that are responsible for putting the eyes into a given position of gaze.

To what does the term cardinal positions refer?

To what does the term primary gaze refer?

Left, Right, and Up and Down.

To what does the term nine positions refer?

Nine positions are used in evaluating ocular motility and alignment.

- **Primary position (1)**
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How many cardinal positions are there?

Six cardinal positions of gaze are implied (correctly).

What are the yoke muscle for gaze up and right?
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The nine positions are divided into three groups—what are they?
- Primary position (1)
- Cardinal positions (6)
- Up and down (2)

Likewise, the yoke muscles for gaze up and left are again the mirror image of those on the other side.
Sherrington's Law vs Hering's Law

Sherrington's Law: Increased innervation to a muscle is accompanied by decreased innervation to its antagonist. Violated in Duane syndrome.

Hering's Law: Innervation to yoke muscles is equal.

To what does the term yoke muscles refer? It refers to the two muscles—one for each eye—that are responsible for putting the eyes into a given position of gaze.
Define Sherrington's law and Hering's law, and for each state the classic example of a strabismus-type in which it is violated:

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Speaking of positions of gaze…How many positions are used in evaluating ocular motility and alignment? Nine.

The nine positions are divided into three groups—

- Primary position (1)
- Cardinal positions (6)
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Well, we just said that 9 gaze positions are used in evaluating the EOMs. There's one primary gaze (plue up and down) make three. This implies that there are six cardinal positions of gaze. What are they?

**Right Left**

- **Up and right**
- **Down and right**

**Down and left**

What are the yoke muscle for gaze down and right?...
**Define Sherrington’s law and Hering’s law, and for each state the classic example of a strabismus-type in which it is violated:**

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**Sherrington’s Law vs Hering’s Law**

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Likewise, the yoke muscles for gaze down and left are the mirror image of those on the other side.

What are the six cardinal positions of gaze?...
Define Sherrington’s law and Hering’s law, and for each state the classic example of a strabismus-type in which it is violated:

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Define Sherrington’s law and Hering’s law

- Sherrington’s law: Increased innervation to a muscle is accompanied by decreased innervation to its antagonist. Violated in Duane syndrome.

- Hering’s law: Innervation to yoke muscles is equal. When the oculomotor control system is intact, it doesn’t matter which eye is fixating. But when one eye has a muscle paretic, which eye is fixating has an enormous effect.

Speaking of Hering’s law... What determines the total amount of innervational input?
Define Sherrington’s law and Hering’s law

- **Sherrington’s law**: Increased innervation to a muscle is accompanied by decreased innervation to its antagonist. Violated in Duane syndrome.

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Consider a pt with a paretic right lateral rectus (RLR).
Sherrington’s Law vs Hering’s Law

Consider a pt with a paretic right lateral rectus (RLR). As expected, his muscle balance is ET. What happens when he looks at an object to his right? If he fixates with his intact left eye, a normal, moderate amount of innervational input to the left medial rectus (LMR) is all that is required to get this eye into right gaze. And by Hering’s law, an equivalent moderate amount of innervation will be sent to the RLR.

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Next consider what happens if the pt fixates the same object of regard to his right, but this time with the paretic right eye. To get the paretic RLR to contract enough to cause the eye to ABduct, our pt must crank in a massive amount of innervational input. By Hering’s law, we know the same (massive) amount of innervation will be sent to the (intact) LMR, causing this eye to way over-adduct, thereby producing a large increase in the measured ET.

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The amount of strabismus present while the pt fixates with the nonparetic eye is called the primary deviation. Whereas the amount of present while the pt fixates with the paretic eye is called the secondary deviation. Hering’s law is the reason these measurements are not identical, and why the secondary deviation is always larger.

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OD fixating (= primary deviation)

Pt with left LR palsy
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**Sherrington’s Law vs Hering’s Law**

The amount present while the pt fixates with the paretic eye is called the secondary deviation. The amount present while the pt fixates with the nonparetic eye is called the primary deviation. Hering’s law is the reason these measurements are not identical, and why the secondary deviation is always larger.

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OK, but both eyes are pointing at the same thing. Why would it matter which is fixating?

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Pt with left LR palsy

OS fixating (= secondary deviation)
Define Sherrington’s law and Hering’s law, and for each state the classic example of a strabismus-type in which it is violated:

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The amount of strabismus present while the pt fixates with the nonparetic eye is called the **primary** deviation. The amount present while the pt fixates with the paretic eye is called the **secondary** deviation. **Hering’s law is the reason these measurements are not identical, and why the secondary deviation is always larger.**
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**OK, now back to a question about Sherrington’s law**
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**Q**

Briefly, what is Duane syndrome?

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Briefly, what is Duane syndrome?
An motility disorder with the following key findings:
- At least some limitation of movement
- Attempted movement causes the globe to up- or downshoot, and may cause it to this or that movement.

What is the cause?
The nucleus for cranial nerve VI is missing, and the lateral rectus is innervated by cranial nerve III.
Define Sherrington’s law and Hering’s law, and for each state the classic example of a strabismus-type in which it is violated:

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Briefly, what is Duane syndrome?
A motility disorder with the following key findings:
--At least some limitation of horizontal movement
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Horizontal movement limitation

Downshoot

Globe retraction

Upshoot

Primary

Downshoot

Upshoot/downshoot

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**Q/A**

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How does this dysinnervation result in the key findings listed above?
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When someone with an intact oculomotor system adducts an eye, Sherrington’s law dictates that innervation is increased to the medial rectus and decreased to the lateral rectus.
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The nucleus for cranial nerve VI is missing, and the lateral rectus is innervated by cranial nerve III.

**How does this dysinnervation result in the key findings listed above?**
When someone with an intact oculomotor system adducts an eye, Sherrington’s law dictates that innervation is increased to the medial rectus and decreased to the lateral rectus. However, in a Duane’s pt CN3 innervates the LR, so when she attempts to adduct her eye, innervation is increased to both the medial rectus and the aberrantly-innervated lateral rectus, so the eye doesn’t adduct. And when two muscles on opposite sides of the eye contract simultaneously, the net result will be that the eye will *retract*. Further, if this co-contraction is sufficiently vigorous, one or the other rectus muscle might ‘slip’ upwards or downwards, causing the eye to *up- or downshoot*. 
Define **Sherrington’s law** and **Hering’s law**, and for each state the classic example of a strabismus-type in which it is violated:

- **Sherrington’s law**: Increased innervation to a muscle is accompanied by decreased innervation to its antagonist
  - Violated in… **Duane syndrome**

- **Hering’s law**: Innervation to **yoke muscles** is equal
  - Violated in… **strabismic condition** (3 words)
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Who is the typical DVD pt?

A child with infantile/congenital ET or XT.

What is the classic clinical finding?

An eye will slowly elevate and extort, either spontaneously (manifest DVD) or when occluded (latent DVD). A crucial finding occurs when the drifting eye reorients downward, and it is this—the fellow eye does not move downward simultaneously (as would normally be the case).

How does Hering’s law relate to DVD?

As noted, in DVD the downward reorientation movement by the drifting eye is not accompanied by a downward movement of the fellow eye. As the muscles that depress the eyes are yoke muscles, this means that DVD represents a violation of Hering’s law.
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**Dissociated vertical deviation (DVD)**
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