

This slide deck was presented by Rick Maddock, MD as part of a dharma talk entitled “How perception and memory shape experience: Converging views from neuroscience and early Buddhist teachings,” presented at Sacramento Insight Meditation on March 16, 2023.

The Five Aggregates (Skandhas)

1. **Rupa** = form.

This refers to the body and the experience of materiality in general.

2. **Vedanā** = feeling tone.

This mainly refers to the spectrum of basic feeling tones ranging from pleasant, through neutral, and to unpleasant.

3. **Sanña** = recognition or ***perception***.

This refers to how we “make sense” of our experiences.

4. **Saṅkhāra** = intention or fabrication or choices.

This refers to the intentions that lead to thoughts, speech and actions.

Saṅkhāras give rise to reactions or responses to our experiences.

5. **Viññāṇa** = consciousness or awareness.

This enables awareness of direct experience.

The Five Aggregates (Skandhas)

1. **Rupa** = form.

This refers to the body and the experience of materiality in general.

➤ 2. **Vedanā** = feeling tone.

Valuation

This mainly refers to the spectrum of basic feeling tones ranging from pleasant, through neutral, and to unpleasant.

➤ 3. **Sanñā** = recognition or perception.

Perception

This refers to how we “make sense” of our experiences.

➤ 4. **Saṅkhāra** = intention or fabrication or choices. **Intention**

This refers to the intentions that lead to thoughts, speech and actions. Saṅkhāras give rise to reactions or responses to our experiences.

5. **Viññāṇa** = consciousness or awareness.

This enables awareness of direct experience.

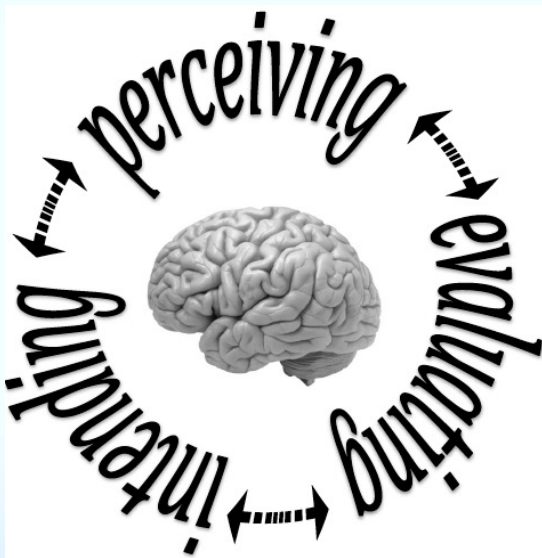
The brain is the organ of behavior.

Three main functions are required to effectively govern behavior:

Making sense of what is happening,

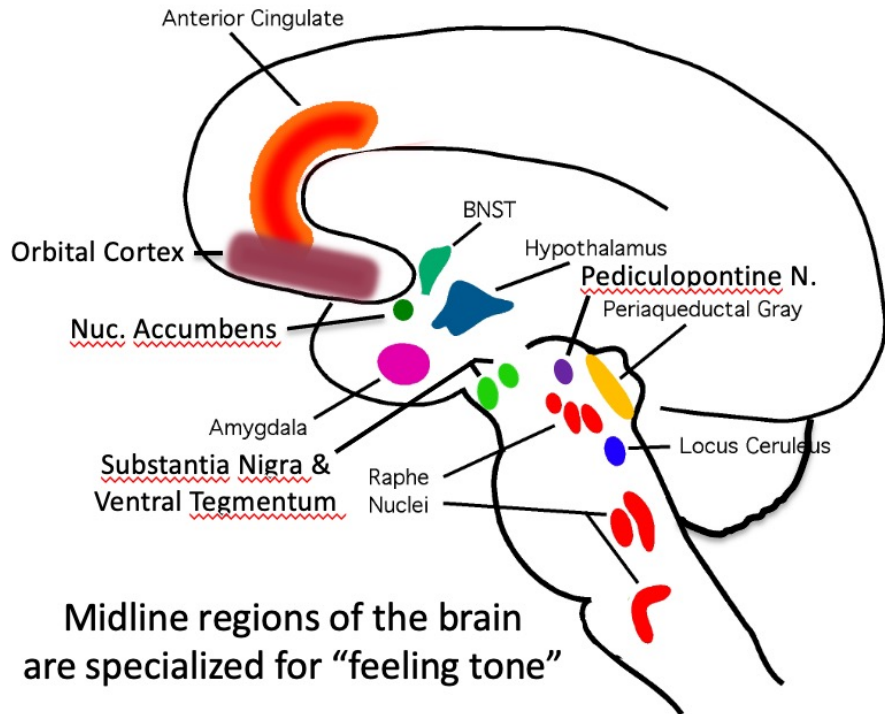
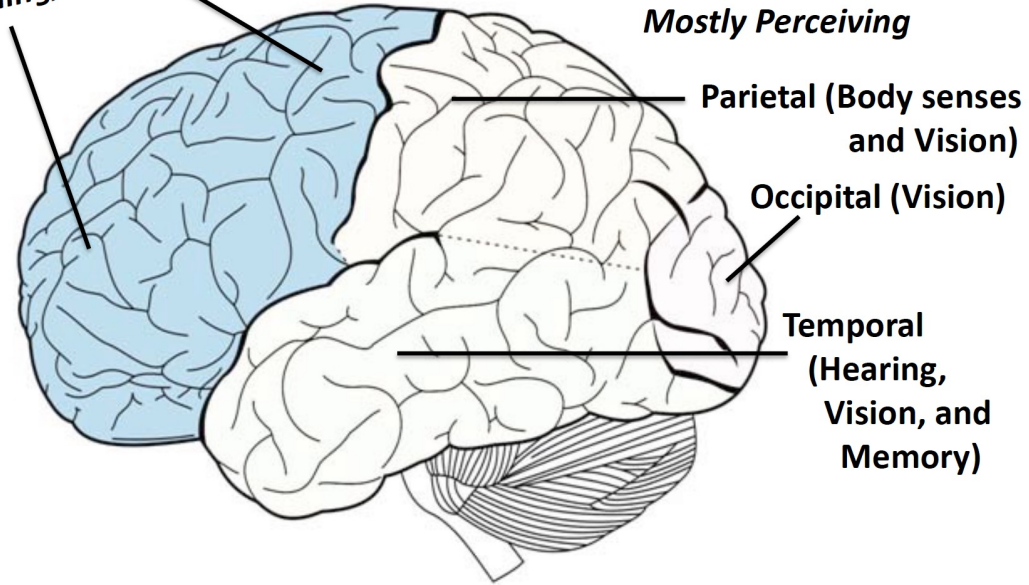
Caring appropriately about what is important or valued,

Taking actions to optimize what's important, given what's happening.



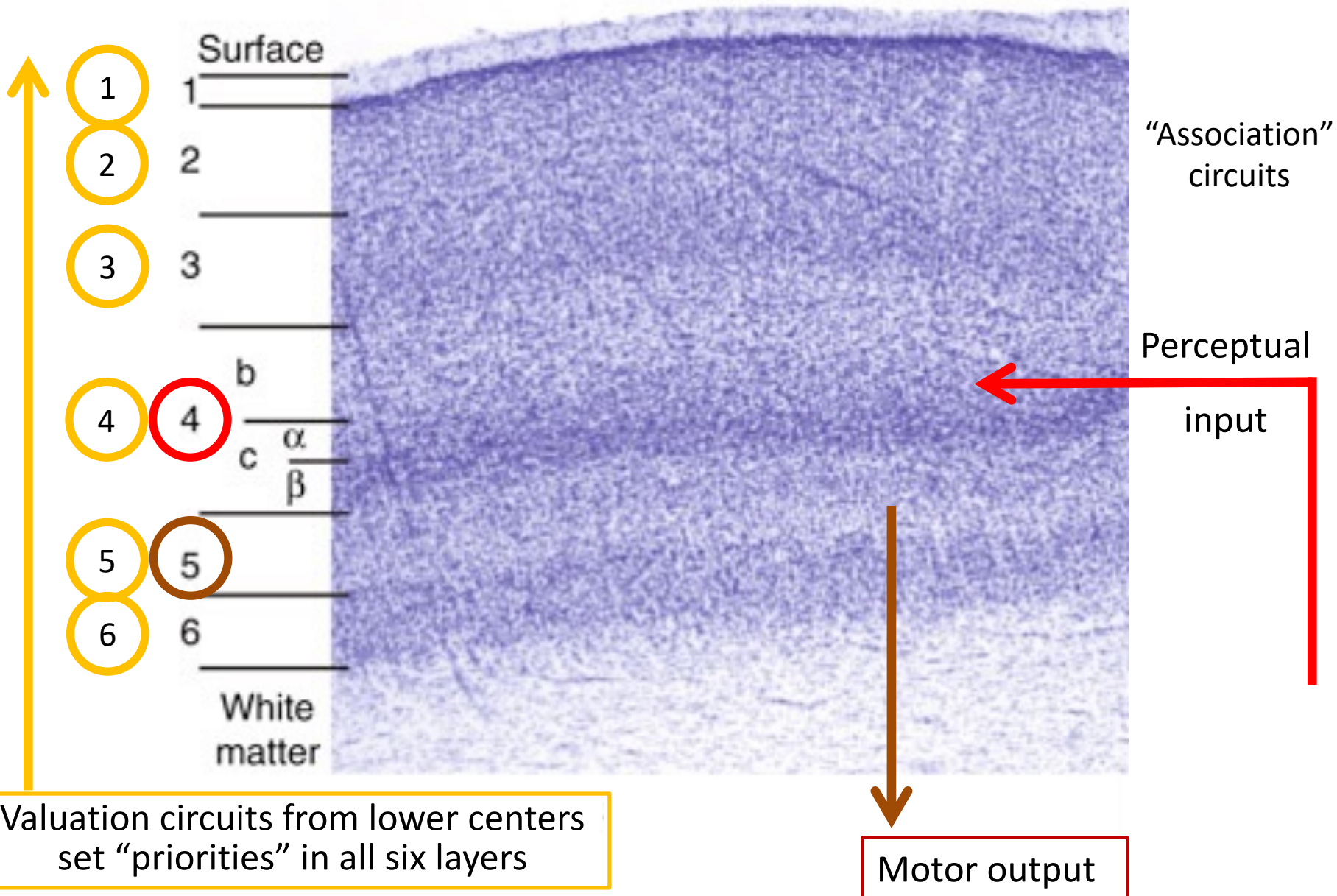
Frontal Cortex
Mostly Planning,
Intending, Behaving

Posterior Cortices
Mostly Perceiving



Midline regions of the brain
are specialized for "feeling tone"

Perception & Intention are in distinct cortical layers. Valuing influences all layers.



The Five Aggregates *Susceptible to Clinging*

1. **Rupa** = form. This refers to the body and to materiality in general.

2. **Vedanā** = feeling tone.

This mainly refers to the spectrum of basic feeling tones ranging from pleasant, through neutral, and to unpleasant.

3. **Sanñā** = recognition or perception.

This refers to how we “make sense” of our experiences.

4. **Saṅkhāra** = intention or fabrication or choices.

This refers to the intentions that give rise to thoughts, speech and actions. Saṅkhāras impel how we react or respond to our experiences.

5. **Viññāṇa** = consciousness or awareness.

This enables awareness of direct experience.

The Vipallasa sutta (AN 4.49) excerpts:

These four, O Monks, are **distortions of perception**, distortions of thought, distortions of view...

Sensing no change in the changing, Sensing pleasure in suffering,
Assuming "self" where there's no self, Sensing the un-lovely as lovely —
Gone astray with wrong views, beings Mis-perceive with distorted minds.

...When those with wisdom have heard this [*dharma*], They recuperate their right mind:

They see change in what is changing, Suffering where there's suffering,
"Non-self" in what is without self, They see the un-lovely as such.

By this acceptance of right view, They overcome all suffering.

- Transl. by Olendski

In: The Nibbana Sutta (AN 4.179)

Ananda asks Sariputta why some people become fully free in the present life. Sariputta replies:

"it's because some sentient beings truly understand
which perceptions make things worse,
which keep things steady,
which lead to distinction,
and which lead to penetration."

(transl. by Ajahn Pasanno in The Island)

Neuroscience Perspectives on Perception

The evolved function of perception:

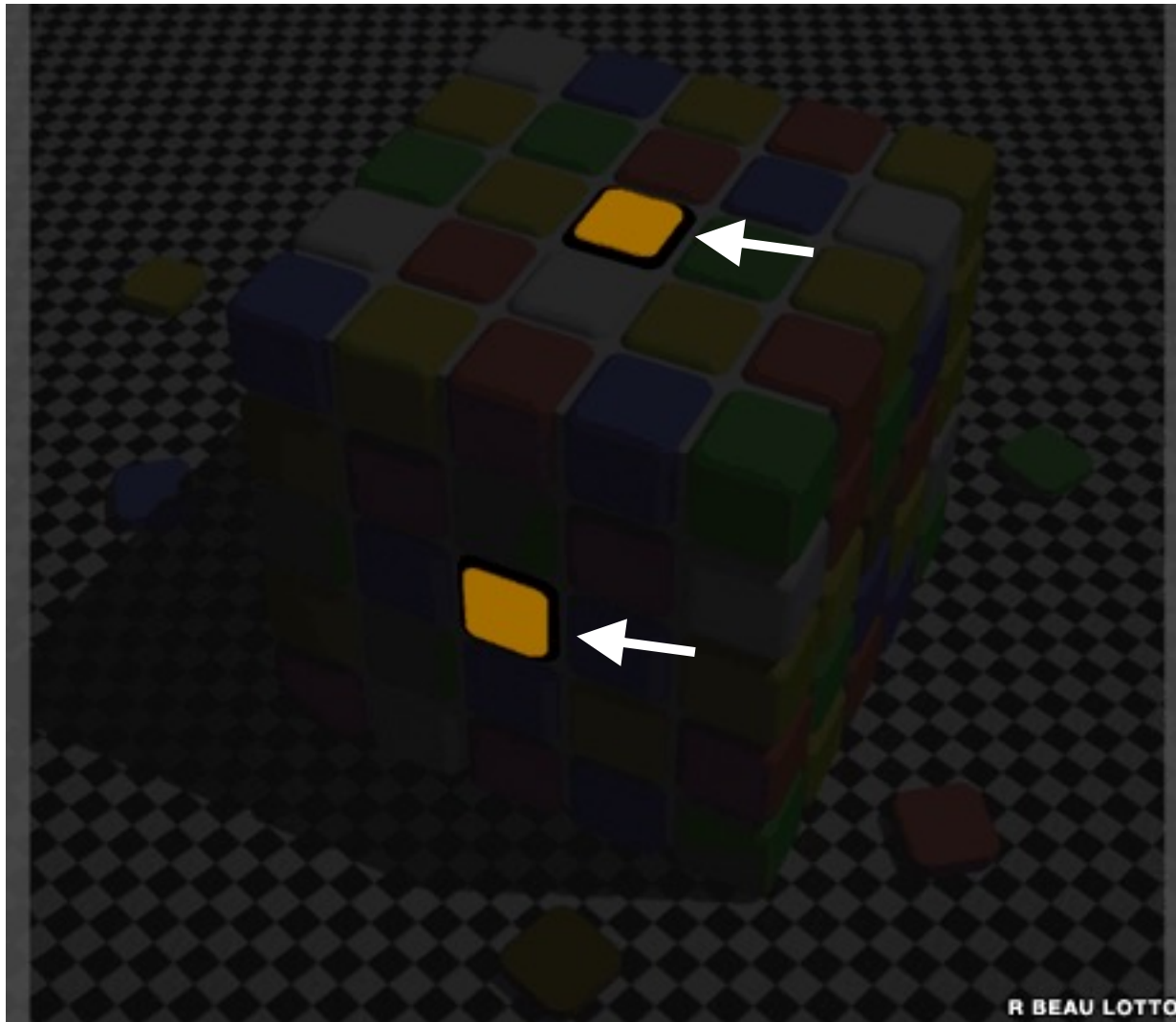
To construct representations of the world that can guide adaptive behavior.

Perception constructs “meaning” from our interactions with the world.

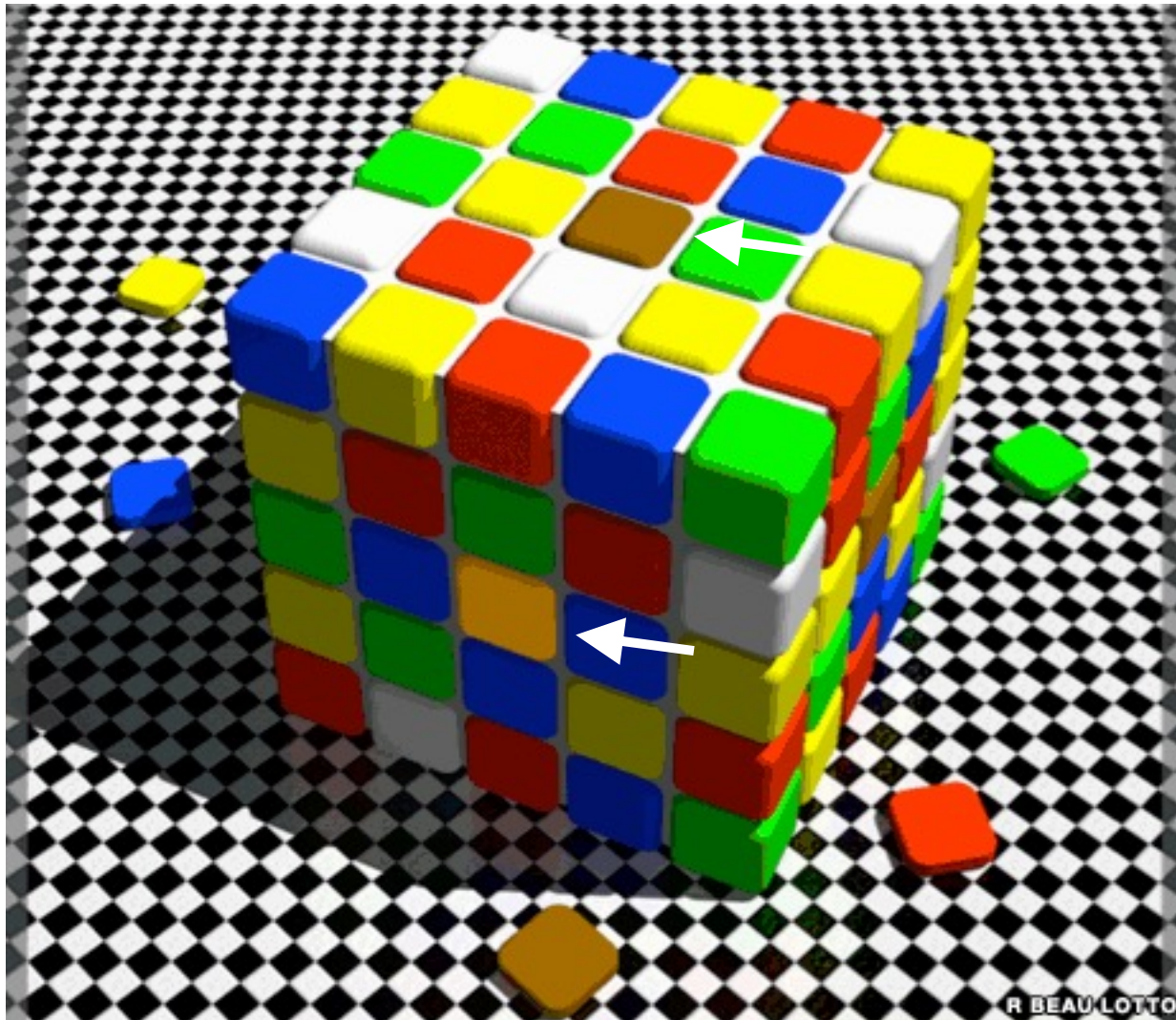
“Meaning” guides our behavior.

→ Utility is prioritized over Accuracy

Against a dark background, we see two tiles identical in color and brightness. What happens if we change the context (and thus the meaning)?

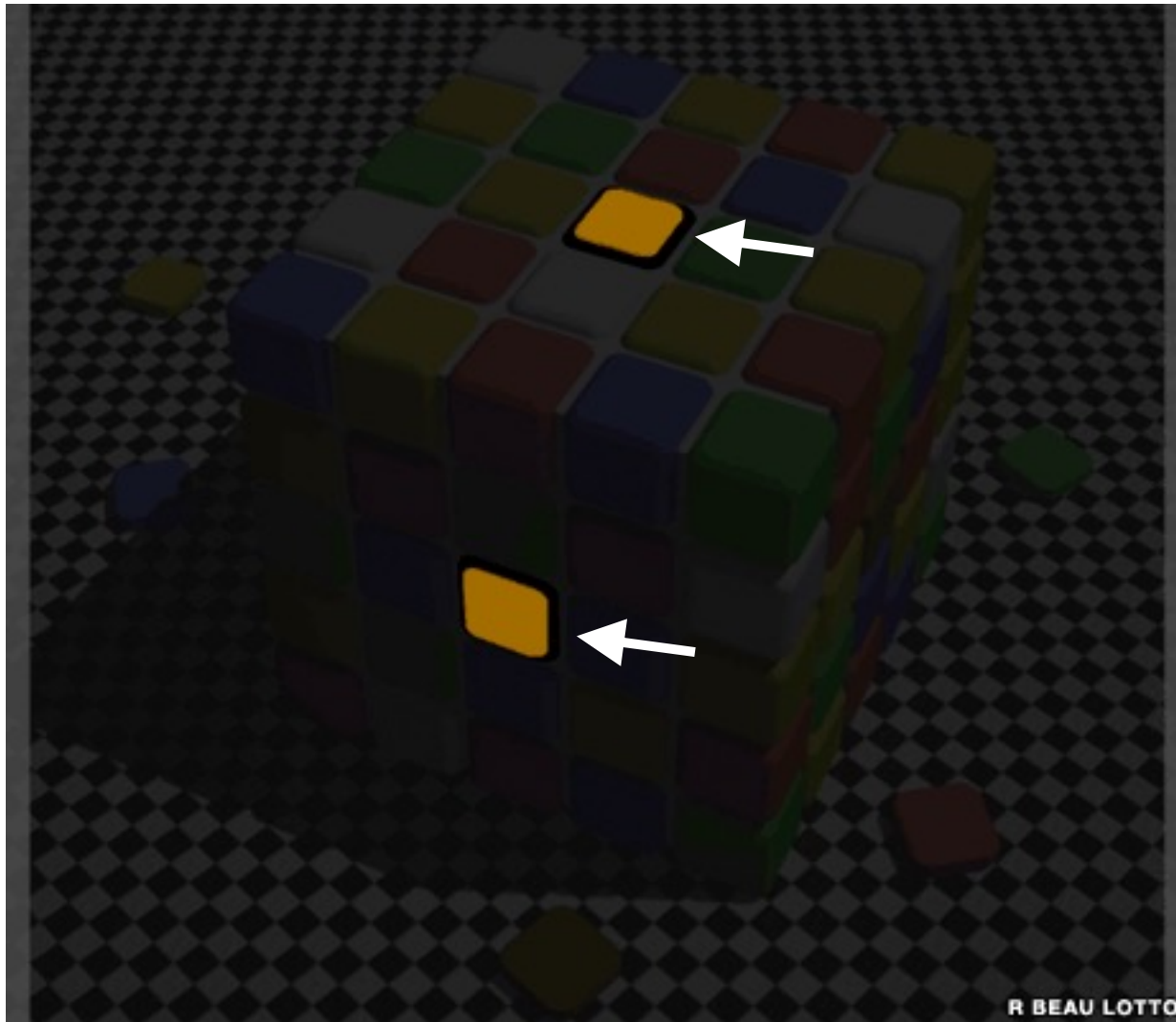


Now the top tile is *perceived* as much darker than the bottom tile.

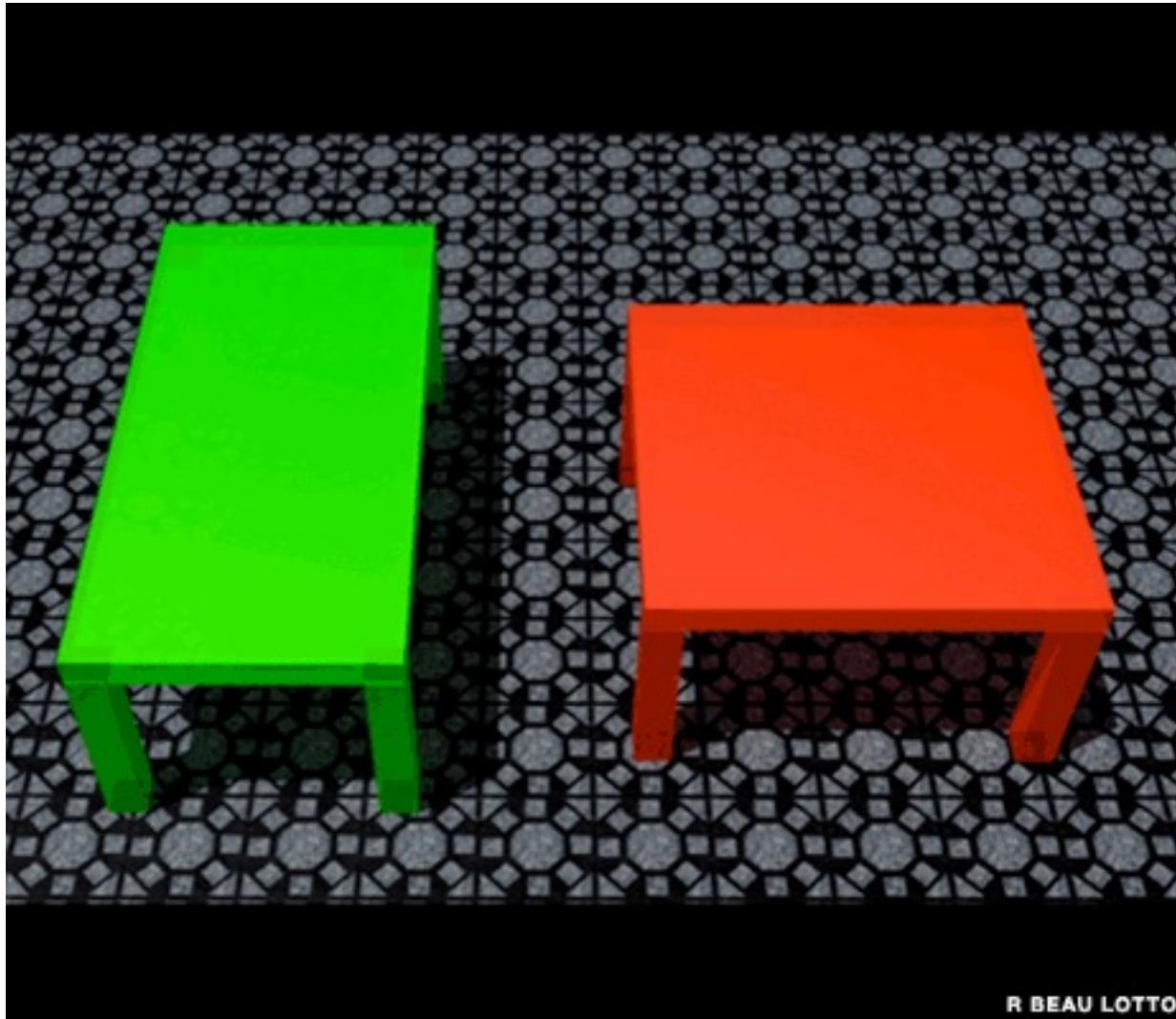


The context strongly suggests that the tile on the top *means* a dark tile under bright light, while the one on the side *means* a bright tile in shadow.

Again, here we see the color alone, without “meaning” imposed from within the brain by other processing circuits

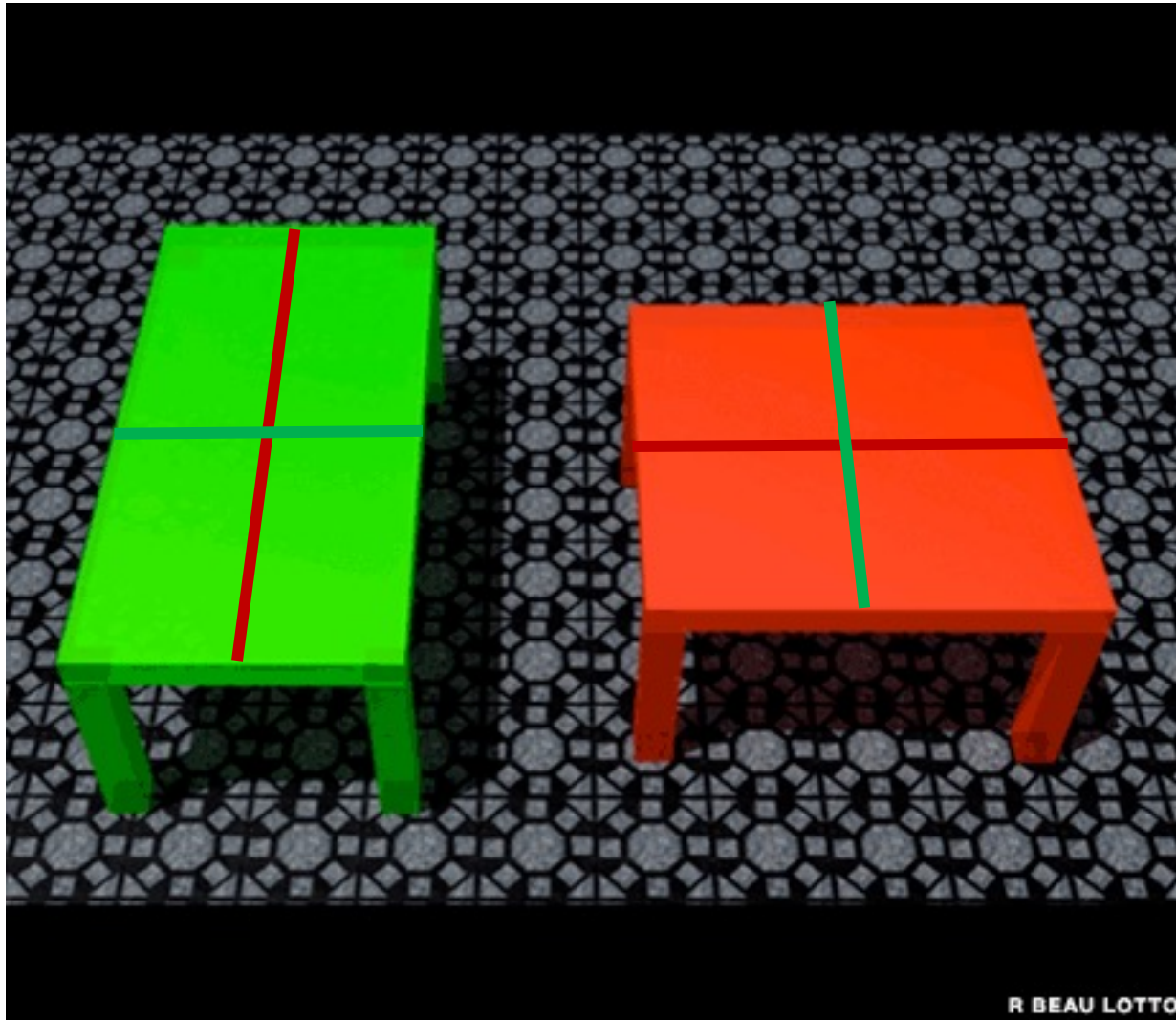


Do these two tables have different dimensions, or the same dimensions rotated 90°?

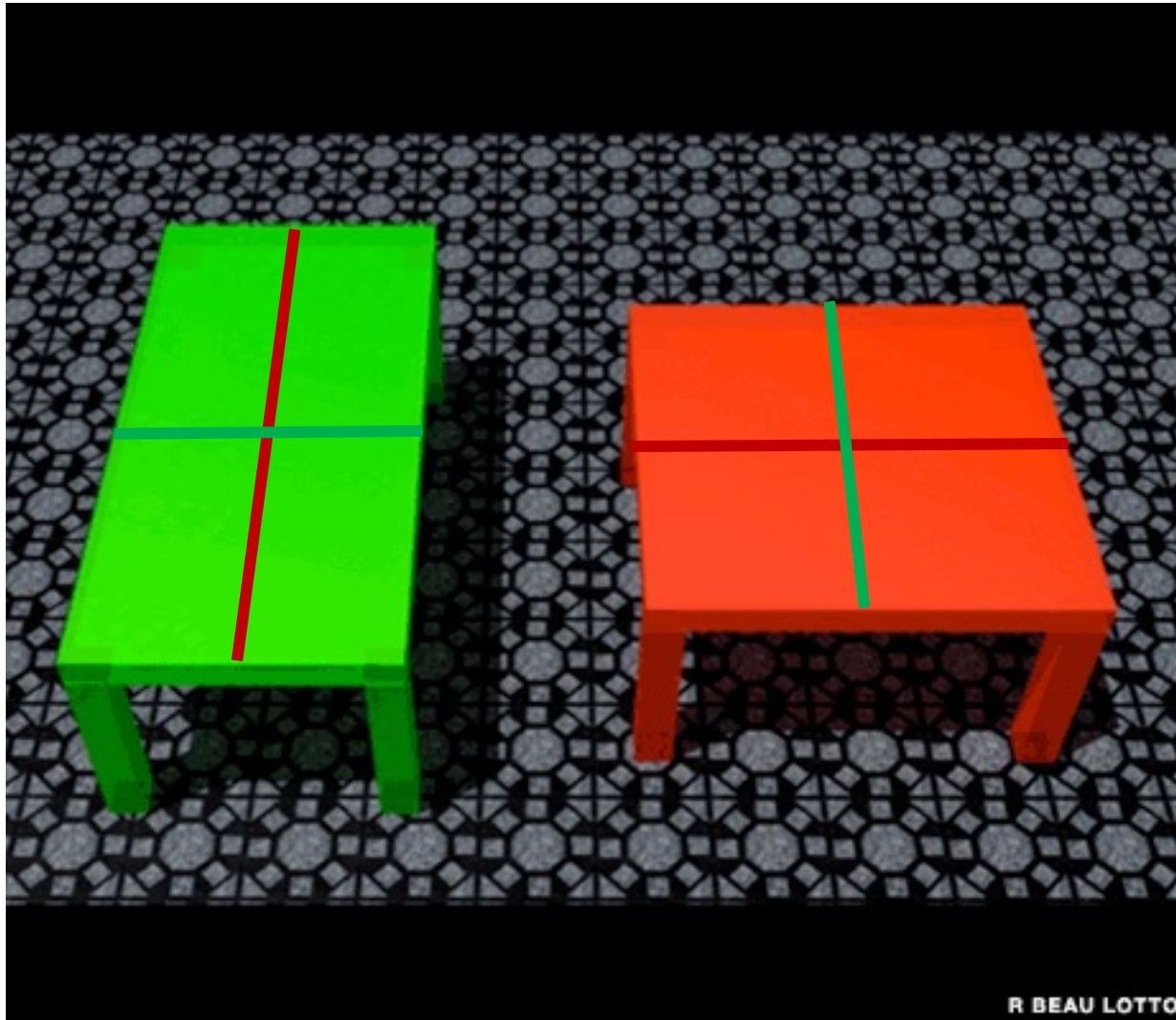


The red line is the left table's length AND the right table's width.
The green line is the left table's width AND the right table's length.
The two tables have the same dimensions, just rotated 90°

2.3"
1.7"



Changing the **angles** at their **corners** suggests depth & perspective.
We “know” greater distance makes things appear smaller,
so we expand them in our mind.

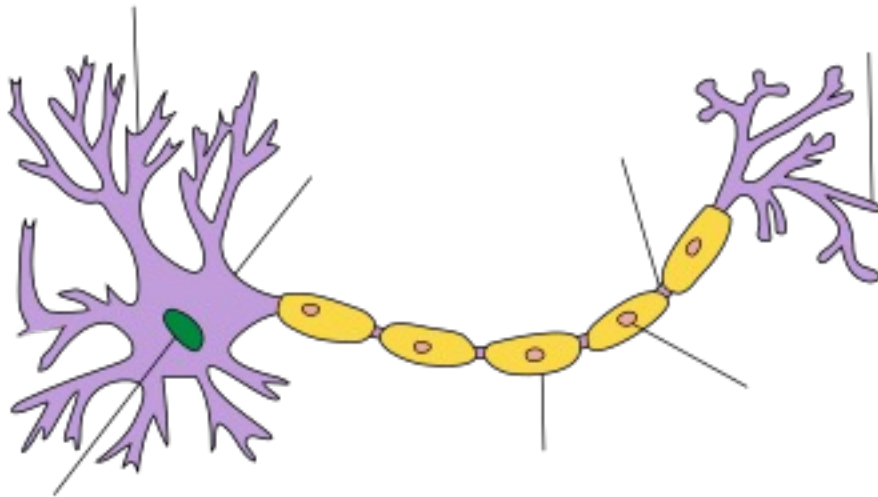


Simple overview of a neuron (brain cell)

**Input is received
at one end**

**Output is delivered
via the other end**

**Simplified representation
of a neuron for diagrams**



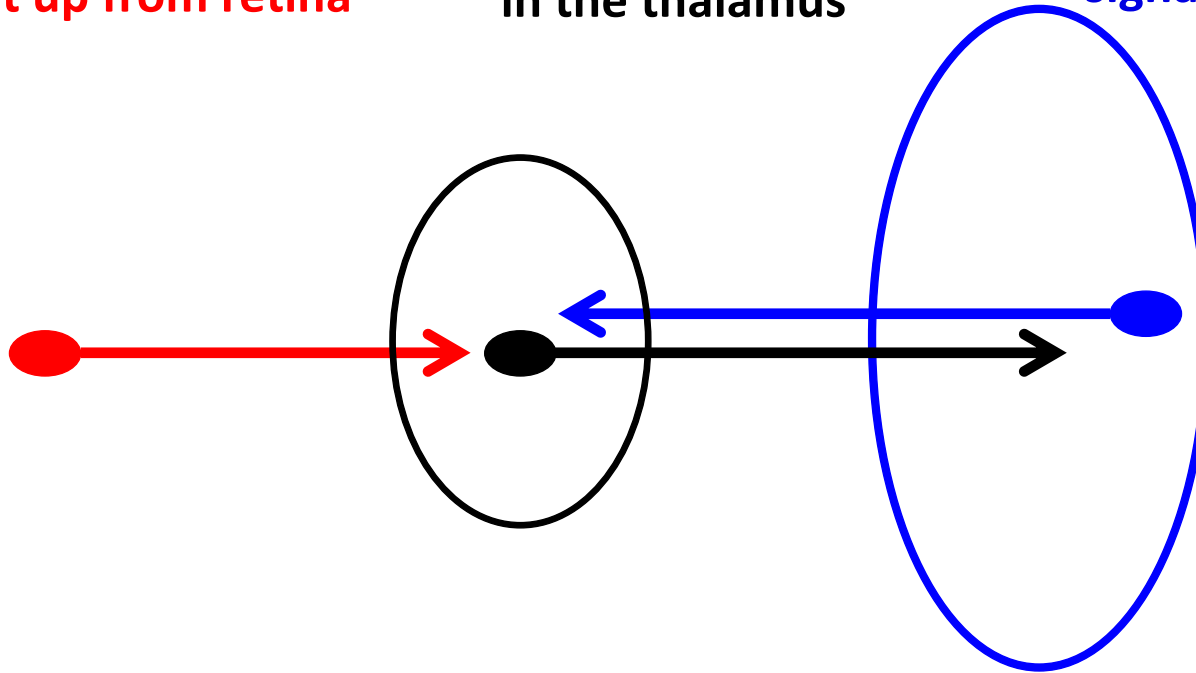
Perceptions are built from external AND internal information

example of vision

**Neurons bring
input up from retina**

**Input is processed
in the thalamus**

**visual cortex receives
signals from thalamus**



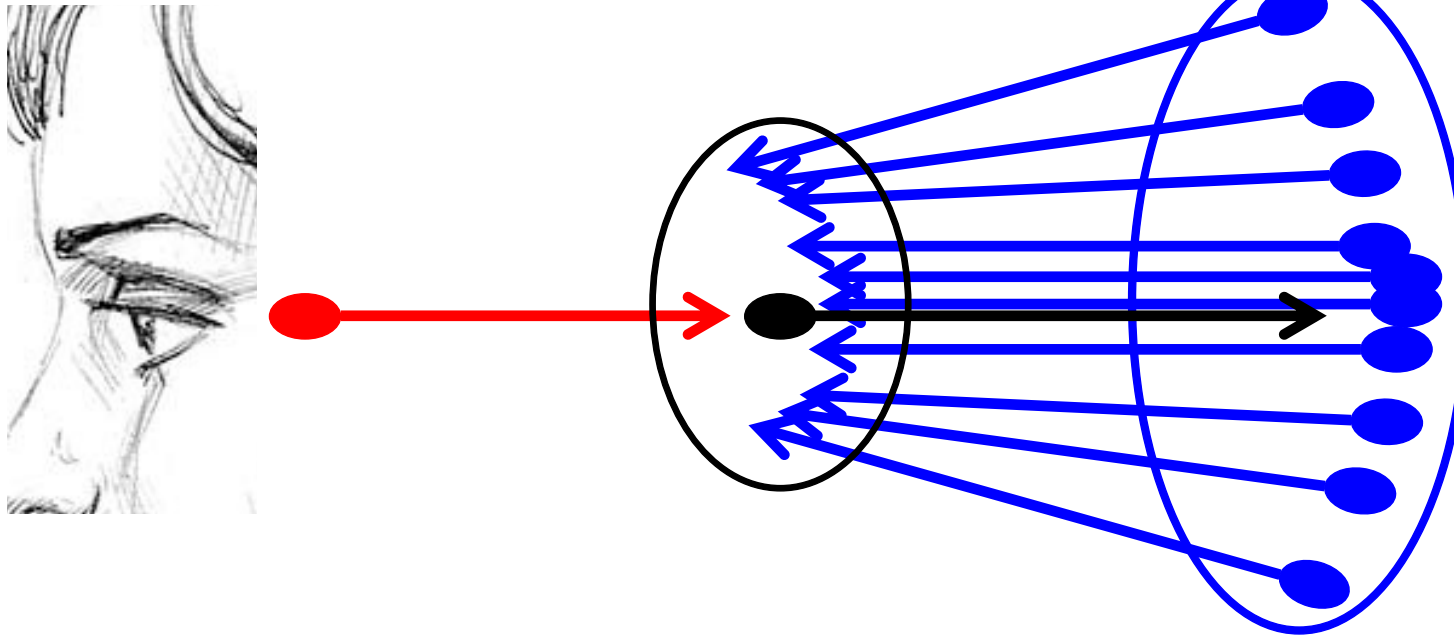
**Using prior knowledge, visual cortex
modifies incoming signal to thalamus**

Internal information **predominates** construction of meaning

**Neurons bring
input up from retina**

**Input is processed
in the thalamus**

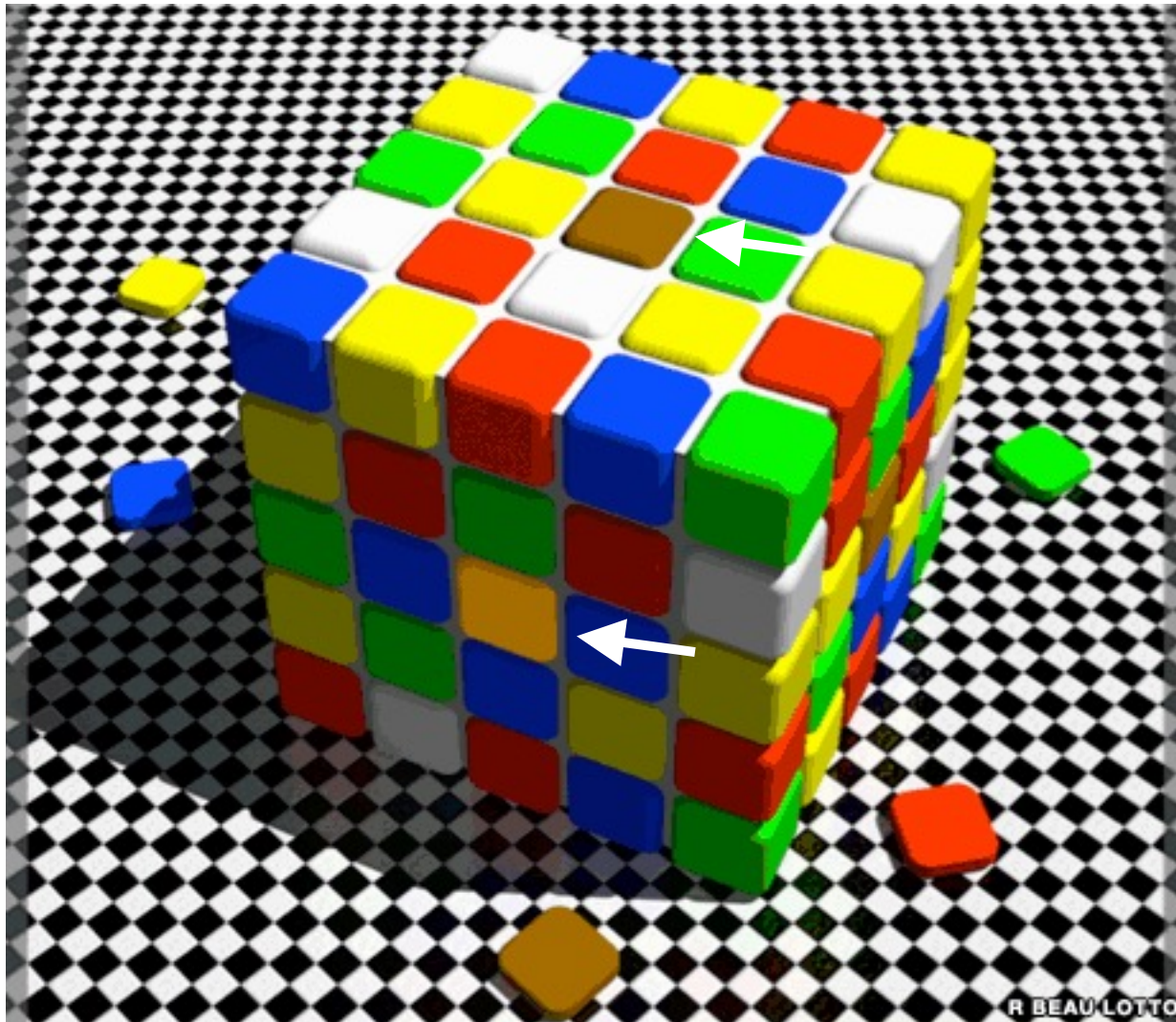
**visual cortex receives
signals from thalamus**

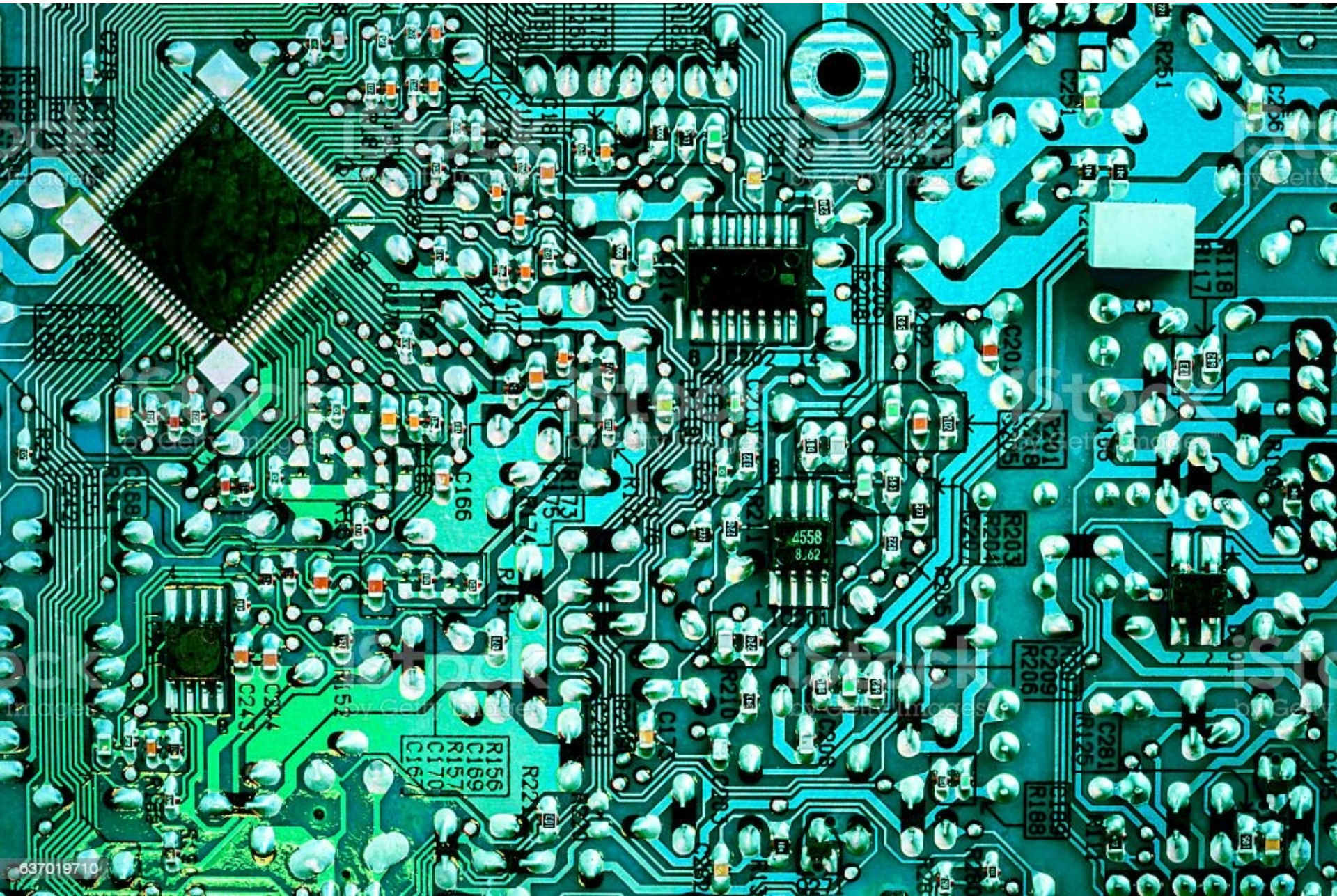


**> TEN neurons bring internally generated information from
visual cortex to modify visual processing for ONE neuron from thalamus**

> 10:1 ratio of modifying neurons to incoming sensory neurons for ALL senses

What we perceive is not "just what is there", but more like "what should be there," based on what we already "know".





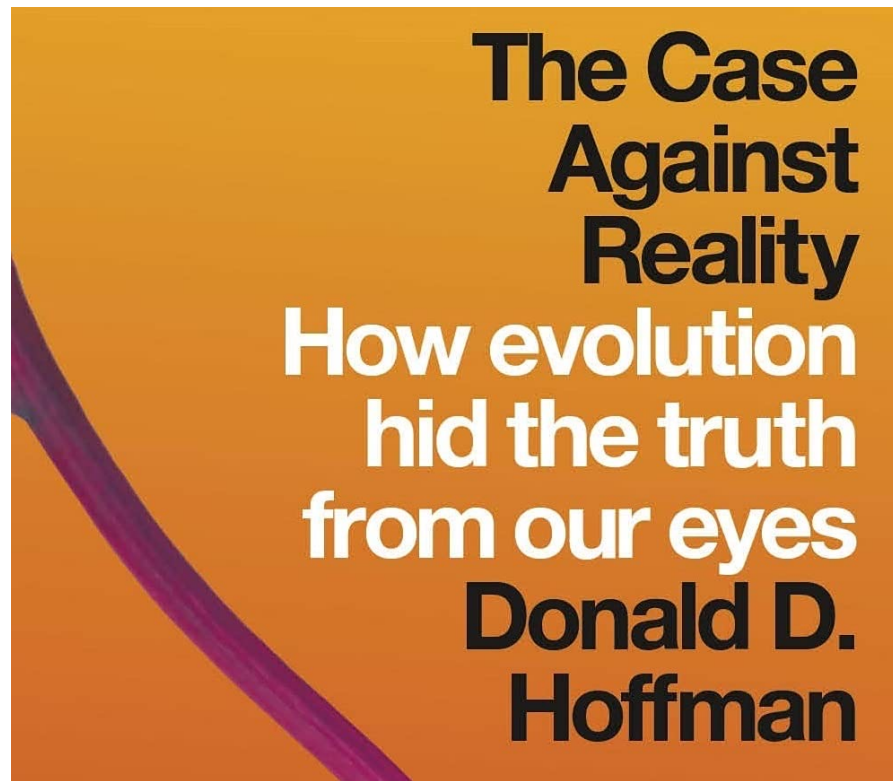
Perceptions -
to be taken seriously but not literally



OP



Recycle Bin



In mathematical models of evolution by natural selection, Hoffman and others show that perceiving only what affects our “fitness” always outcompetes perceiving the whole truth.

Patient MM

(lost sight at age 3½, surgically restored at age 43)

Right after surgery, he couldn't make sense of what he saw.
Over several weeks and months, he learned to “see” again.

Patient MM

(lost sight at age 3½, surgically restored at age 43)

He had been an expert skier while blind.

After surgery, he initially preferred to ski with eyes closed.

With eyes open, he was afraid he would run off course.



After 2 years, he skied eyes open on all but the most difficult slopes.
He now uses his eyes in everyday life, but with limitations.

“The difference between today and over 2 years ago is that I can better guess at what I am seeing. What is the same is that I am still guessing.”



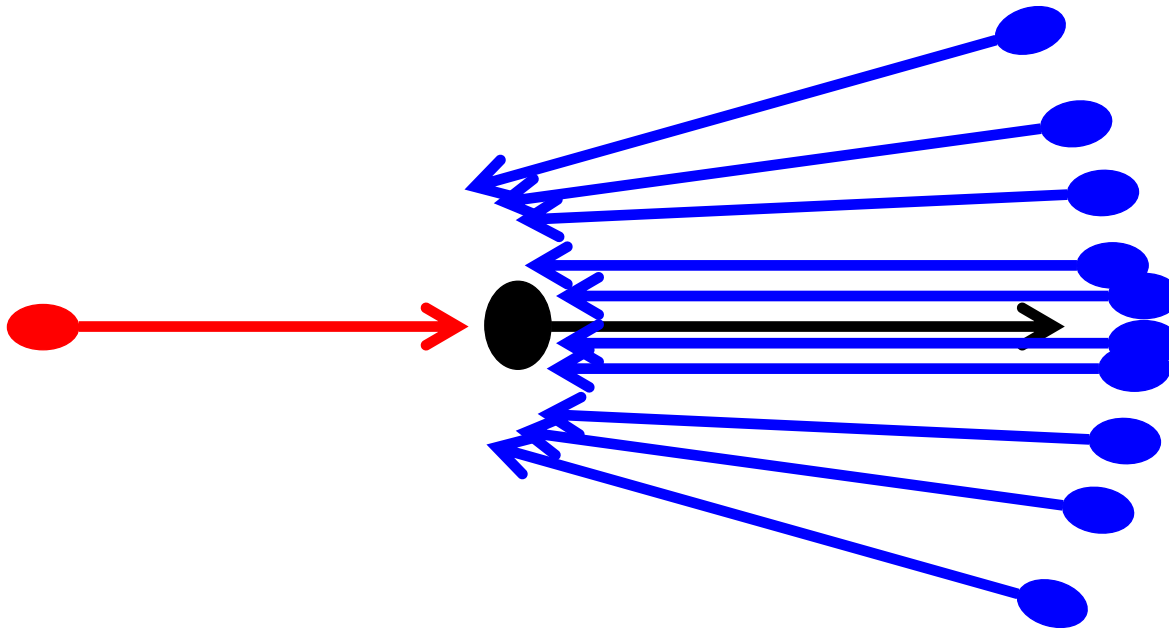
In children who lose and later regain sight, they recover good vision in a few weeks (unlike adults).

They successfully reconstruct the internal maps needed for organizing visual information.

Neuron from retina

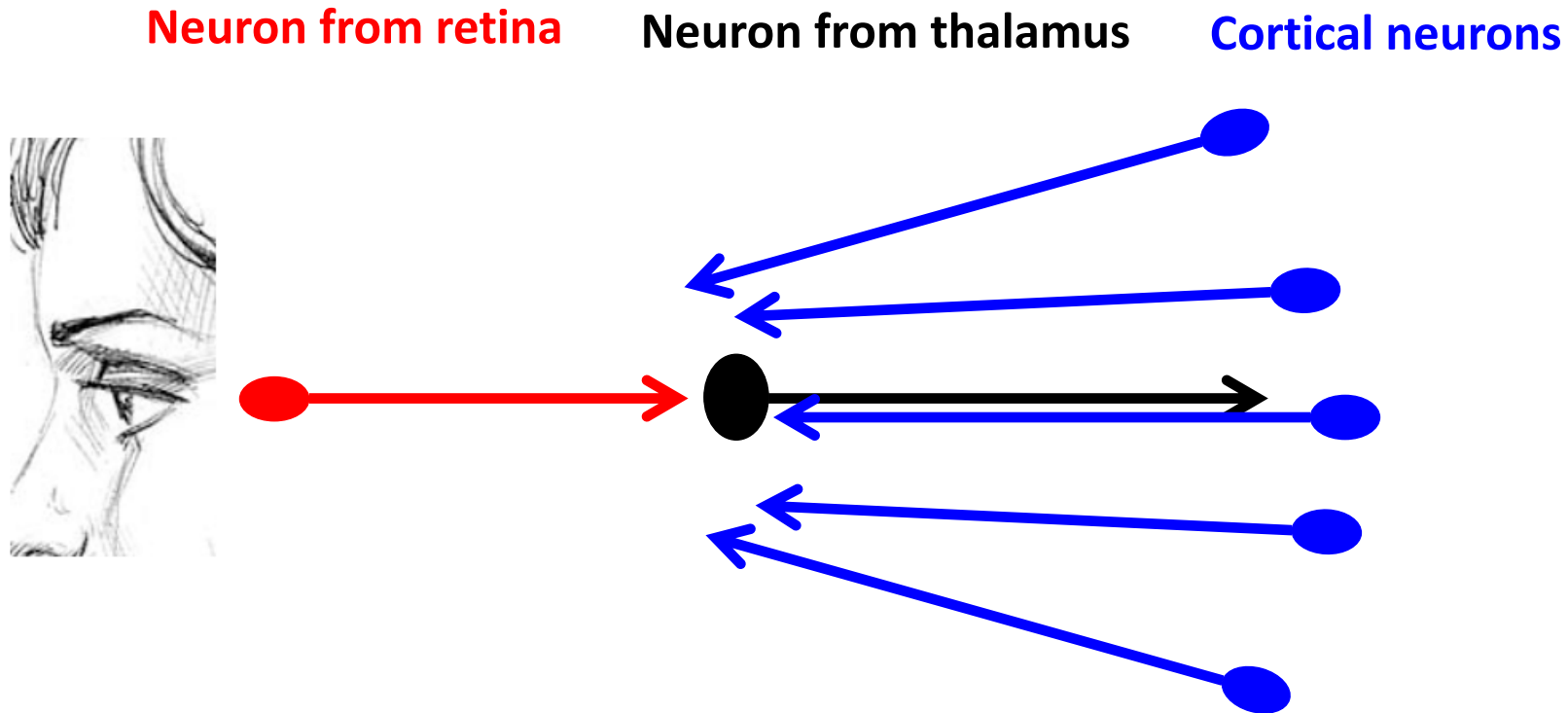
Neuron from thalamus

Cortical neurons



In adults with recovered vision, this process is slower and less complete.

The internal maps are only partially rebuilt.



The internal information circuits can construct perceptions even when minimal external information is present.

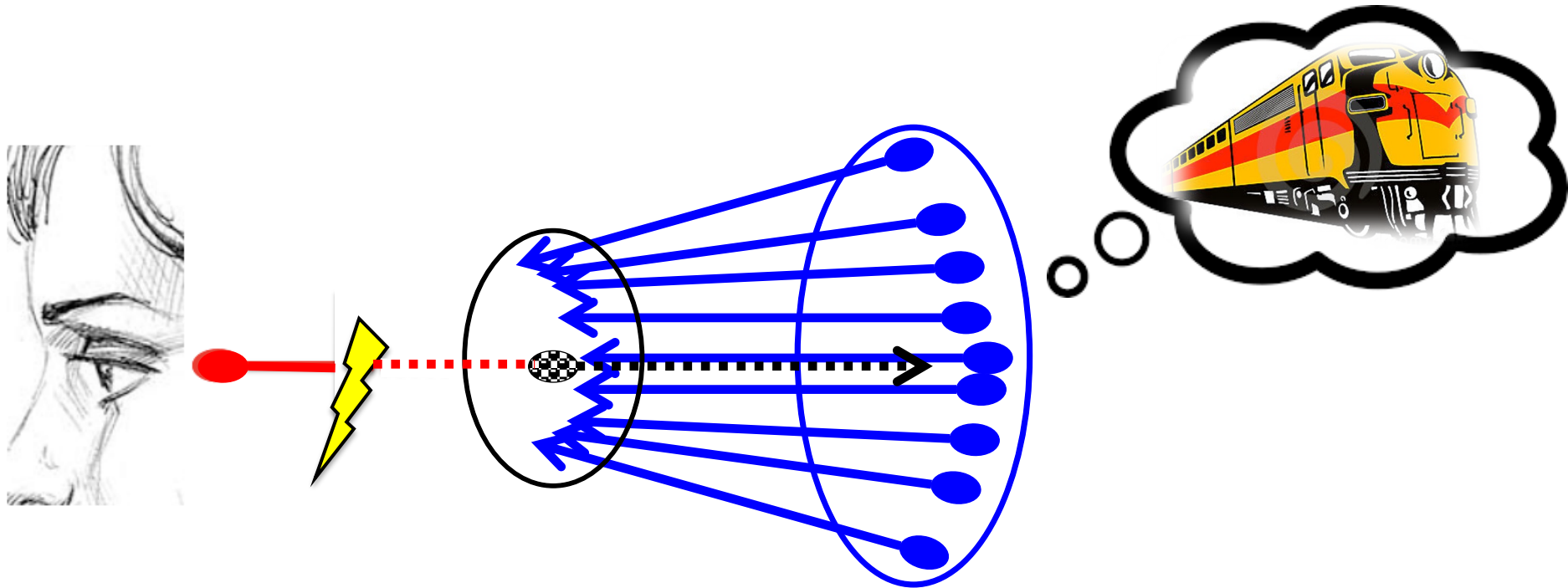
In such cases, they can create problems.

An 82 year-old man with a history of progressive macular degeneration, recently reached the point of functional blindness.

He described new onset, nearly constant, vivid, and distressing visual hallucinations, such as a train or a truck barreling through his apartment.

Charles Bonnet Syndrome

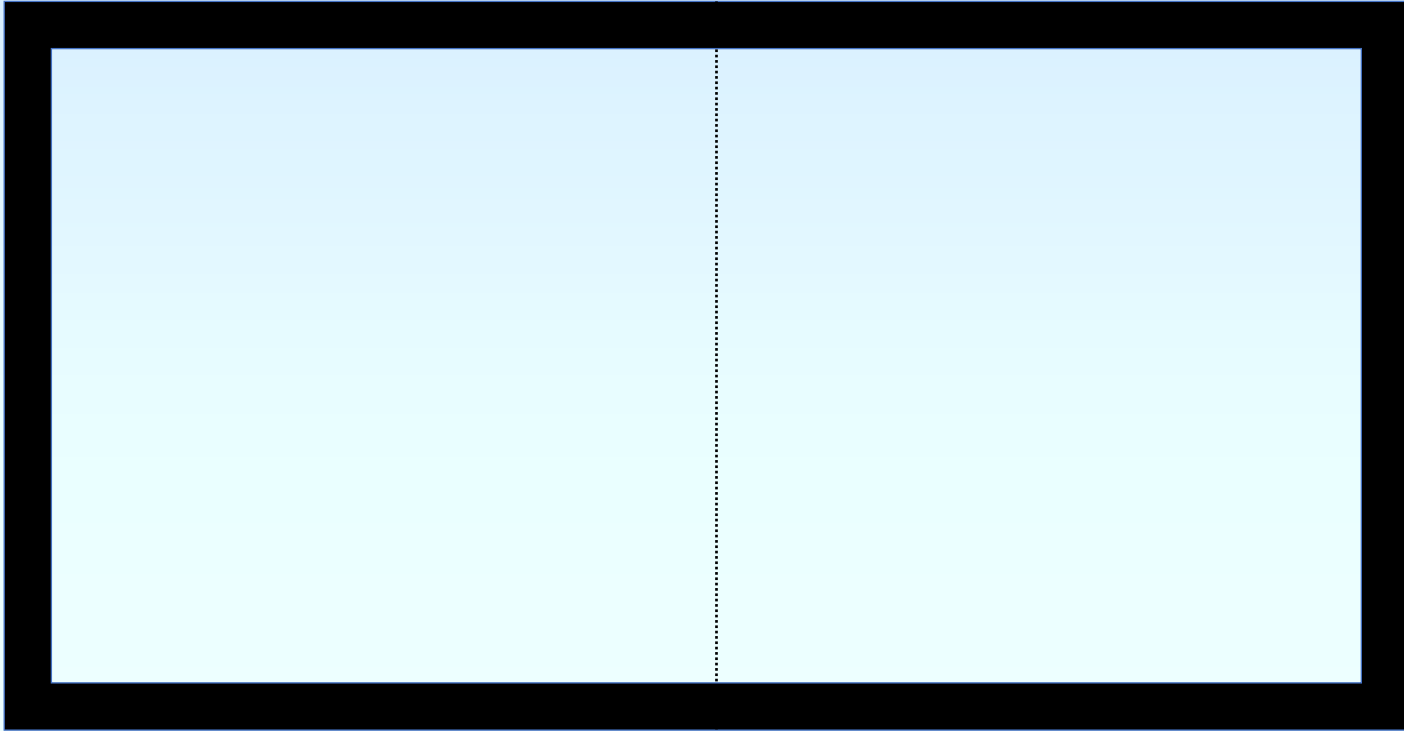
Visual hallucinations following visual impairment



Occurs in 10-40% of people after major visual impairment,
typically occurs in older persons.

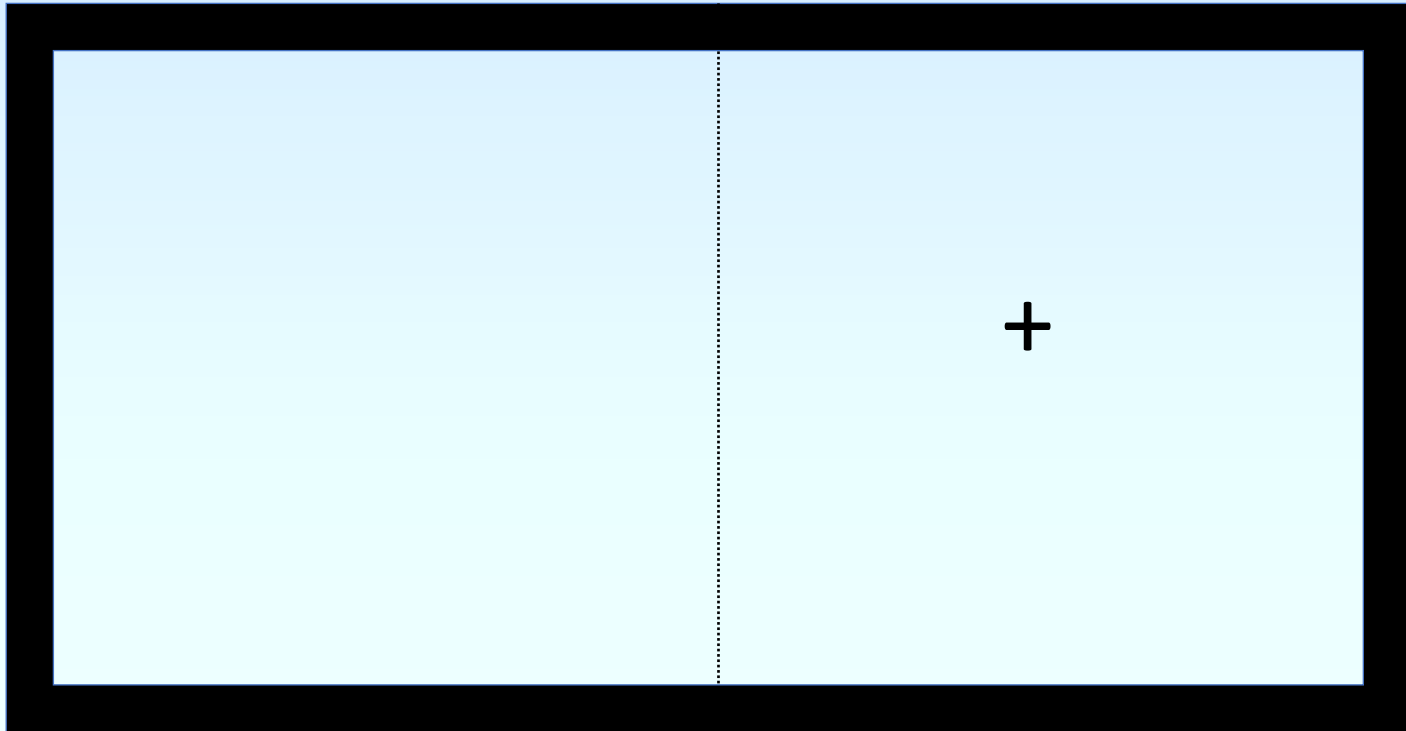
Helped by social dialogue, ***education***, reassurance

A computer unpredictably presents a target,
either on the Right or Left



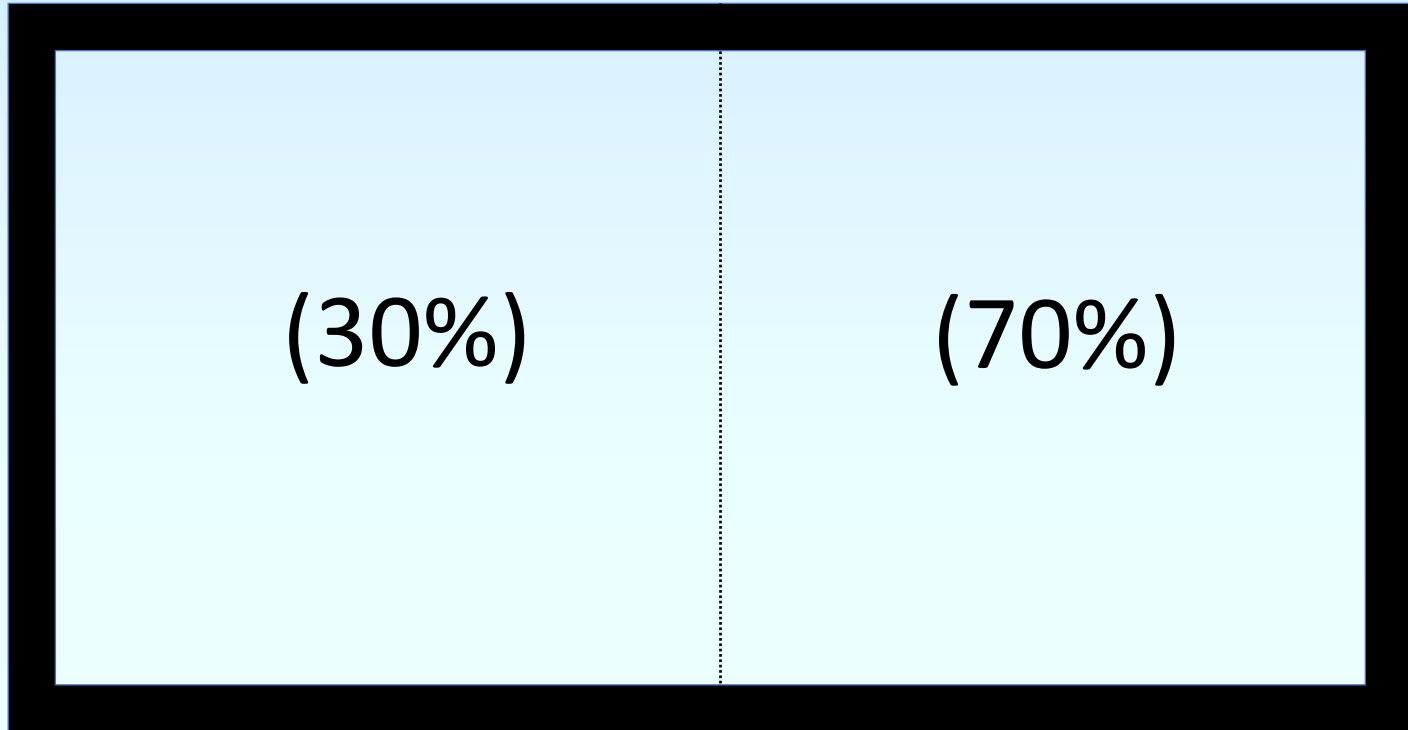
Guess where the target will appear and get a reward!

A computer unpredictably presents a target,
either on the Right or Left

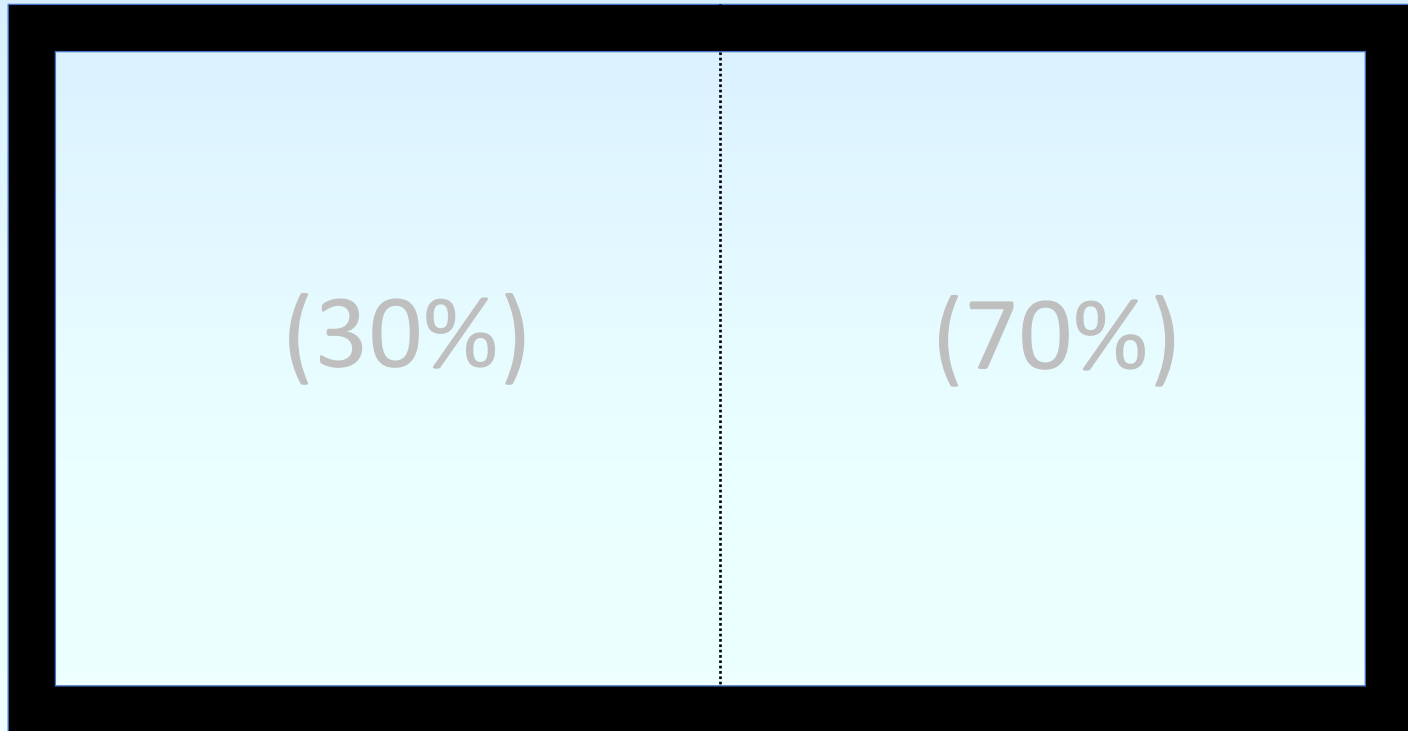


The target appeared on the Right!

Over time, 70% of targets appear on the Right
and 30% appear on the Left

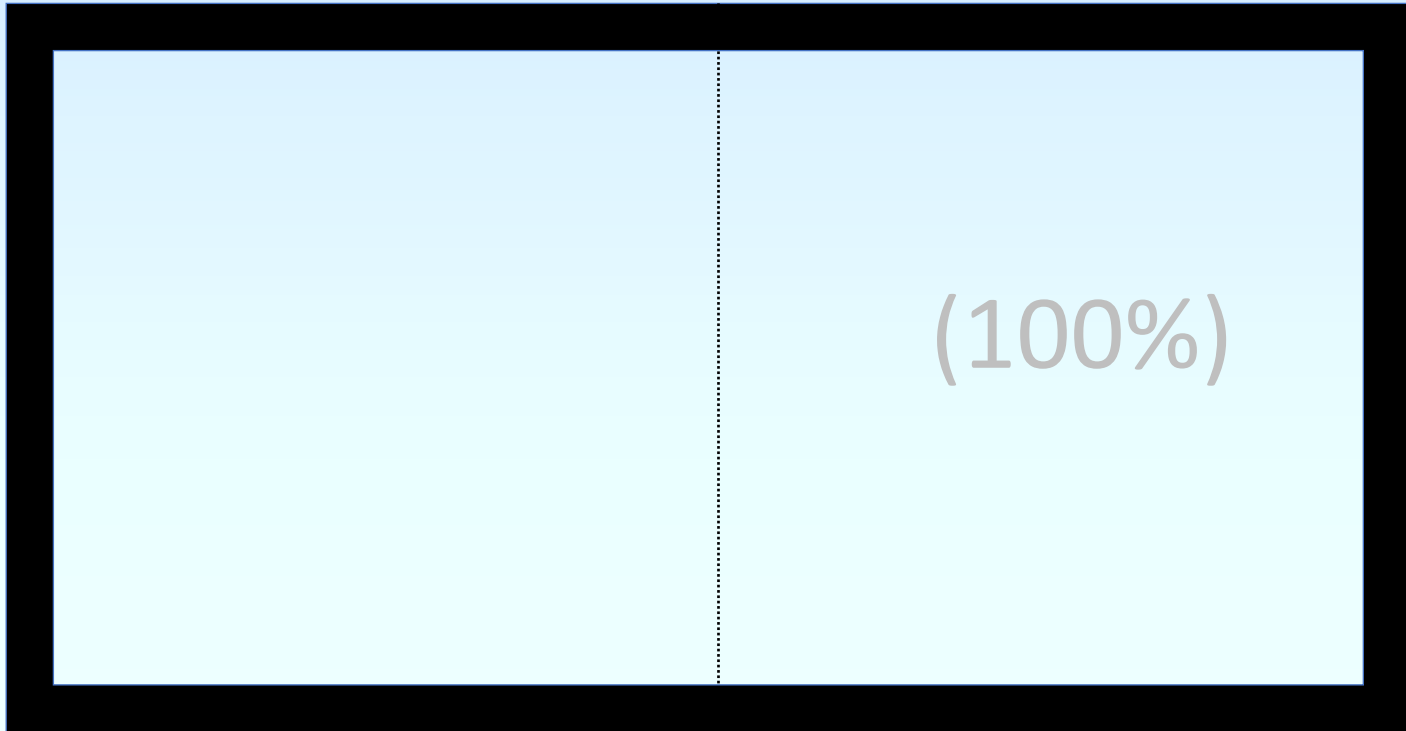


Now guess where the target will appear!



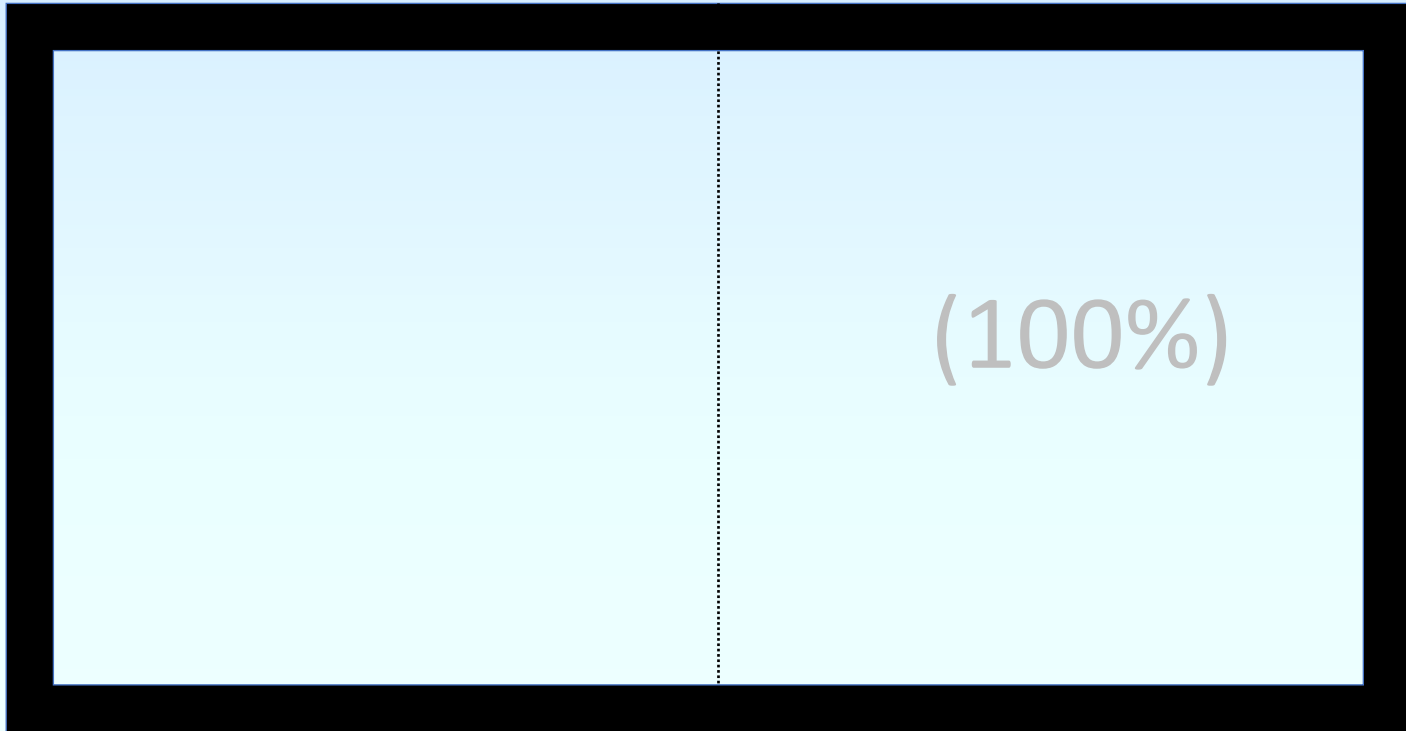
Humans *discern the pattern* and are guided by it,
guessing **left 30%** and **right 70%**

Animals do not impose the 30%/70% pattern.
They are guided by “**right is better than left.**”



Animals simply guess “right” 100% of the time

Animals do not impose the 30%/70% pattern.
They are guided by “**right is better than left.**”



Animals get rewarded on **70% of trials**
Humans get rewarded on **58% of trials**
(we just can't help ourselves!)

- from **Foam Sutta**, SN 22.95 – excerpt transl. by Thanissaro Bhikkhu

"Now suppose that in the last month of the hot season a mirage were shimmering, and a man with good eyesight were to see it, observe it, & appropriately examine it. To him it would appear **empty, void, without substance**: for what substance would there be in a mirage?

In the same way, a monk sees, observes, & appropriately examines any perception... To him it would appear **empty, void, without substance**: for what substance would there be in perception?"

In: The Nibbana Sutta (AN 4.179)

Ananda asks Sariputta why some people become fully free in the present life. Sariputta replies:

"it's because some sentient beings truly understand
which perceptions make things worse,
which keep things steady,
which lead to distinction,
and which lead to penetration."

(transl. by Ajahn Pasanno in The Island)

Blue Cliff Record -*case 14* (A classic Zen text)

A monk asked Yunmen, “What is the work of a Buddha’s whole life?”
Yunmen replied, “An appropriate response.”

Penetrative Sutta -*AN 6.63* excerpt (Thanissaro)

"Intention, I tell you, is kamma.

Intending, one does kamma by way of body, speech, & intellect."

Sutta on the Two Kinds of Thought -MN 19 (Sujato)

Whatever a mendicant frequently thinks about and considers becomes their heart's inclination. ...

If they often think about and consider malicious thoughts ... their mind inclines to malicious thoughts.

If they often think about and consider cruel thoughts ... their mind inclines to cruel thoughts. ...

Whatever a mendicant frequently thinks about and considers becomes their heart's inclination. ...

If they often think about and consider thoughts of good will ... their mind inclines to thoughts of good will.

If they often think about and consider thoughts of harmlessness ... their mind inclines to thoughts of harmlessness. ...

Basic principle of learning

from Donald Hebb, 1949

“Neurons that fire together wire together.”

Instructions to Rahula at Mango Stone - MN 61 (Thanissaro)

"What do you think, Rahula: **What is a mirror for?**" "**For reflection, sir.**"

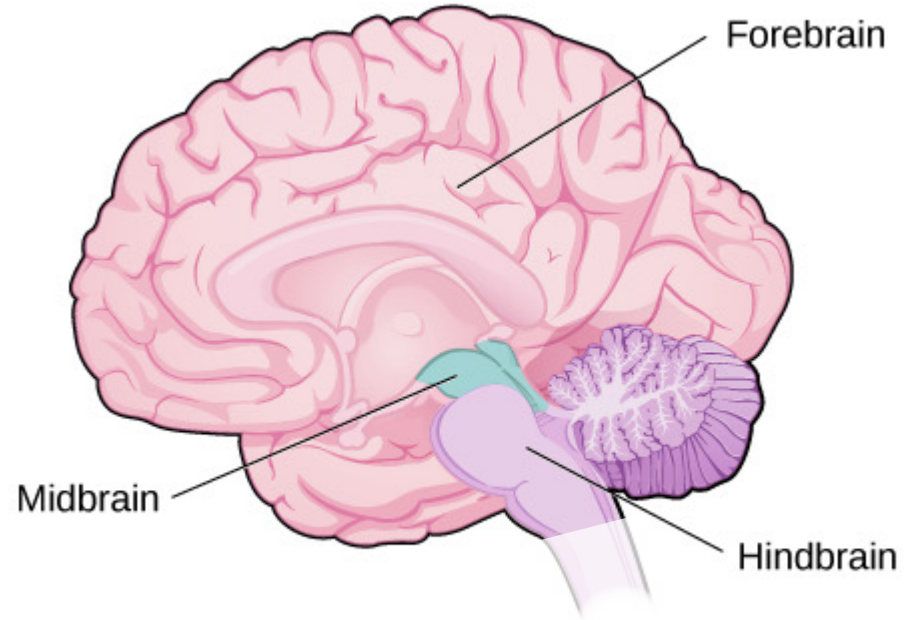
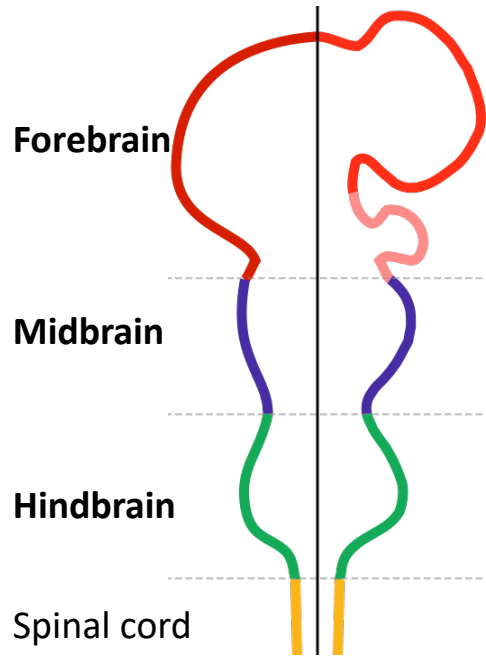
"In the same way, Rahula, bodily actions, verbal actions, & mental actions are to be done with repeated reflection.

"Whenever you want to do a bodily action, you should **reflect on it**: 'This bodily action I want to do — would it lead to self-affliction, to the affliction of others, or to both? ...

"While you are doing a bodily action, you should **reflect on it**: '... is it leading to self-affliction, to the affliction of others, or to both? ...

"Having done a bodily action, you should **reflect on it**: '... did it lead to self-affliction, to the affliction of others, or to both? ...

"Thus, Rahula, you should train yourself: 'I will **purify** my bodily actions ... my verbal actions ... my mental actions through **repeated reflection.**'
That's how you should train yourself."

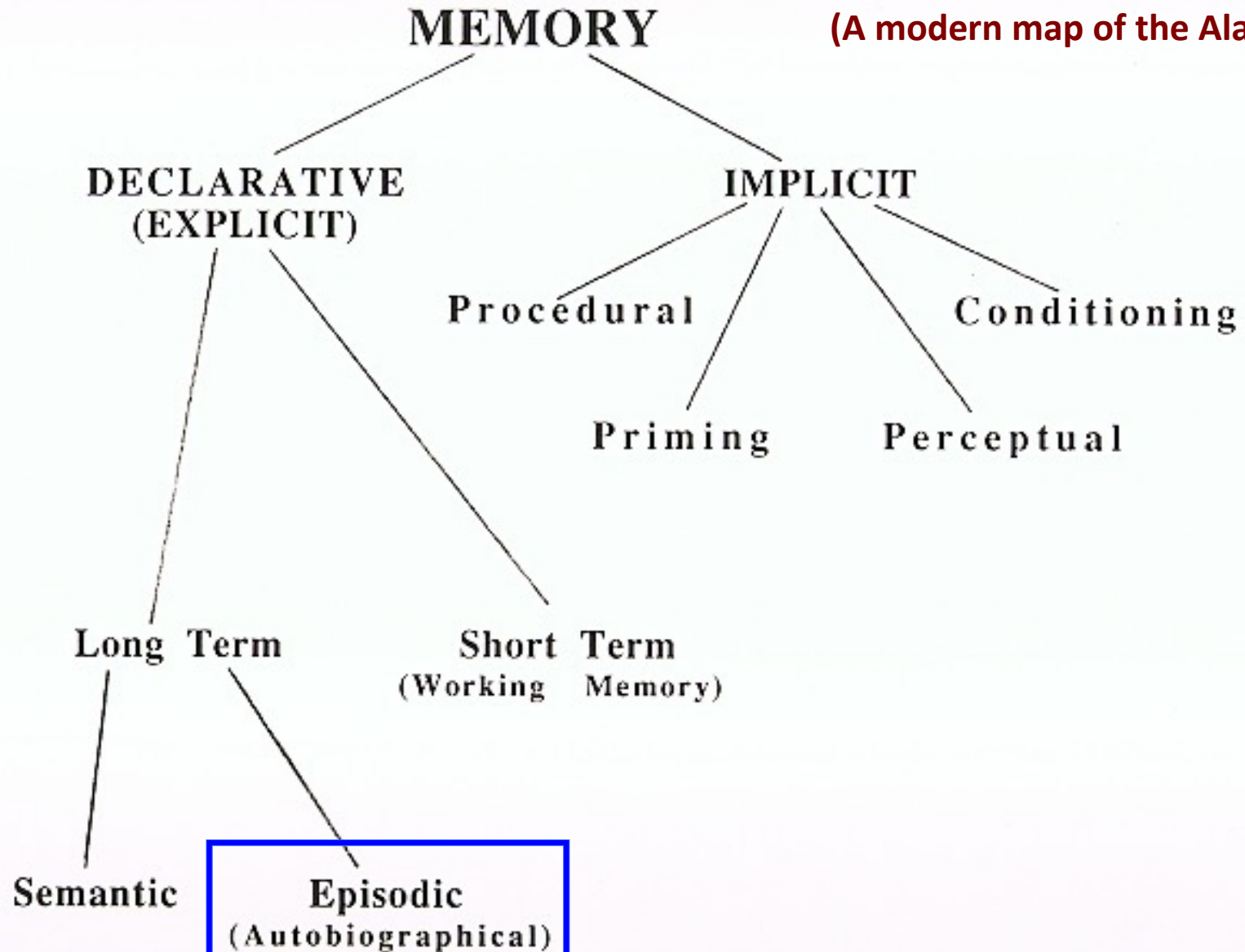


Distinct embodiments of perceiving, evaluating and responding at every level,
AND many different types of “memory”

The memory traces usually involve a change in the strength of connections between different neurons

Some Different Types of Memory/Neuroplasticity

(A modern map of the Alaya)



Episodic (Autobiographical) Memory

Memory for specific episodes of experience

For example:

What did you eat for breakfast today?

Where was your favorite vacation in the last 10 years?

Episodic memories are “*situated*” in an autobiographical context (including specific info about who, where, when, feeling tone, etc).

This differs from fact memories.

Episodic Memories

- Memories are shaped by **internal information**
- Memory serves to ***meaningfully guide behavior***,
NOT to accurately record the past.
- Changing the ***meaning*** changes the memory.
Reframing, or changing the perceived context of a remembered event, can change its meaning.

Episodic Memory for a word list

Please listen to this list of 15 words
(without writing them down)

After the list is finished, please write down all you can recall

Words for the memory test

bed

nap

snore

rest

snooze

wake

awake

blanket

peace

tired

doze

yawn

dream

slumber

drowsy

**Perform mental arithmetic
for about 15 seconds...**

**Then write down all the words
you can remember.**

Words for the memory test

bed

nap

snore

rest

snooze

wake

awake

blanket

peace

tired

doze

yawn

dream

slumber

drowsy

About 50% of people “remember” hearing the word
“SLEEP”

even though it was NOT on the list

The word “sleep” is suggested by
the “gist” or “meaning” of the word list.

Episodic memory *prioritizes the meaning* of an episode

Flashbulb Memories

September 11, 2001



Flashbulb Memories

One year later (Sept. 2002), 97% of Americans said they remembered “exactly” where they were and what they were doing the moment they heard about the attacks.

Why this sense of having such a clear memory of the event?

Emotional arousal, meaningfulness, and frequent recollection together lead to a feeling of “very clear memory”

Flashbulb Memories

One year later (Sept. 2002), 97% of Americans said they remembered “exactly” where they were and what they were doing the moment they heard about the attacks.

148 undergrads reported descriptions of their experience both **one week** and **again one year** after the attacks.

Flashbulb Memories

One year later (Sept. 2002), 97% of Americans said they remembered “exactly” where they were and what they were doing the moment they heard about the attacks.

148 undergrads reported descriptions of their experience both **one week** and **again one year** after the attacks.

Descriptions one year later agreed **only ~63%** with descriptions given 7 days after the attacks.

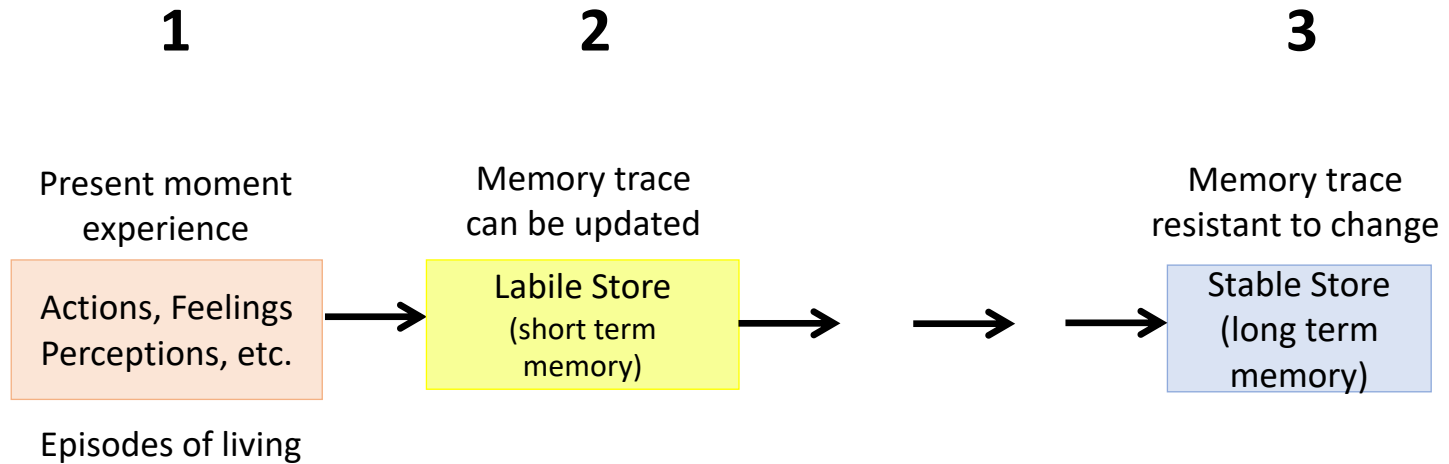
How do memories change over time
and become **less accurate** than we
believe them to be?

The answer lies in how memories are
formed and reformed over time.

Three phases of episodic memory

1. “***Present moment***” experience.
2. A ***labile store***, where they can be updated, modified & consolidated.
3. A ***stable store***, where they can persist relatively unchanged for long periods.

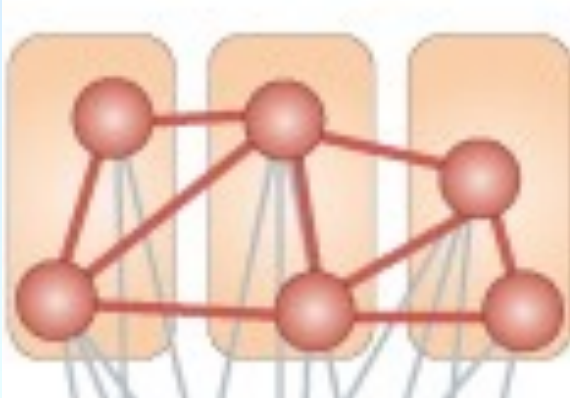
Three phases of episodic memory



Three phases of episodic memory

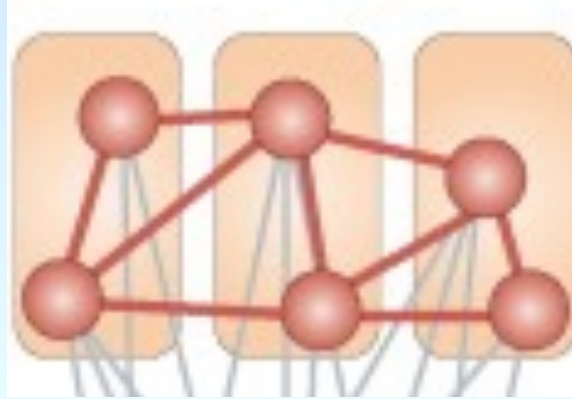
1. “*Present moment*” experience.
 2. A *labile store*, where they can be updated, modified & consolidated.
 3. A *stable store*, where they can persist relatively unchanged for long periods.
- Retrieving a memory from the stable store makes it ***labile*** again!
 - Only ***labile*** memory traces can be updated.
 - ”Updating” = changing it to **enhance its useful *meaning***.

Ongoing “experiences” are represented as patterns of activation in cortical modules.

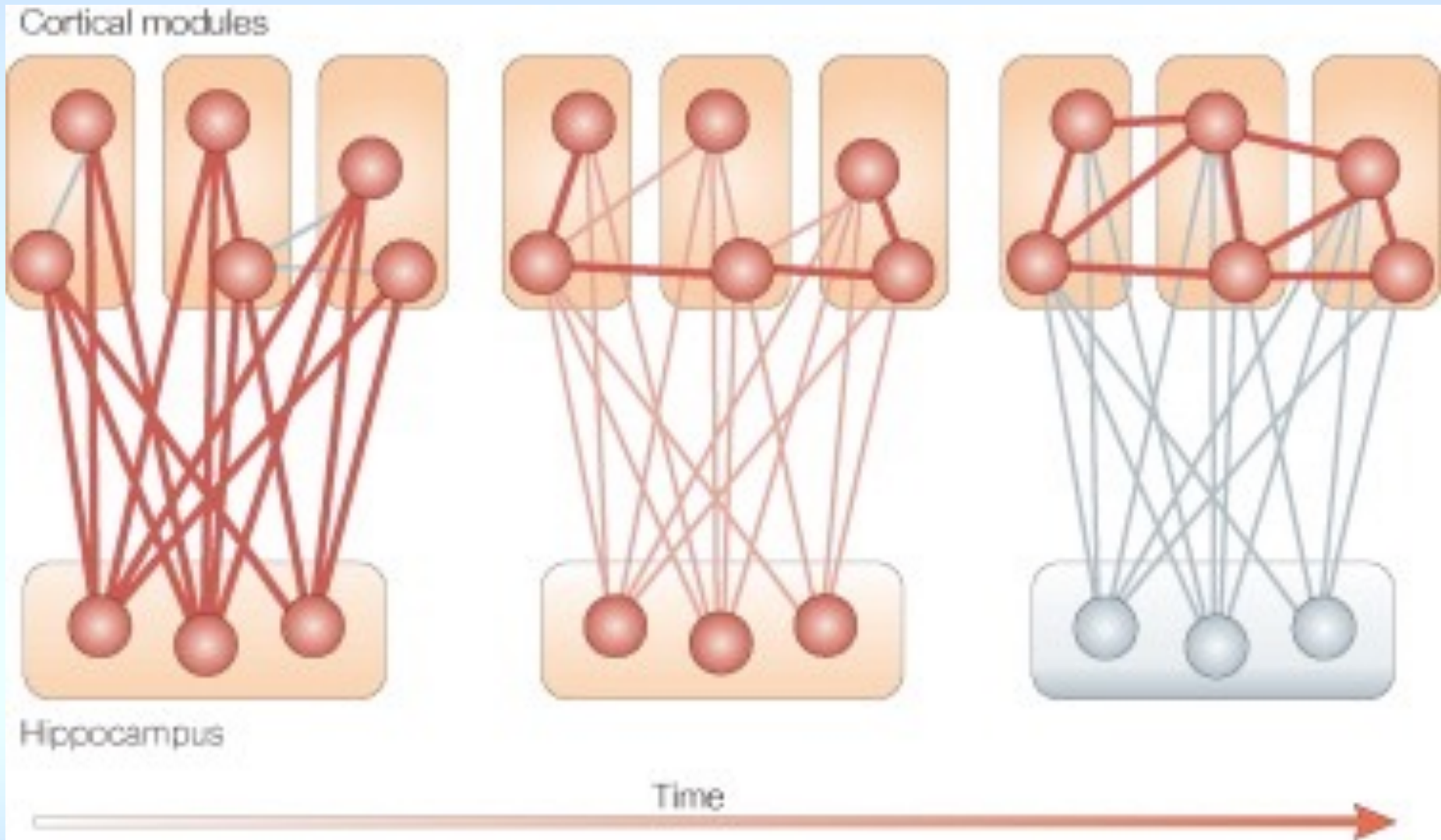


Simplified depiction of
simultaneously activated
cortical modules

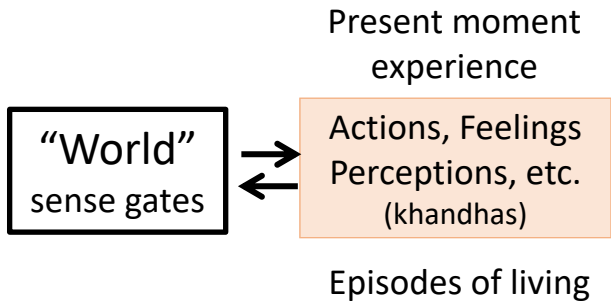
Retrieving a memory involves ***simulating the original pattern*** of simultaneously activated cortical modules

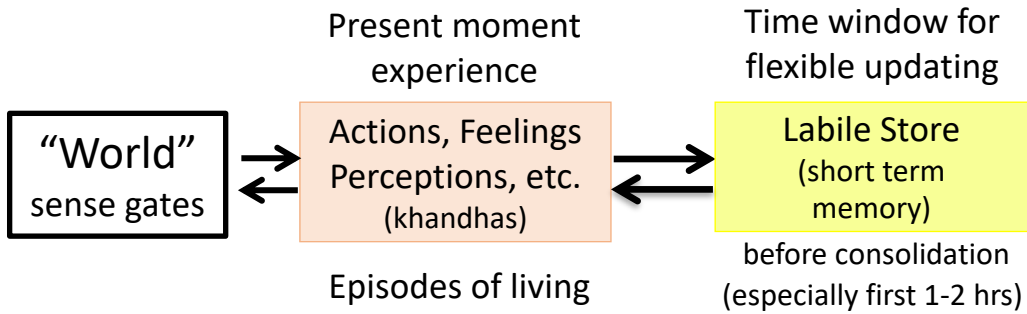


Memory Consolidation takes place over 1 – 4 weeks, giving rise to the Stable Phase of memory embodied in the cortex.

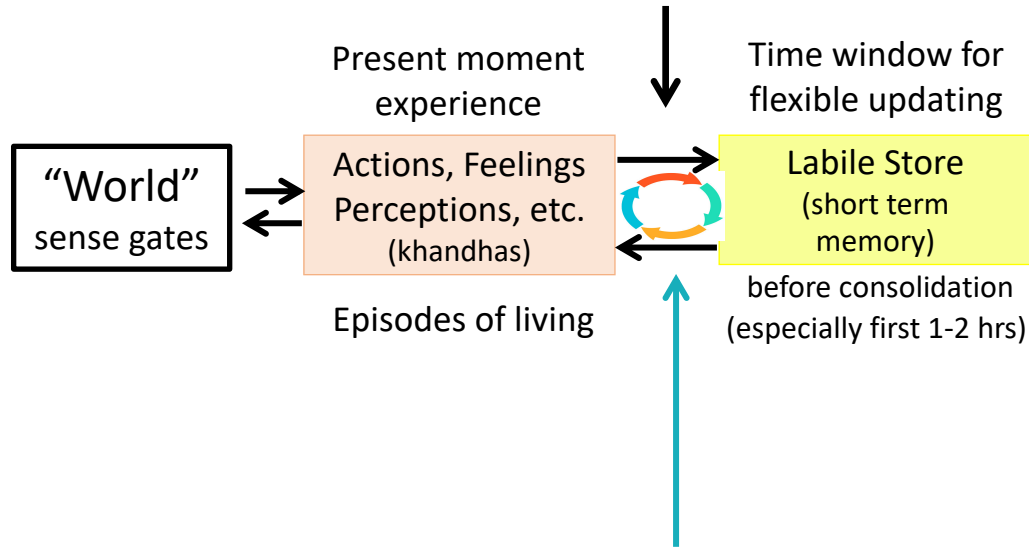


Over 1 – 4 weeks, the cortex “learns” to more fully embody the links.



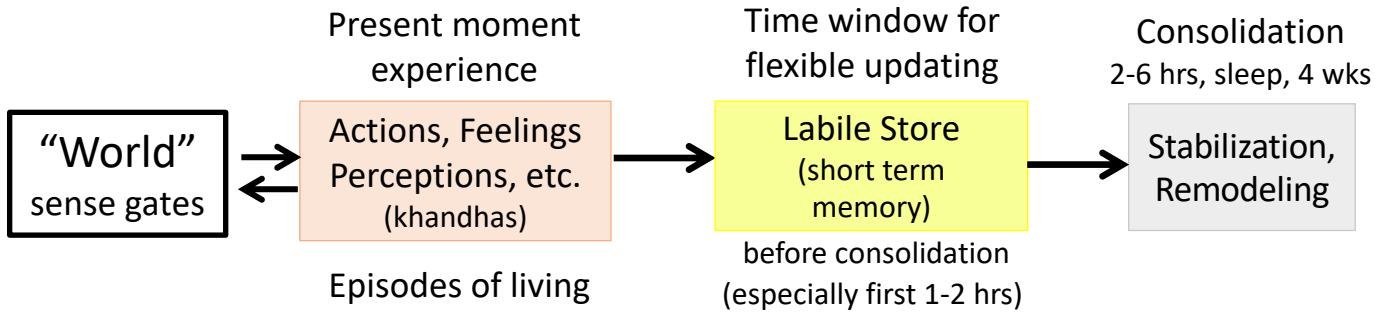


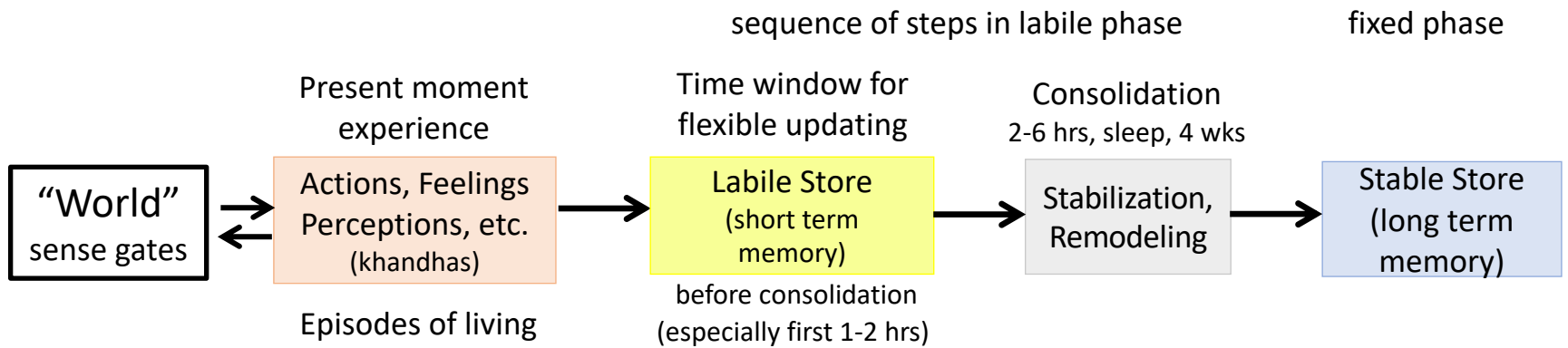
Reflection & Reframing



If the episode of experience is especially meaningful, lots of review and reprocessing (meaning making) occurs in the first minutes and hours after the experience.

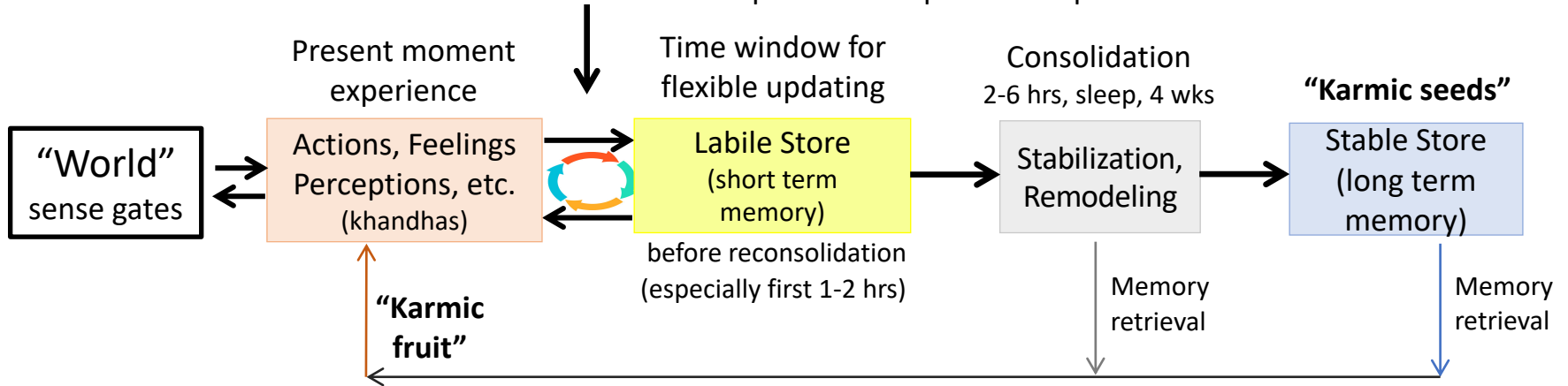
sequence of steps in labile phase





Reflection & Reframing

sequence of steps in labile phase

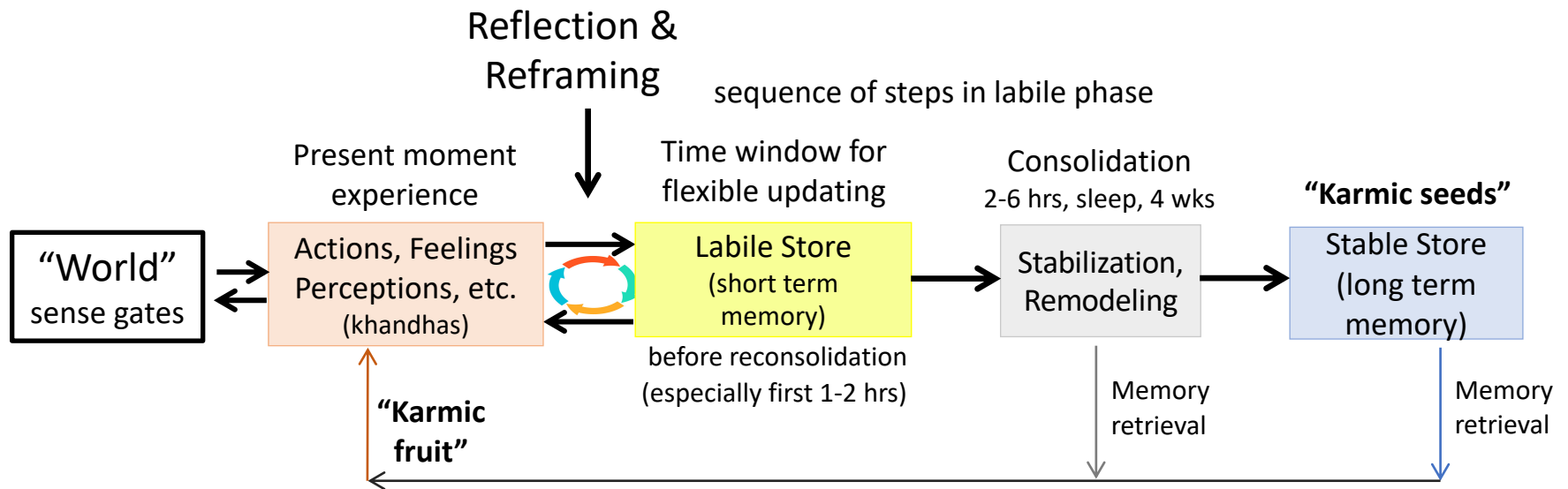


The times when karmic seeds “ripen”

are the times they are susceptible to being “destroyed.”

When memory traces are “reactivated” in present experience, they can be reframed and their meaning can change, ... or not.

Reflection & Reframing



The times when karmic seeds “ripen”

are the times they are susceptible to being “destroyed.”

When memory traces are “reactivated” in present experience, they can be reframed and their meaning can change, ... or not.

"Bhikkhus, I do not say that there is a termination of volitional kamma that have been done and accumulated so long as one has not experienced [their results]...."

—AN 10.206

The Deed-Born Body Sutta