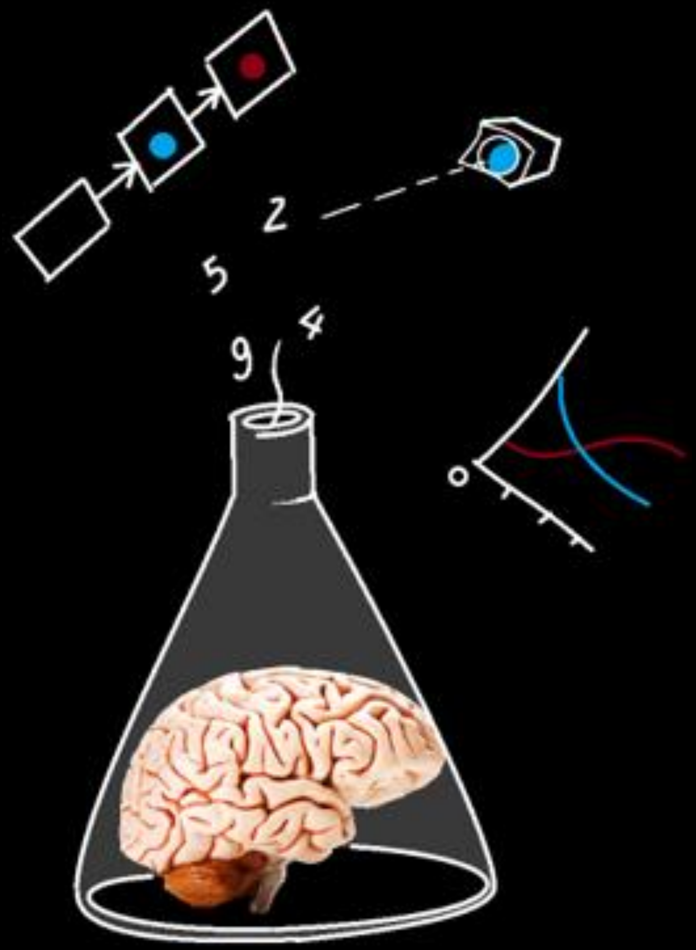
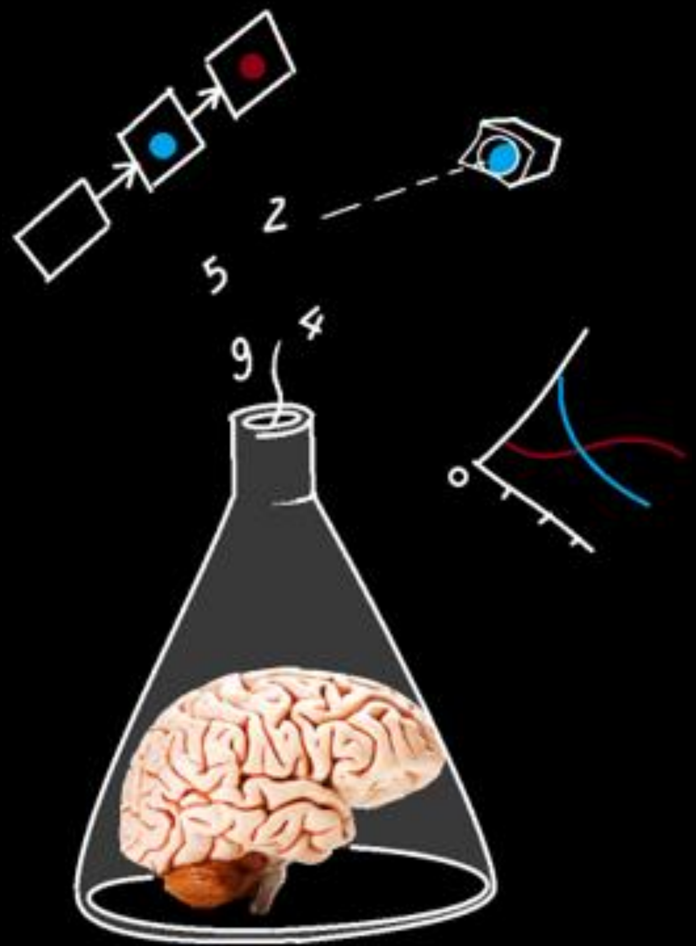
Exam Recap





Today

Practical info

Questions?

Lecture recap

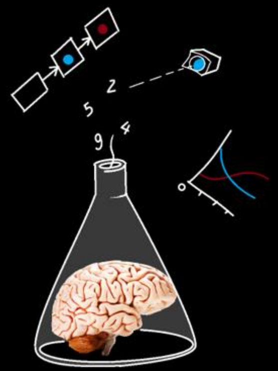
Practical info

Exam: October 25th, 08:30, NU 6B37, 6B57 & 6C13

135 mins (+30 min extra time)

Digital exam in Testvision

No extra tools needed



TestVision Test Exam_October_2023 - Google Chrome

vu.testvision.nl/online/fe/afname_toets.htm?idstr=1697643057973&skin=11

Instruction Exam_October_2023

jsl690
Snell, J.J.

Overview

Candidate: Snell, J.J.

Number of questions: 25

Duration: 135 minutes

Alert testtime: 5 minutes before testtime passes

Instruction

Welcome to the exam of Cognitive Psychology and its Applications!

You'll have 6 multiple choice questions and 19 open questions, for a total of 25 questions. You don't need any external tools (e.g. calculator). If you can't work out an answer without a calculator, you're doing something wrong.

You have a total of 135 minutes (+30min if you have dyslexia).

Good luck!

Help

Start

17:31
18/10/2023

Practical info

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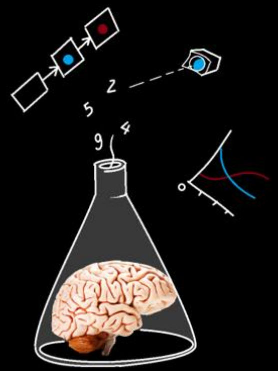
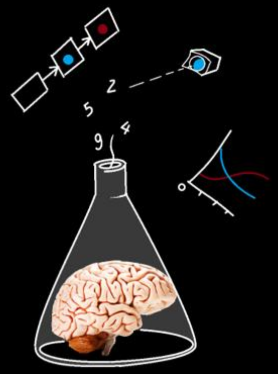


Practical info

Exam: October 25th, 08:30, NU 6B37, 6B57 & 6C13

135 mins (+30 min extra time)

Book chapters 1,3,4,5,6,7,14
Lecture & workshop contents
Papers
SDT reader



Practice exam

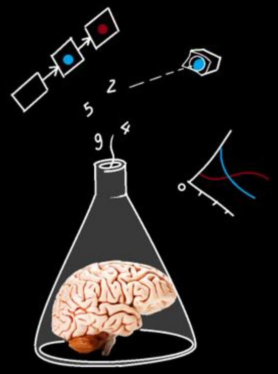
1) What is the inverse projection problem?

A: The fact that visual input projects onto the contralateral hemisphere.
B: The fact that from a retinal image alone there is no certainty about the visual environment.
C: The fact that bottom-up visual processing is biased by top-down expectations.
D: The fact that the visual cortex has to support both visual perception and memory recall.

2) Rank the fovea, parafovea and perifovea from best to worst, on:

a) Color vision:
b) Acuity:
c) Light sensitivity:

3) Imagine in an experiment you're comparing conditions A and B, and you hypothesize better performance in A than B. You find faster responses in A, and also a higher number of errors in A. Both effects are significant. Would you consider this study evidence for your hypothesis? Explain.



4) Why is a within-subjects design typically preferred over a between-subjects design?

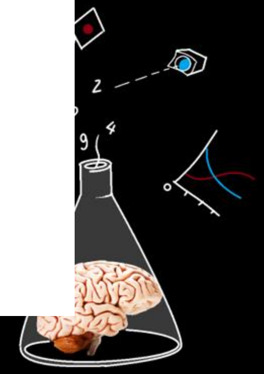
5) Give an example of a situation where a between-subjects design is unavoidable.

6) Rank sensory memory, short-term memory and long-term memory, from best to worst, on:

a) Capacity:
b) Longevity:

7) Which of the following is *not* a Gestalt principle?

A: symmetry
B: closure
C: proximity
D: common ground



8) Imagine a participant has an average response time (RT) of 2000 ms and an accuracy of 80%. What is the inverse efficiency score (IES)? Provide a calculation.

9) What is a potential benefit of inspecting RT density plots rather than just comparing means?

10) The army has an entry exam where candidates have to distinguish target enemies from innocent civilians. Candidates get 200 trials, 100 of which are target enemies (the candidate would have to shoot) whereas the other 100 are innocent civilians (the candidate has to refrain from shooting).

Candidate A classified 80 out of 100 enemies as such, while classifying 20 out of 100 civilians as enemies.

Candidate B classified 100 out of 100 enemies as such, while classifying 50 out of 100 civilians as enemies.

Using signal detection theory, how would you calculate sensitivity (d') for both candidates? Provide all values that are needed in the calculation.

11) In a staircase procedure, the task difficulty is adjusted less and less after each oscillation. Explain why this is important.

12) Provide two arguments against Expected Utility Theory

13) In a linear mixed-effects model, you can have random intercepts and random slopes for participants. Explain what these two things mean.

14) What are two key defining properties of language (i.e., what sets 'language' apart from 'communication')?

15) Many interfaces make use of predictions. For example, in Google Chrome, when typing the first letter of your name in a field, Chrome might automatically fill in your entire name, address, phone number, et cetera. Using at least two interface design principles, explain why this could be both good and bad.

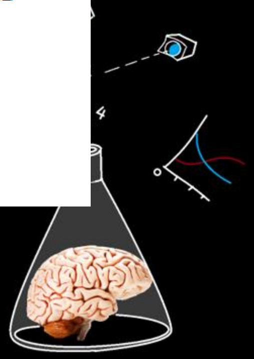
16) In most swimming locations (e.g., beaches, lakes), colored flags communicate whether or not it is safe to swim, whether certain things need to be taken into account (e.g., presence of jellyfish, bacteria), et cetera.

Jasmine theorizes that adding icons to the flags (e.g., an icon of a jellyfish on the 'jellyfish' flag) will improve comprehension, but only if viewers are within a 50m radius of the flag.

Using three criteria for theoretical quality, explain how well this theory scores in your opinion.

17) Robbie hypothesizes that when there are stripes on clothing, thicker stripes lead to higher aesthetic appraisal (i.e., how pretty people find the clothing). In his study Robbie measures this through pupil size, as prior studies have suggested that higher aesthetic appraisal leads to larger pupils. Robbie tests white dresses with black stripes.

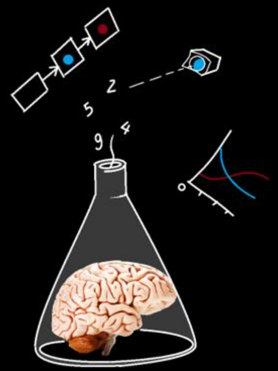
Can you come up with a reason why pupillometry may be problematic in this setup?



Lecture recap

Lecture recap

1 – Theories
2 – Perception & Attention
3 – RT, accuracy, SDT
4 – Eye-tracking & Pupillometry
5 – Memory & Decision-making
6 – LMMs
7 – Language & Reading
8 - Interfaces

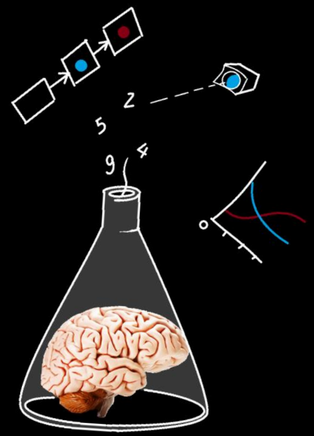


What is a good theory?

Explanatory scope

Parsimony

A theory must be *falsifiable*
If a theory cannot be tested,
we have zero knowledge about its plausibility



Testing a theory in cognitive psychology

"A causes B"
"B relies on A"
"The influence of A on B relies on C"

The cognitive psychologist's challenge:
How can we manipulate A and measure B?

Do we take other factors into account?

"But wait, older people are more sensitive to yellow than to blue"

"But wait, when the sky outside is blue, this may influence responses"

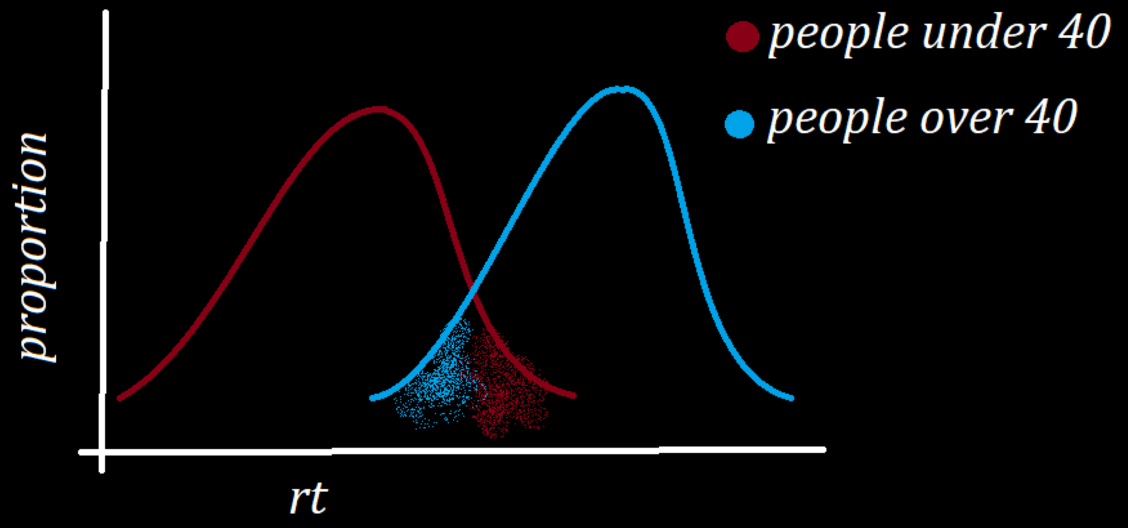
No problem: within-subjects design

Do we take other factors into account?

Within-subjects design: each subject is tested in all conditions
Between-subjects design: different subjects are tested in each condition

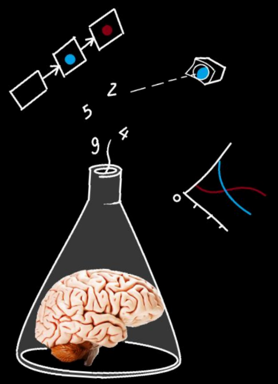
We typically always prefer a within-subjects design over a between-subjects design, as it allows us to ignore factors that potentially have an influence

The replication crisis in psychology



Statistical power
→ the chance that an effect is established, given that the hypothesis is true

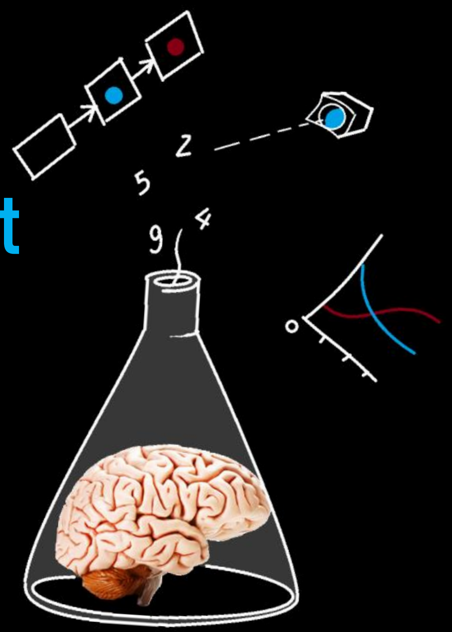
Brysbaert & Stevens (2018): 1,600 measurements per condition (e.g., 25 subjects, 64 trials per condition)



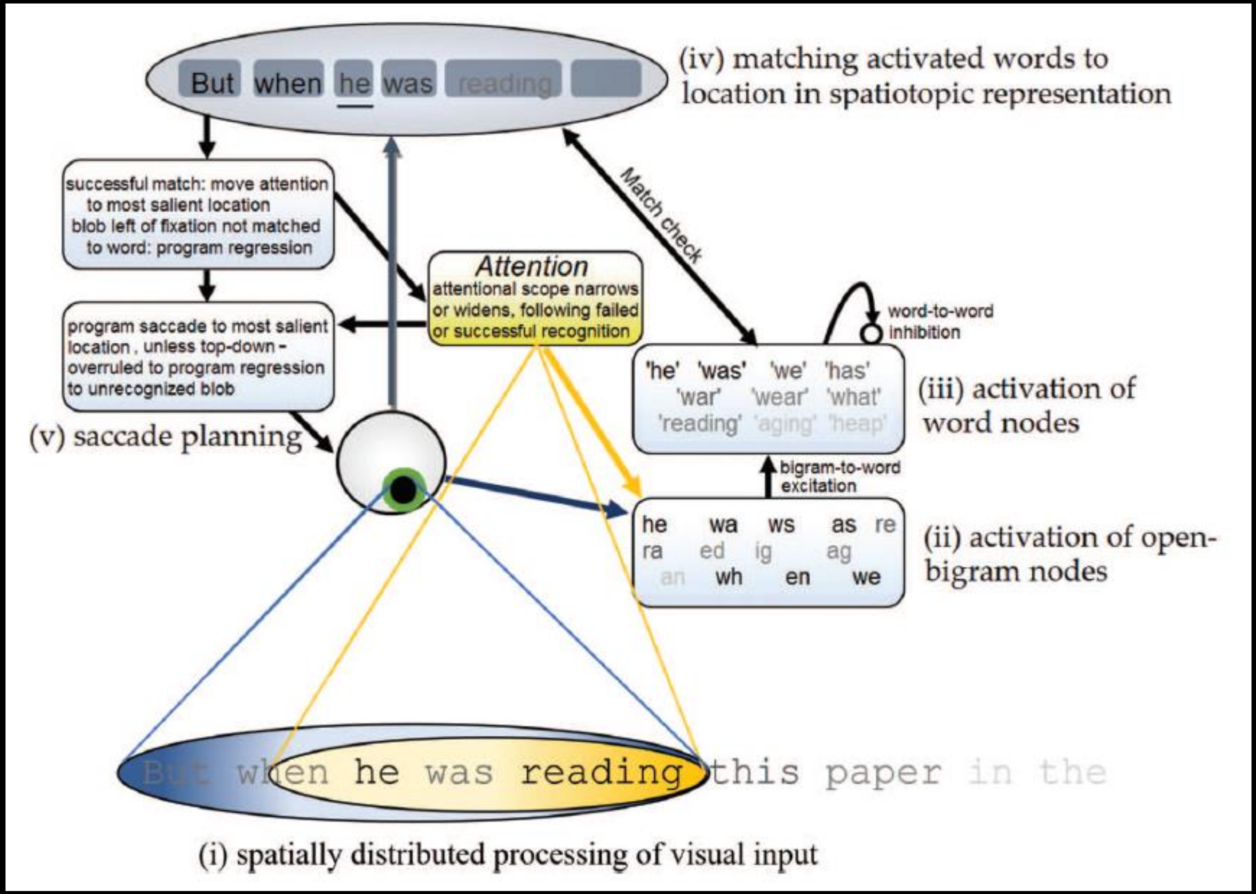
Testing theories without experiments

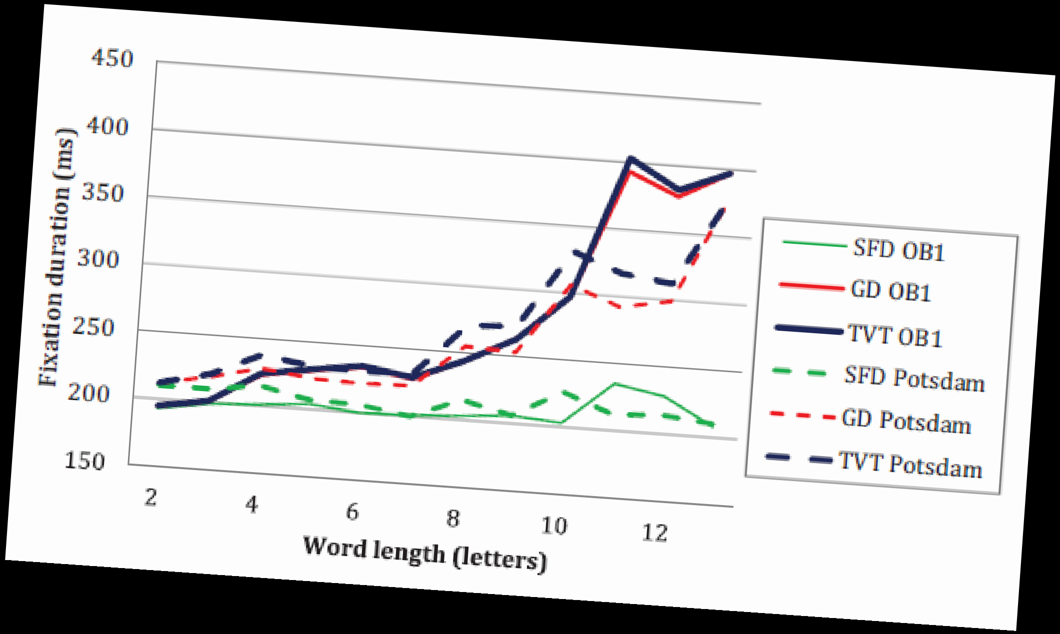
→ Computational models

We can test the extent to which a computer model can accurately simulate behavior. The more accurately it simulates behavior, the more support we have for each of the model's assumptions.

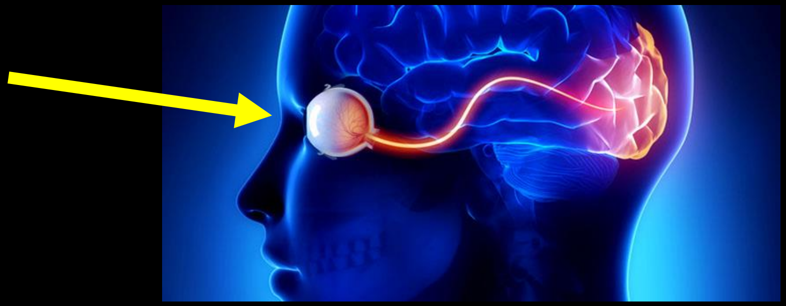


Testing theories without experiments
→Computational models

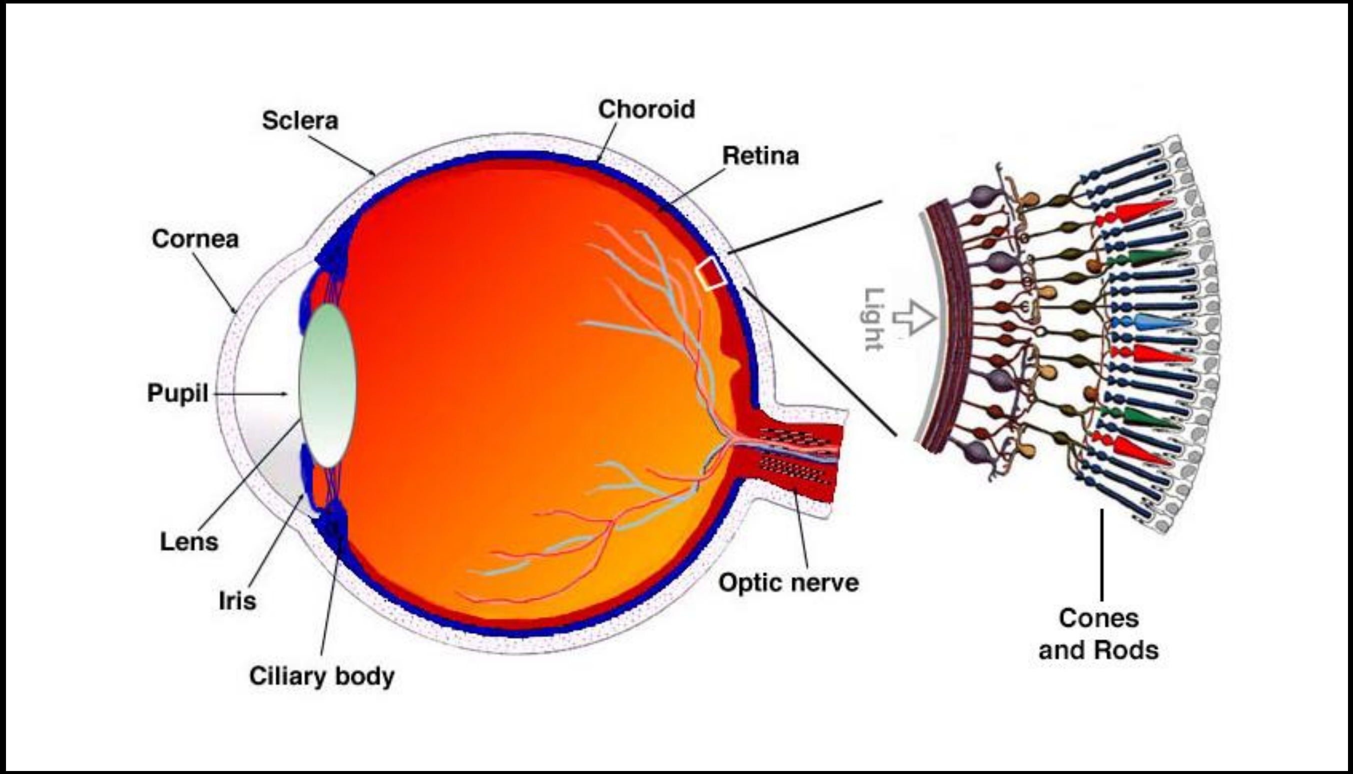


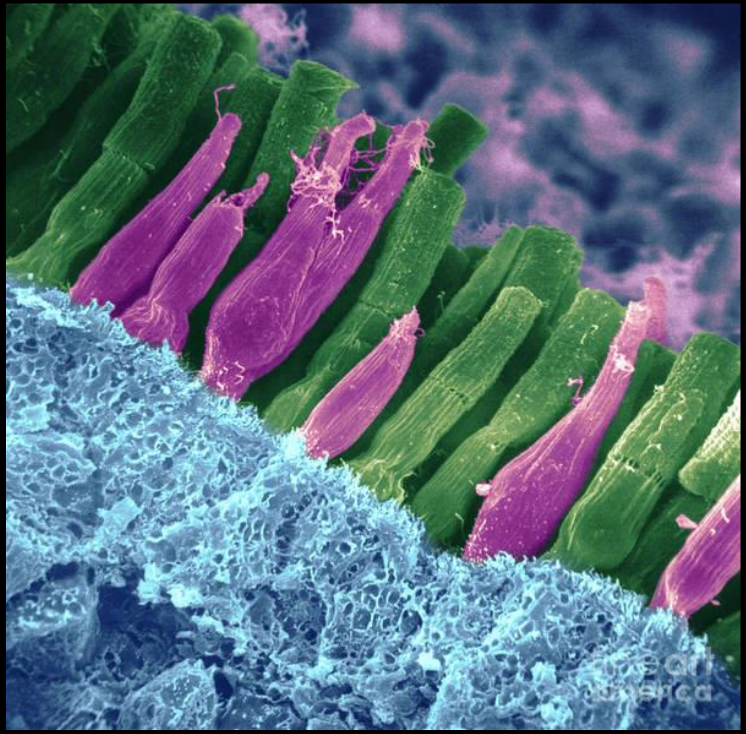


What is perception?

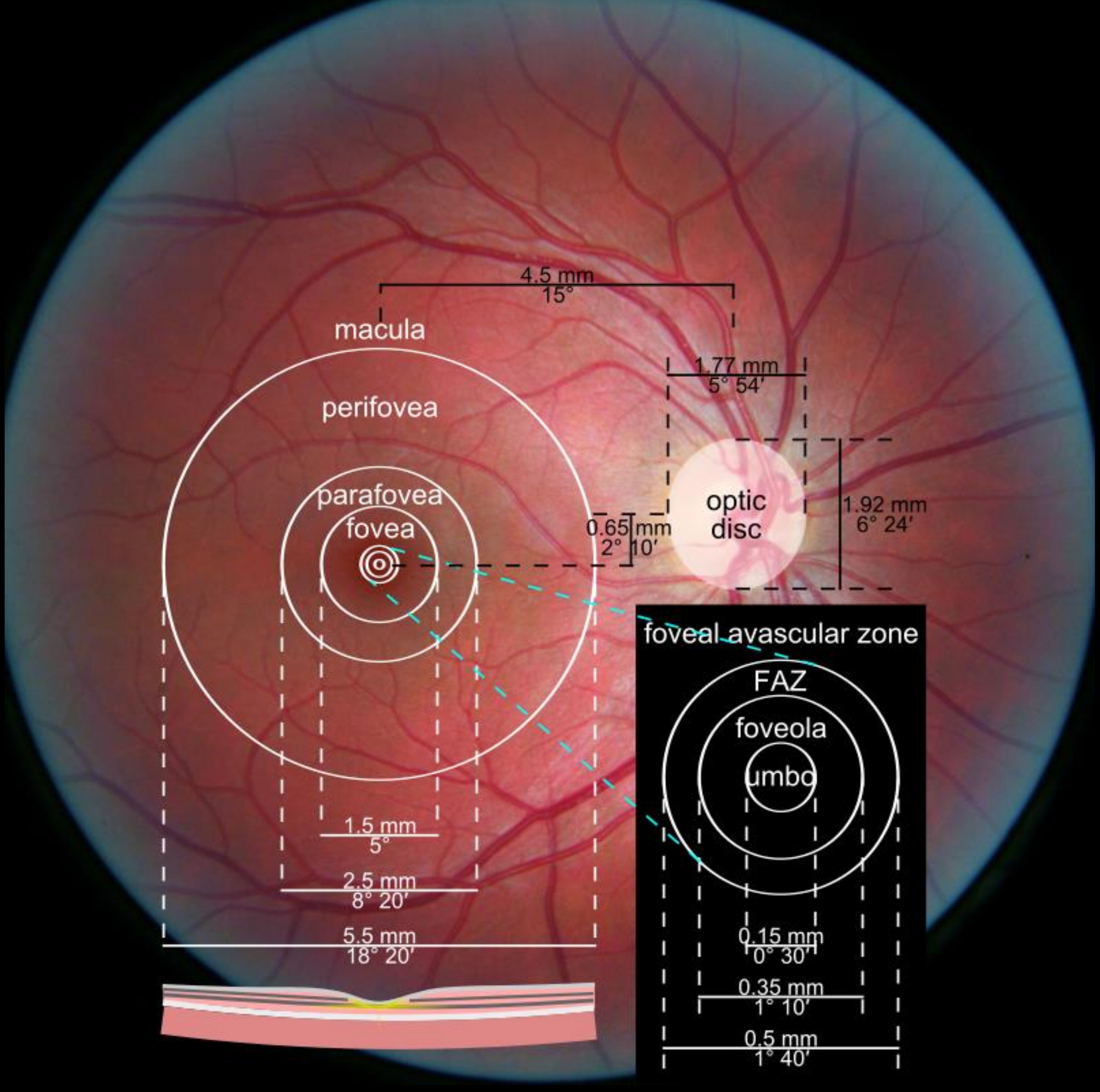


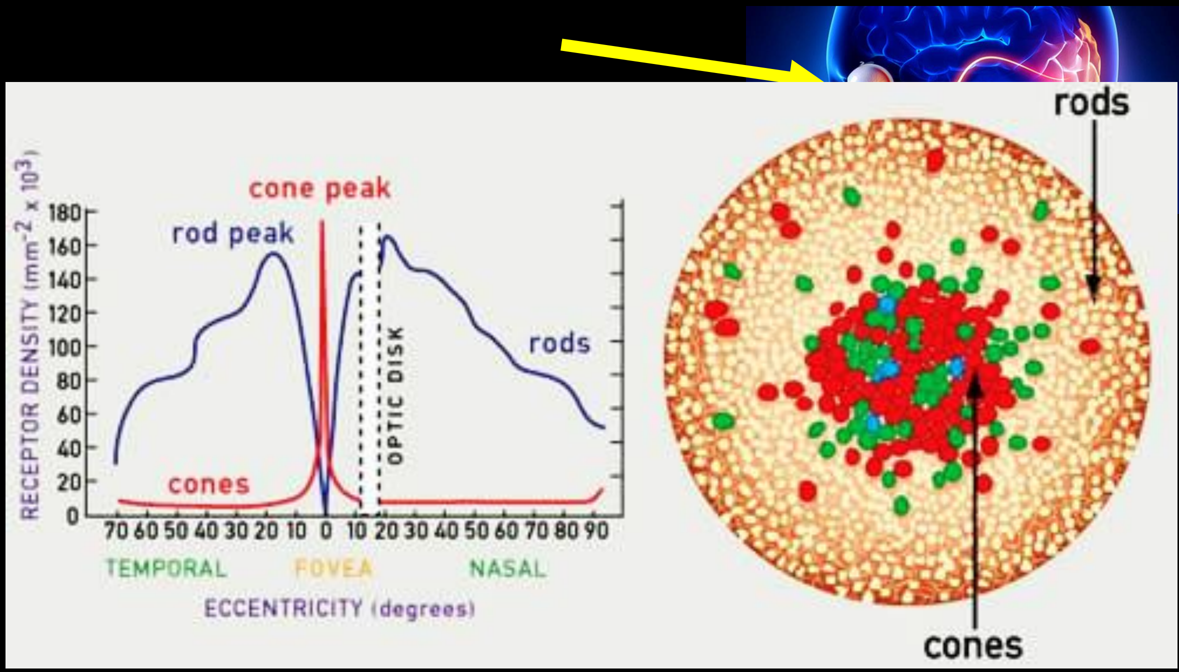
Sensation: A physical, factual thing, not susceptible to interpretation etc.





Example: activation of visual cortex





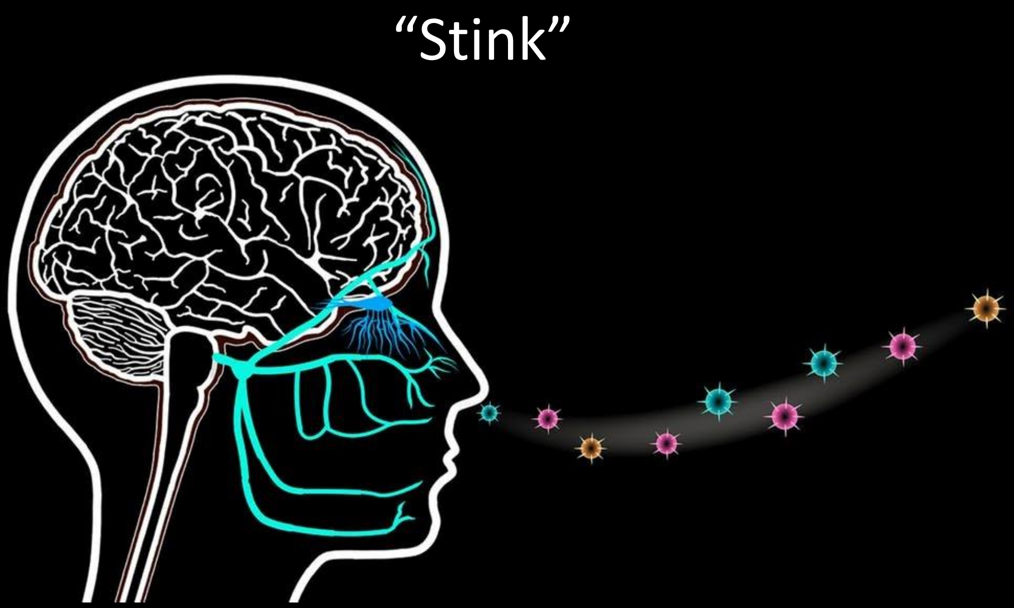
Fovea (1°): many cones, sharp vision (high *acuity)*, color vision, lower sensitivity

Parafovea (6-8°): mix of cones and rods

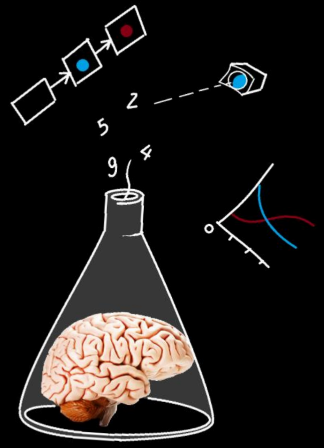
Perifovea (>8°): mostly rods, low acuity, no color vision, more sensitivity

What is perception?

Perception: the process of *interpreting* sensations



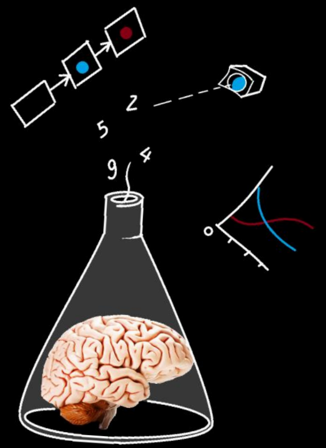
Example: Smelling



The core challenge in perception:
to resolve ambiguity

The inverse projection problem

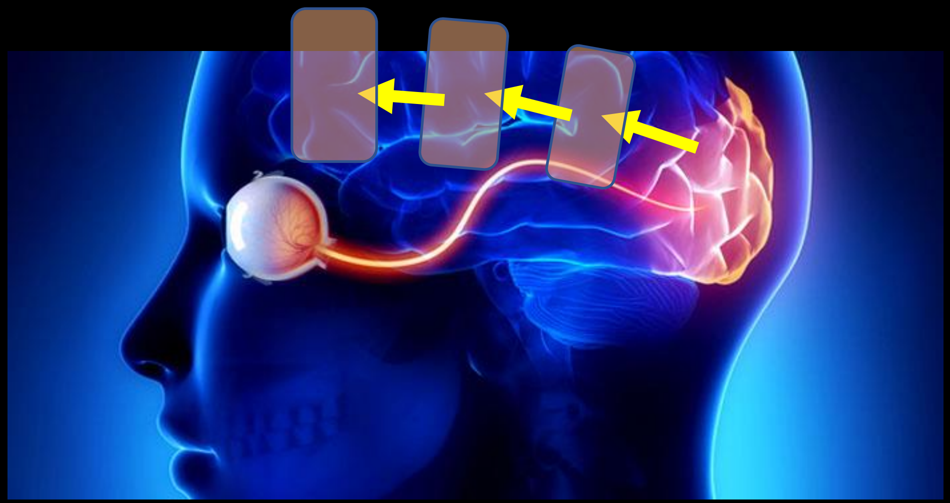
→ From sensory processing alone we cannot say anything conclusive about the world!

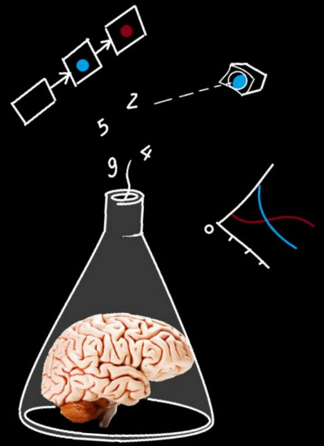


Bottom-up versus top-down processing

bottom-up: Sensory organs provide activation of 'low' cortical regions, cascades to 'higher' regions

Crucial concept!

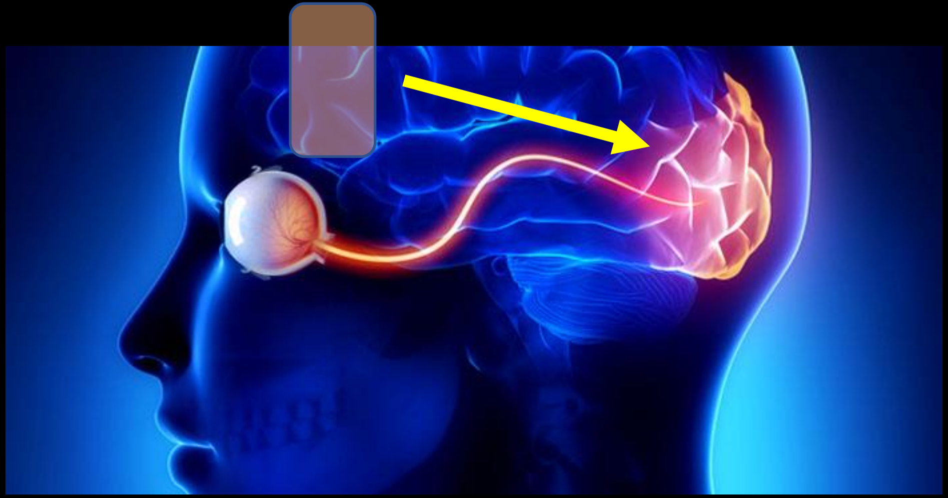


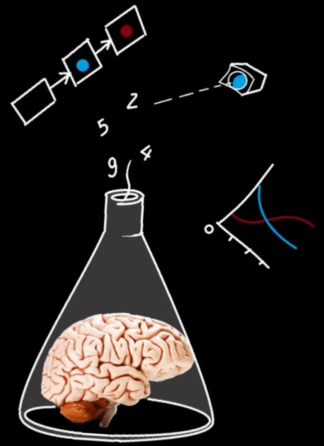


Bottom-up versus top-down processing

Top-down: 'higher' regions influence activation of 'lower' regions

Crucial concept!



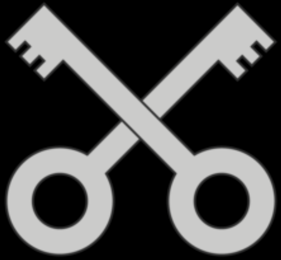


Bottom-up processing

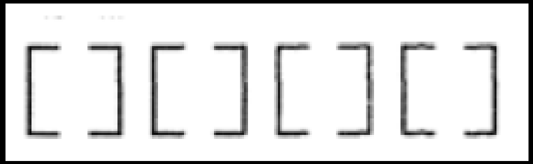
Gestalt principles: A set of assumptions about things that happen in an automatic, bottom-up fashion

…a mere product of the system's architecture

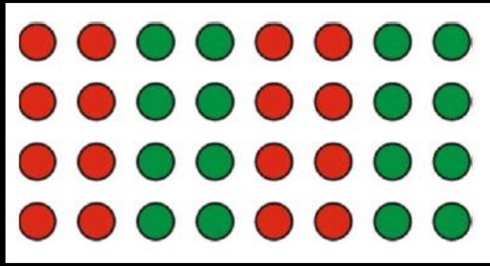
continuity



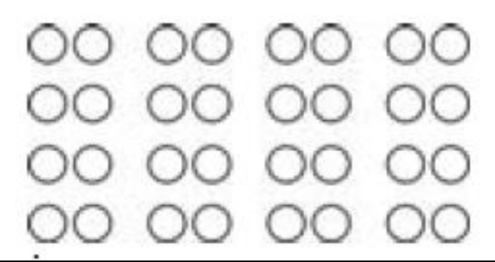
closure



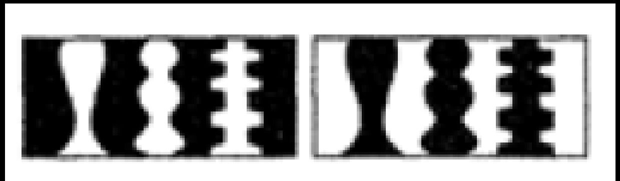
similarity



proximity



symmetry



and one that relies on motion →

common fate

Bottom-up processing

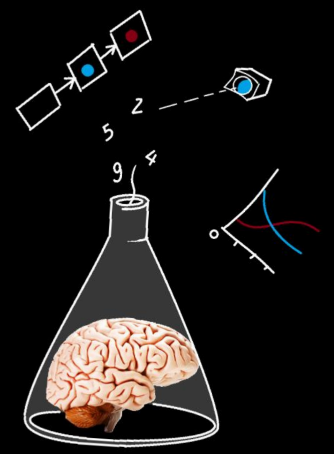
Gestalt principles: A set of assumptions about things that happen in an automatic, bottom-up fashion

...a mere product of the system's architecture

But are all these 'effects' really the result of bottom-up processes?

Probably not. Our life experiences bolster the expectation that

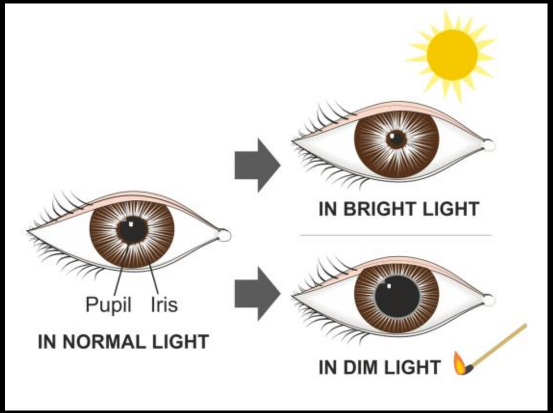
- Similar-looking things belong together
- Objects are most often symmetrical



Top-down processing

This is how we typically conceptualize processing in the brain.

- *various <u>levels</u> of processing*
- *<u>interactions</u> among levels*



"Sun"

semantics / memories
e.g. furriness, animalness, your cat Mr. Mittens

↕

words
e.g. detector for *dog*, detector for *cat*, etc.

↕

letters
e.g. detector for 'A', detector for 'B', etc.

↕

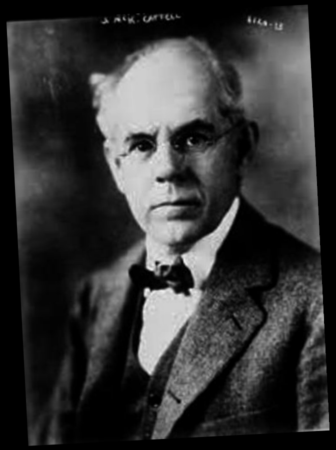
Features
e.g. horizontal line detectors curve detectors, etc.

↑

Visual input

green needle vs. brainstorm

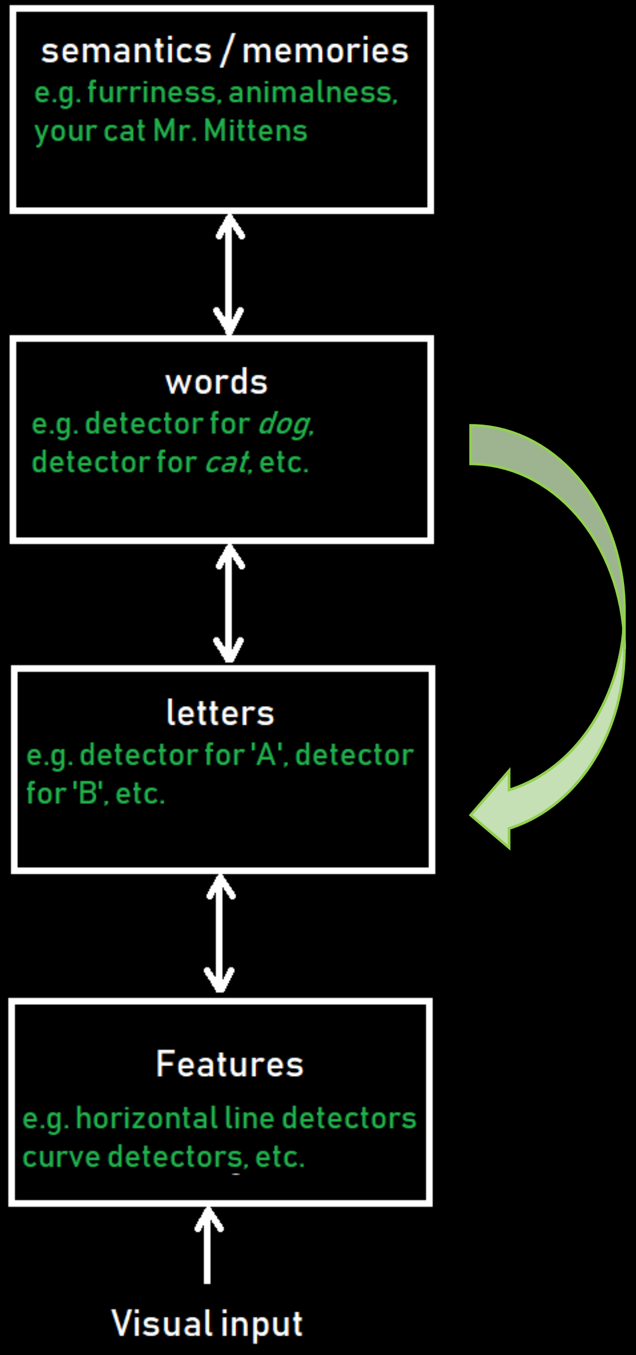
Top-down processing



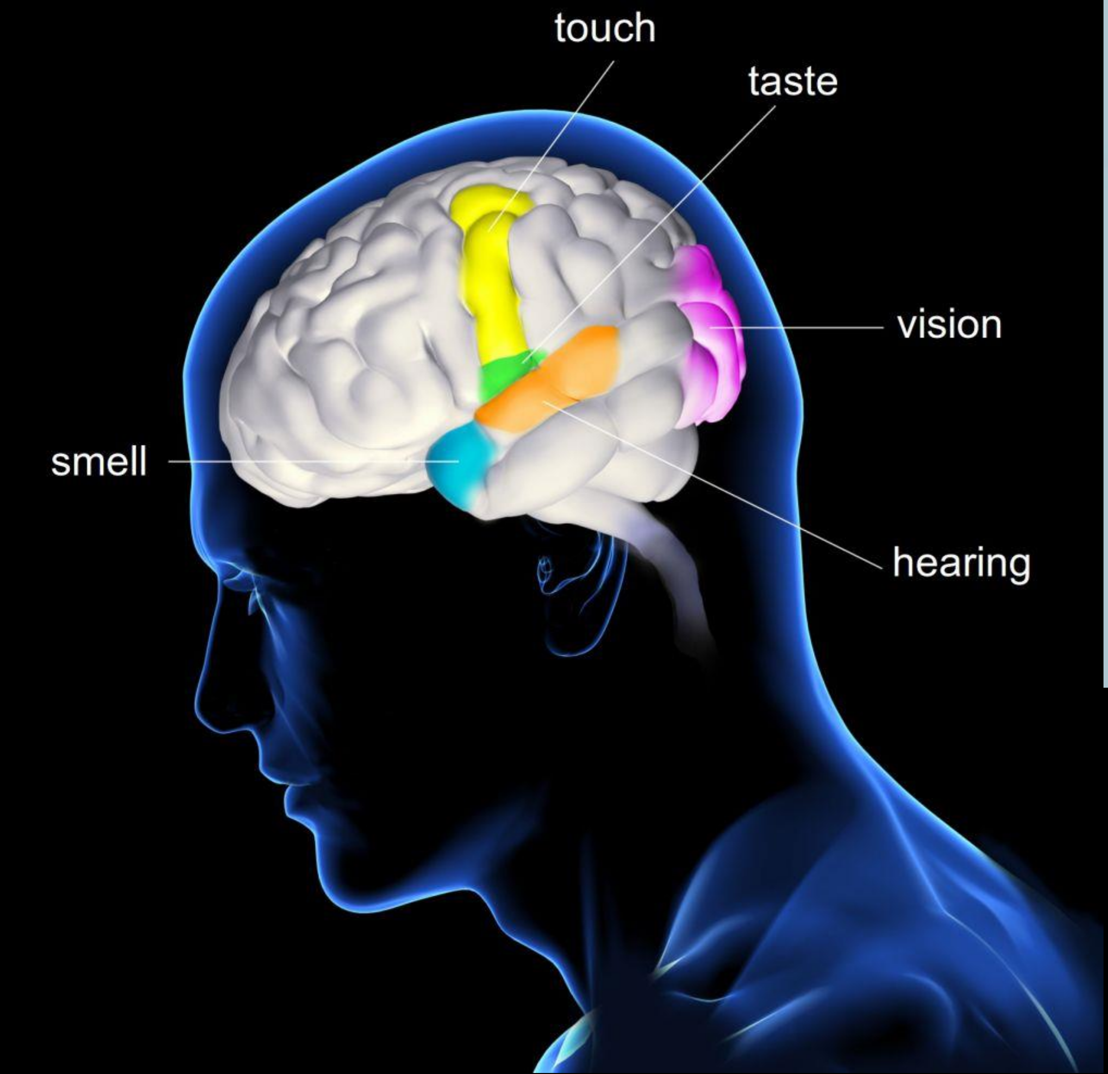
James McKeen Cattell, 1886

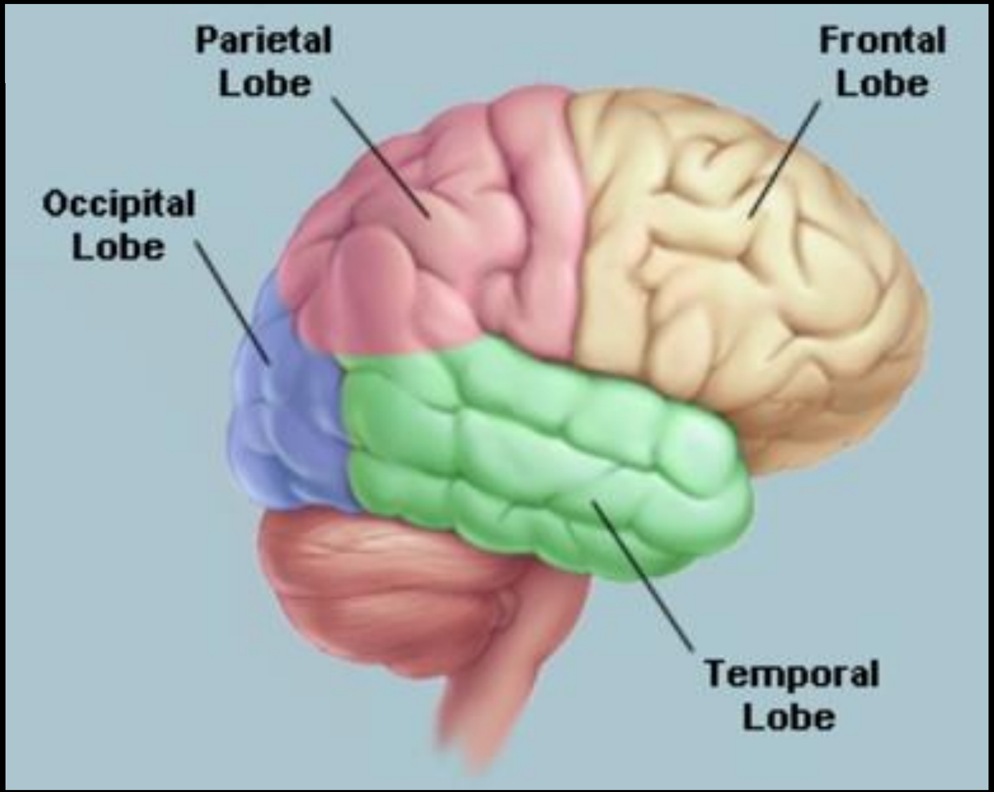
The *word-superiority effect*: a letter is recognized faster if if it is in a word than if it is in a non-sensical string

PL<u>U</u>MP PM<u>U</u>LP

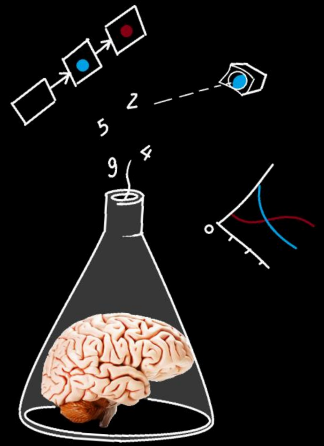


Neurophysiology: perception in the brain



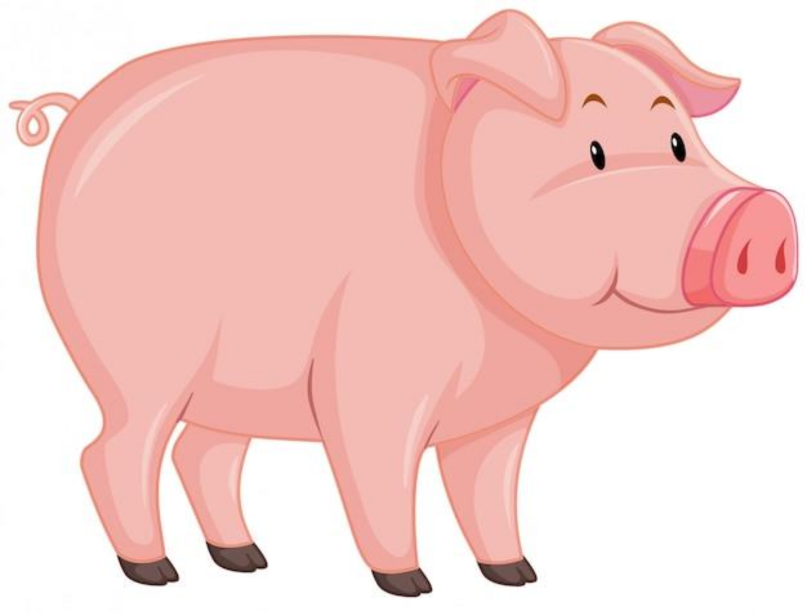


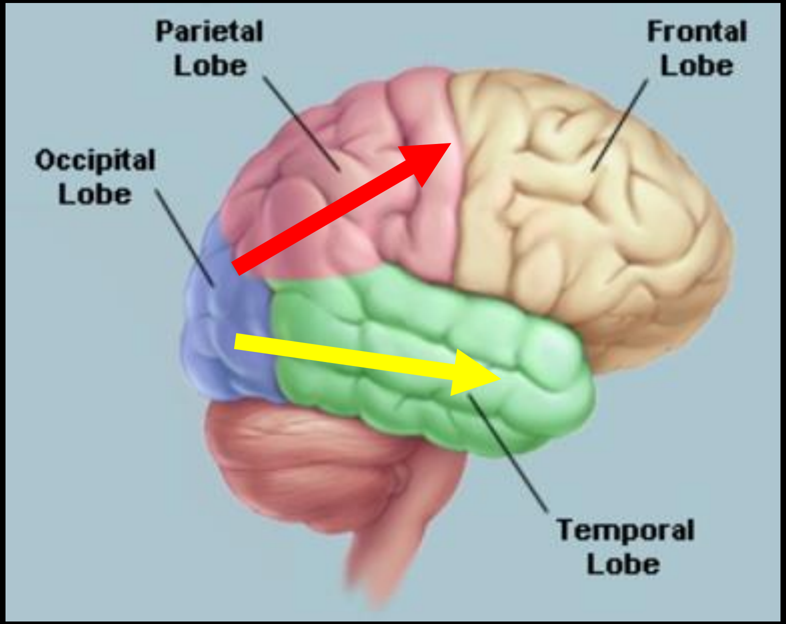
BUT: it’s never about isolated brain area’s



Neurophysiology: *Dorsal* and *Ventral* pathways

'Dorsal' = backside: 'Where' pathway





'Ventral' = belly: 'What' pathway

Plasticity in the brain: the brain is flexible

Where do ‘detectors’ come from?

Our experiences shape dedicated clusters of neurons

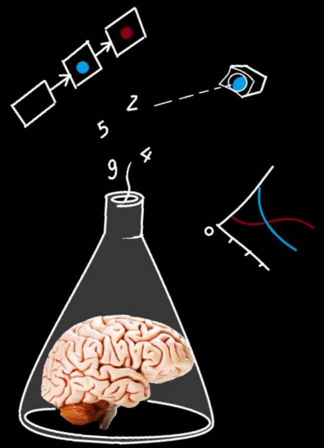
The sad-cat story

What is attention?

Many psychologists have provided definitions… Here is one:

Attention is the mind's capacity to enhance and suppress sensory input and internal representations

Also applies to things that we keep in memory



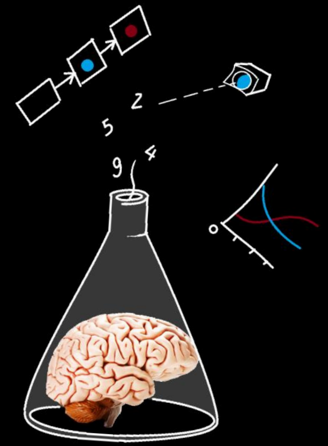
Let’s discuss various types of attention…

Within the realm of vision: Overt & Covert attention

Overt is Obvious to others; the eyes and head move
Covert is Concealed to others; the eyes and head do not move

In the lab we often track overt attention

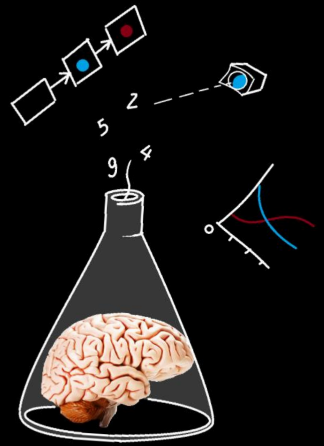
How might we track *covert* attention?



Let’s discuss various types of attention…

Within the realm of vision: Spatial vs. Feature-based attention

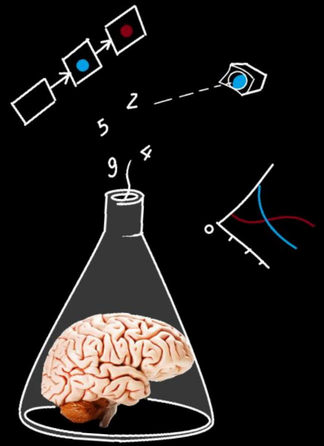
Attentional orienting in vision is often spatial …but you can choose to be more ‘sensitive’ to apples; we focus in terms of both *where* and *what*



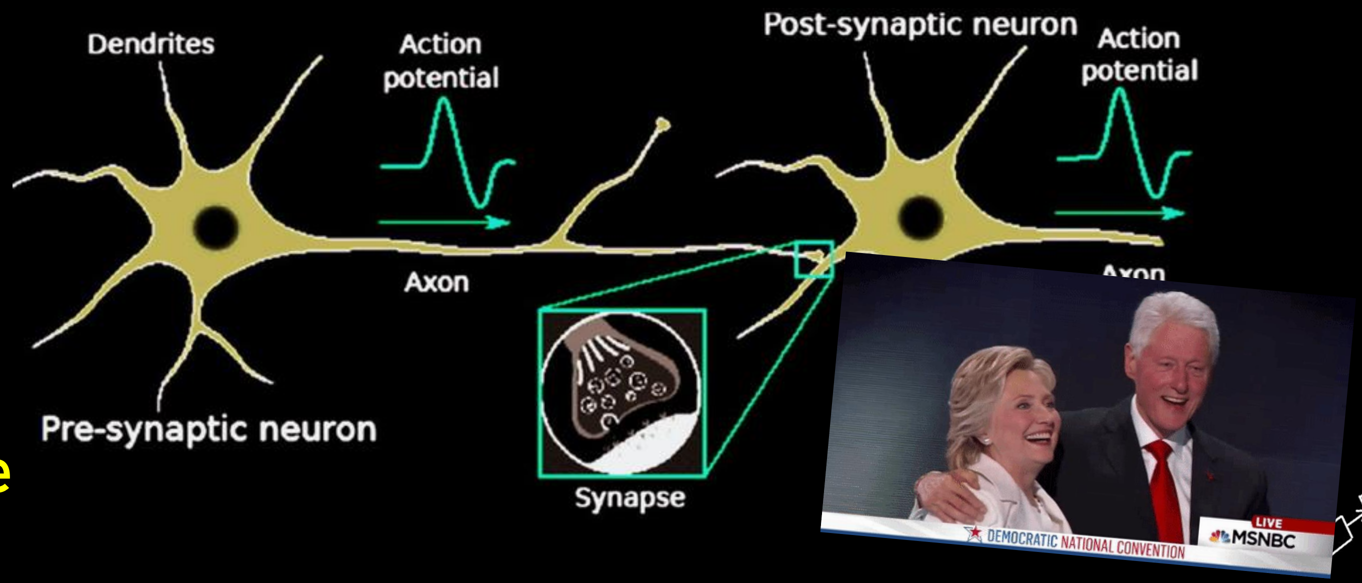
Let's discuss various types of attention…

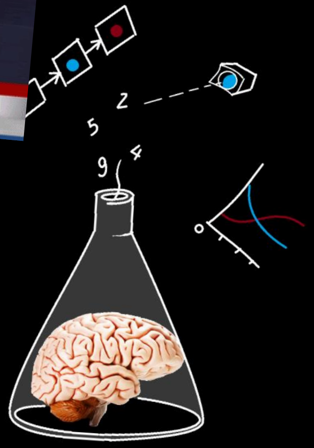
Endogenous vs. Exogenous attention

internally driven (by ourselves) vs. externally driven (by the world)



So how does all this work, cognitively?
Let's look at neurons…

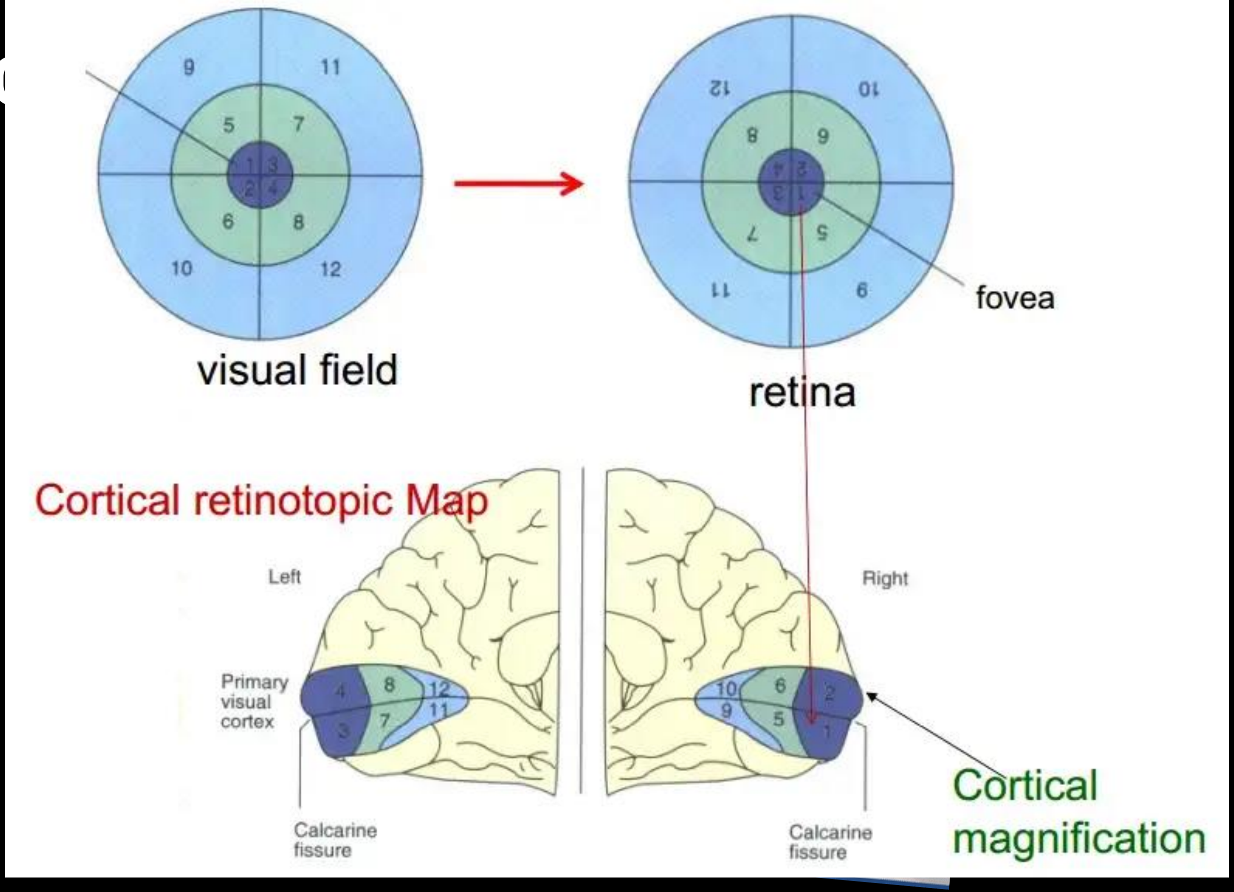




Neurons have thresholds for when to fire

The more a neuron is excited (the more input it receives via its dendrites), the more frequently it will fire action potentials

So how does all this work,
Let’s look at neurons…



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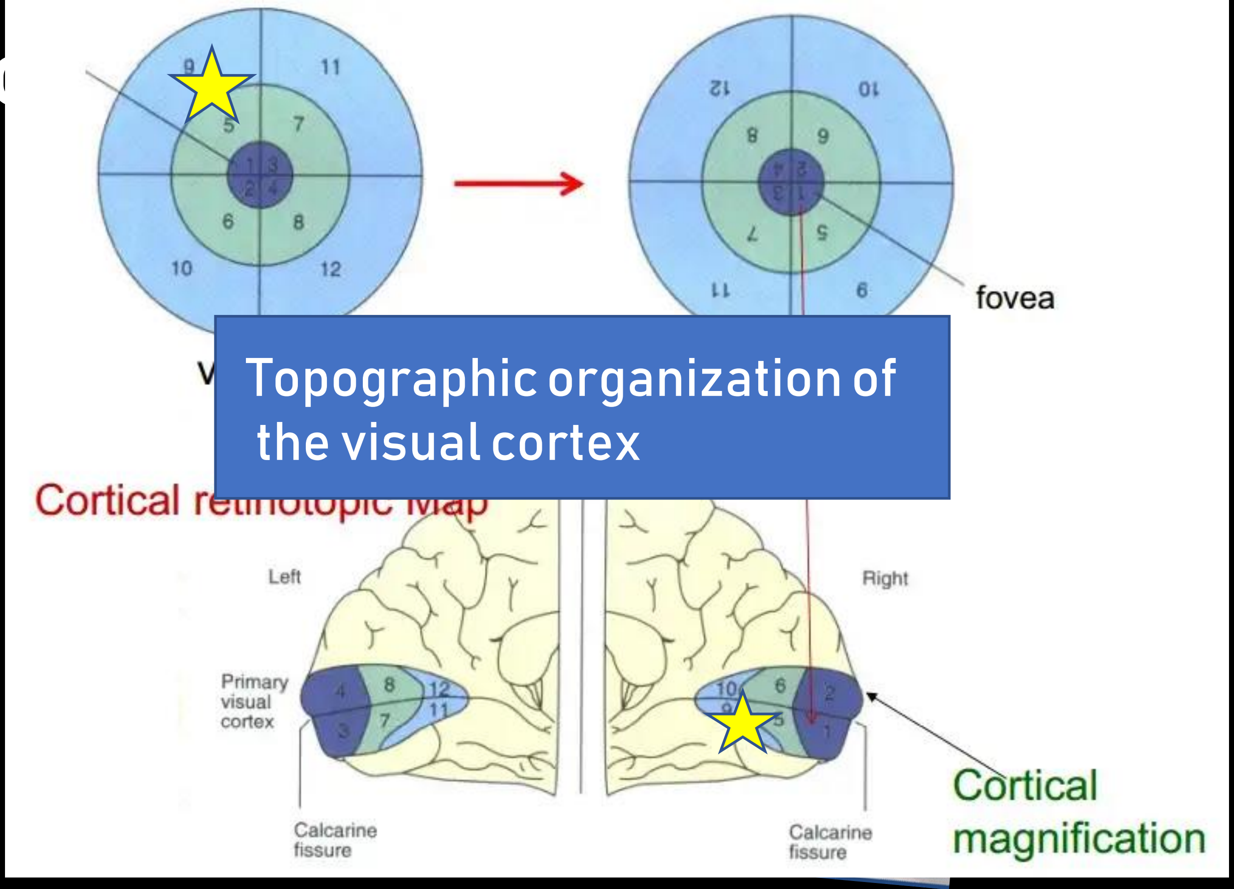

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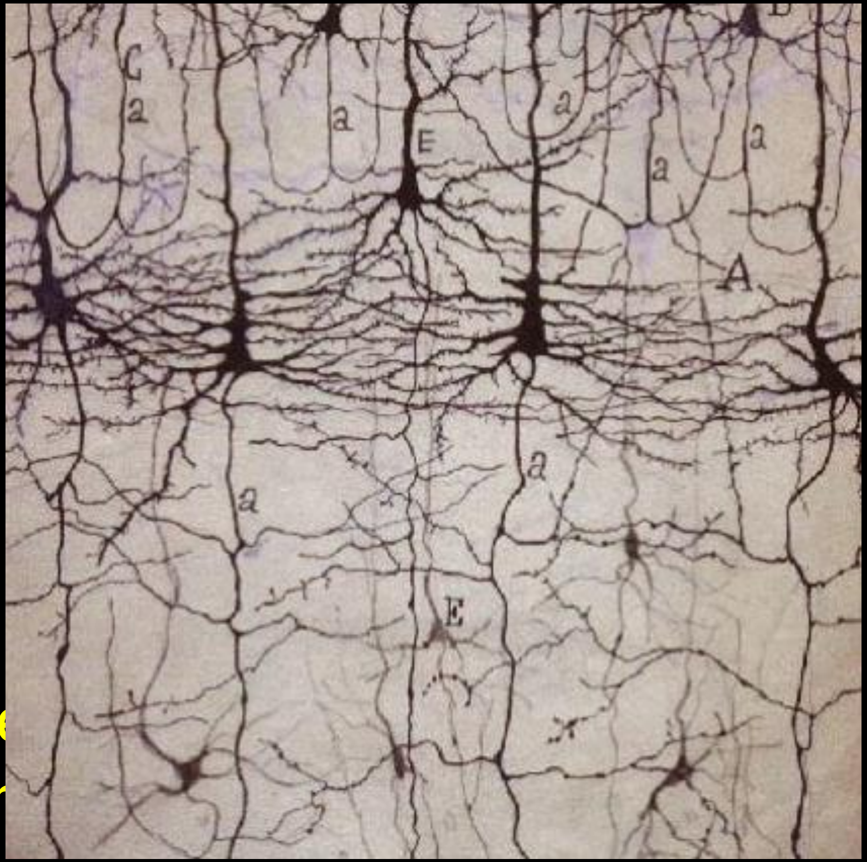


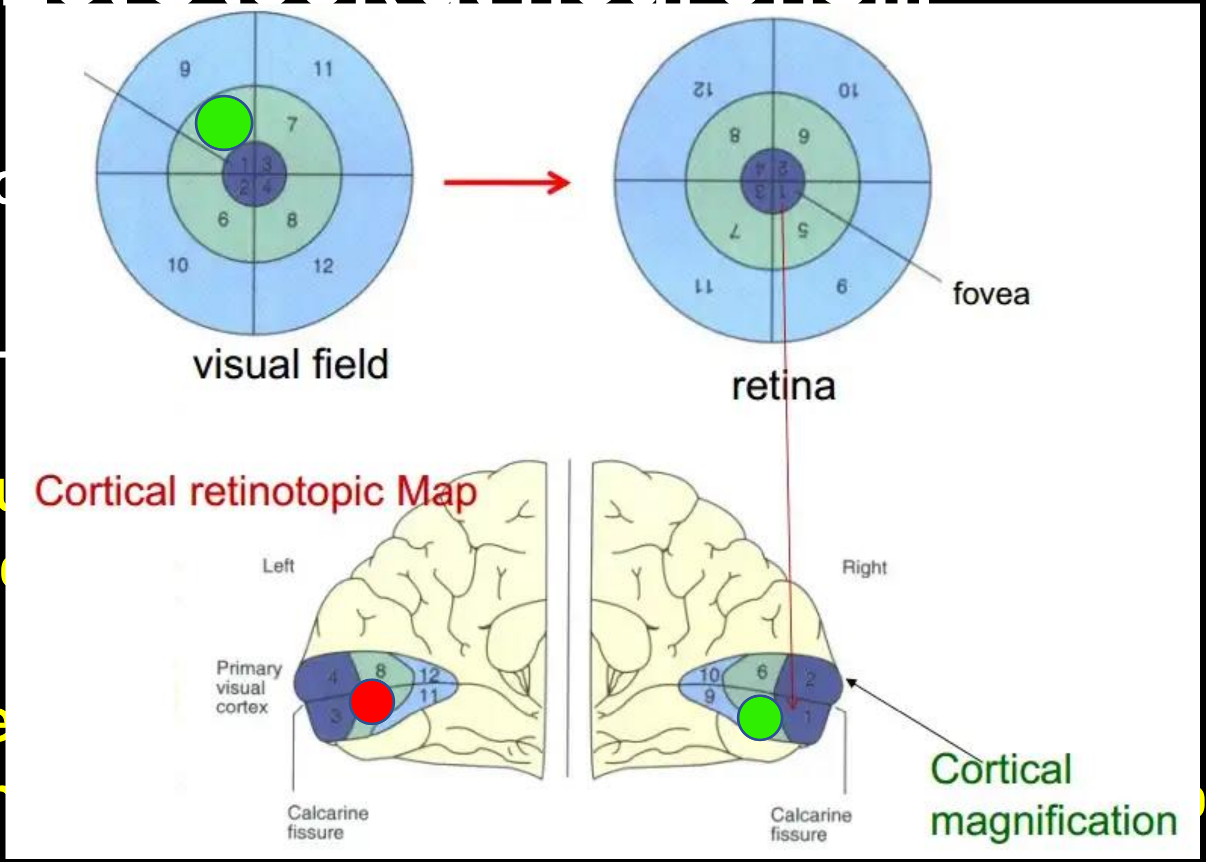
Neurons have
thresholds for when to fire

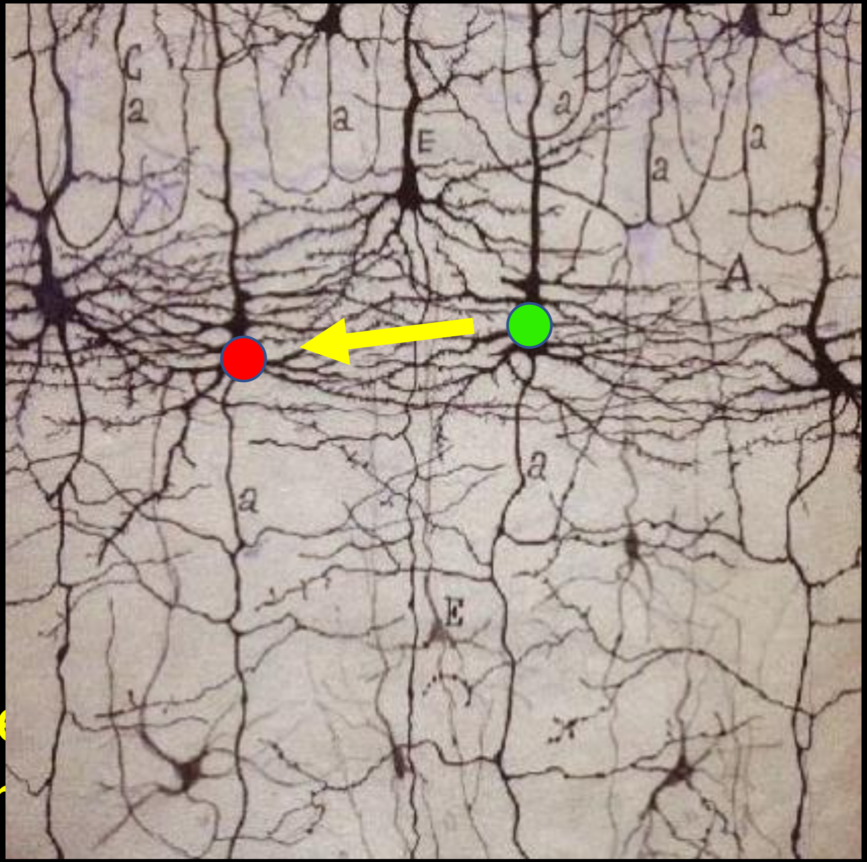
The more a neuron is excited (the more input it receive
dendrites), the more frequently it will fire action poter

Some connections are ***inhibitory*** rather than ***excitatory***.

Neurons coding for Hillary’s upper visual field may have suppressed neurons coding for Hillary’s lower visual field when ‘the thing’ happened.

So how does all this work, cognitively?
Let's look at neurons...





Rec
me
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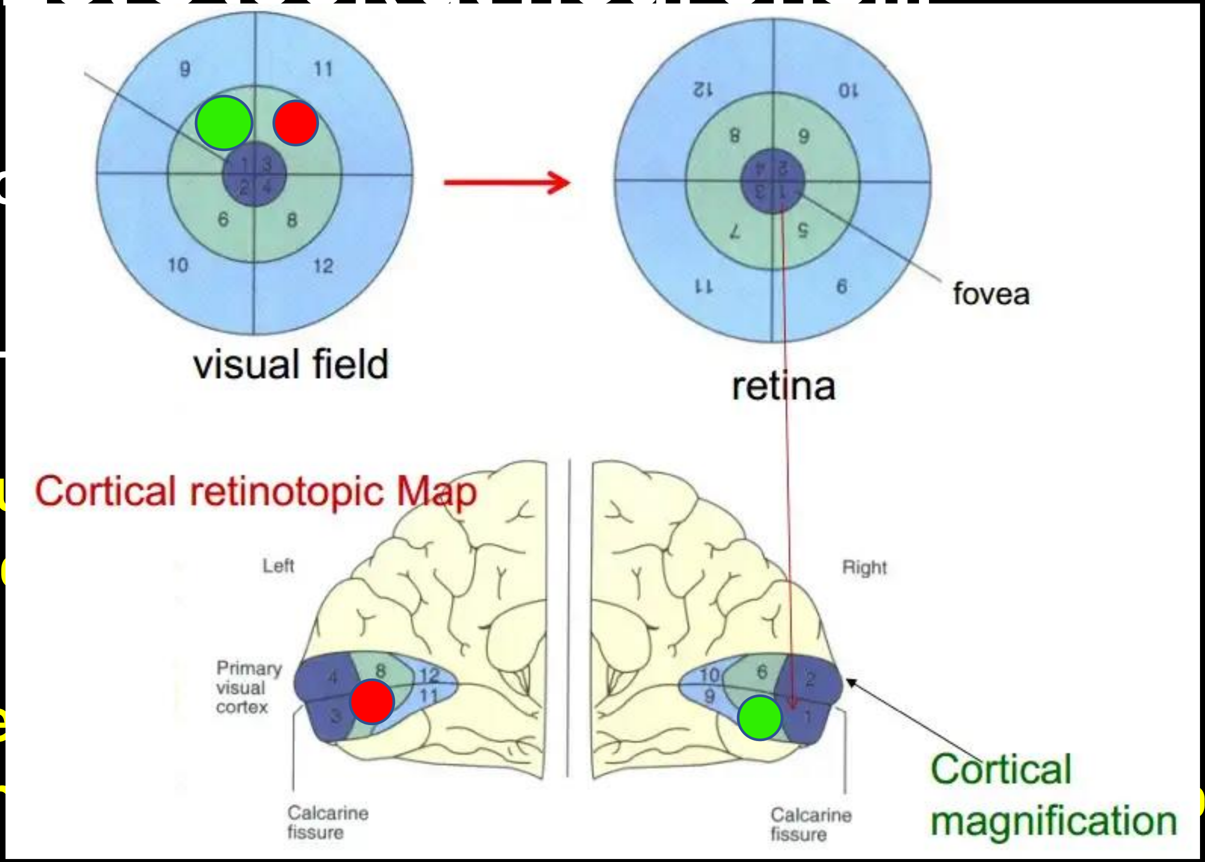

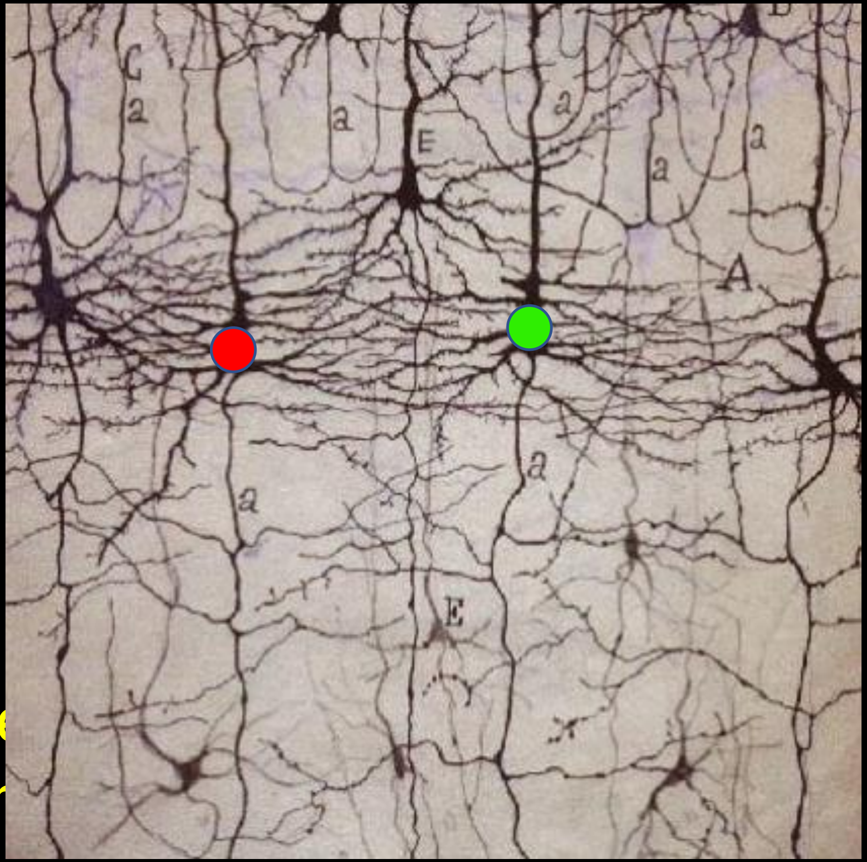

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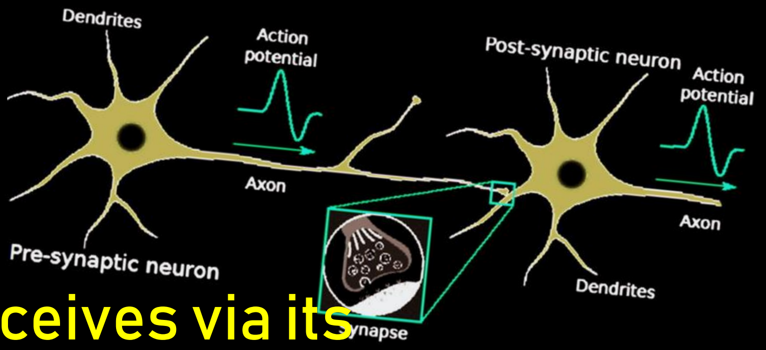
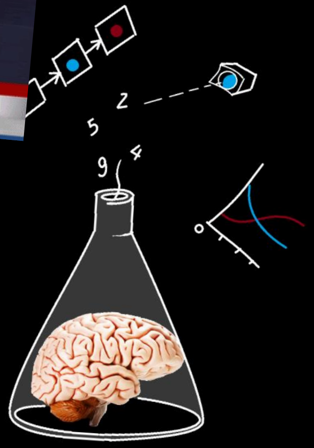


Neurons have
thresholds for when to fire

The more a neuron is excited (the more input it receives via its dendrites), the more frequently it will fire action potentials

Some connections are <u>*inhibitory*</u> rather than <u>*excitatory*</u>.
Neurons coding for Hillary's upper visual field may have suppressed neurons coding for Hillary's lower visual field when 'the thing' happened.

Signals sent by the upper-visual-field neurons will have entered conscious awareness (frontal brain regions) faster



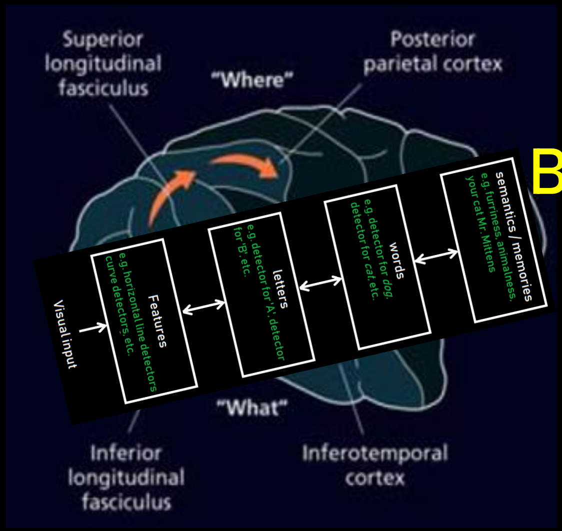
So how does all this work, cognitively?

Exogenous attention: strong sensory input tips the balance

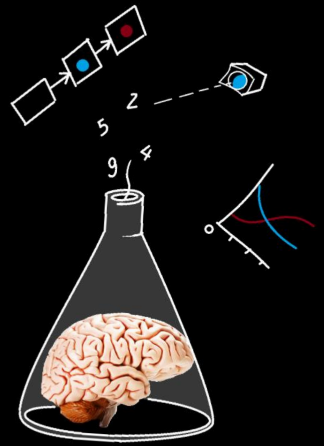
(in terms of the 'neuron battle' described on previous slide)

Endogenous attention: higher-order neurons suppress or excite neurons at the level of perception

Recall story about bottom-up & top-down interactions



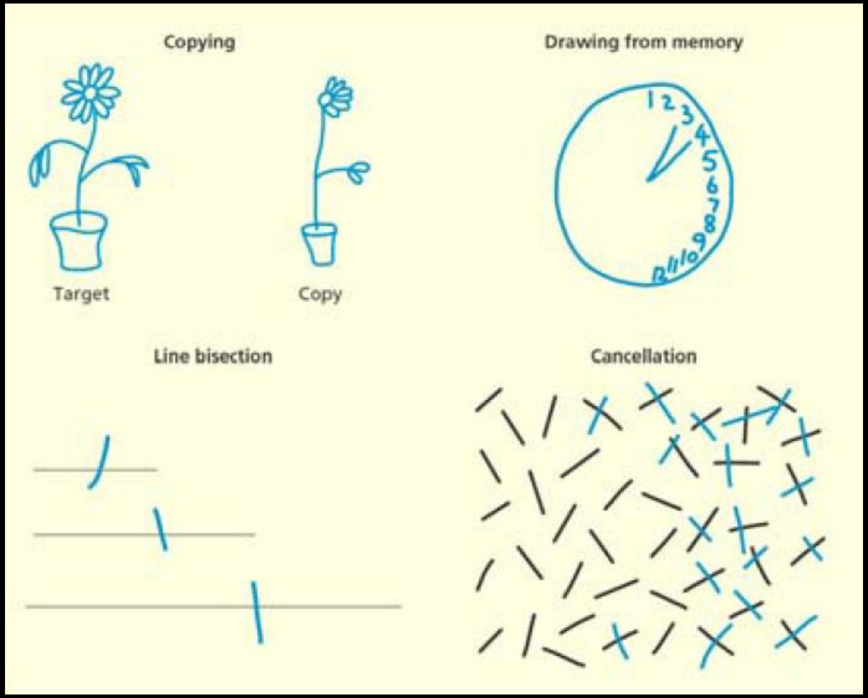
Biasing of low-level detectors by higher levels is a form of endogenous attention!

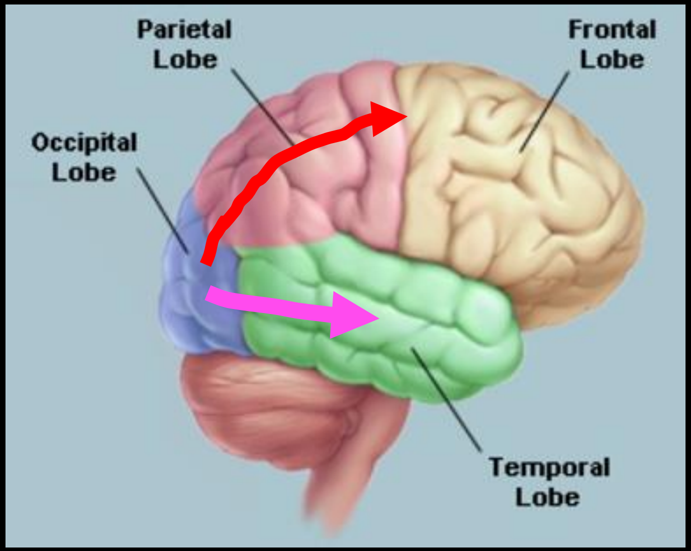


Attentional disorders

(Hemispatial) neglect *Where is the lesion?*

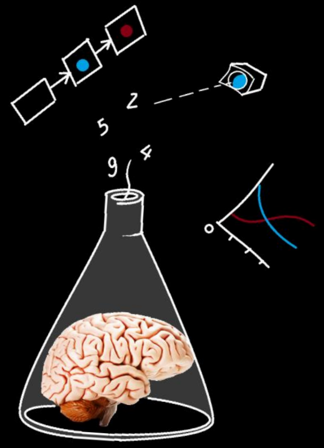
In all these tasks, one side (hemifield) is ignored, even though the patient *can* see things in that hemifield when attention is forcefully directed to it





“where”

“what”



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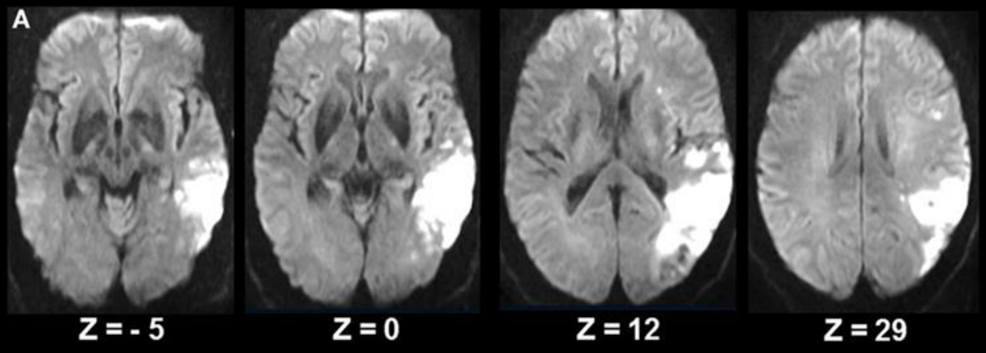
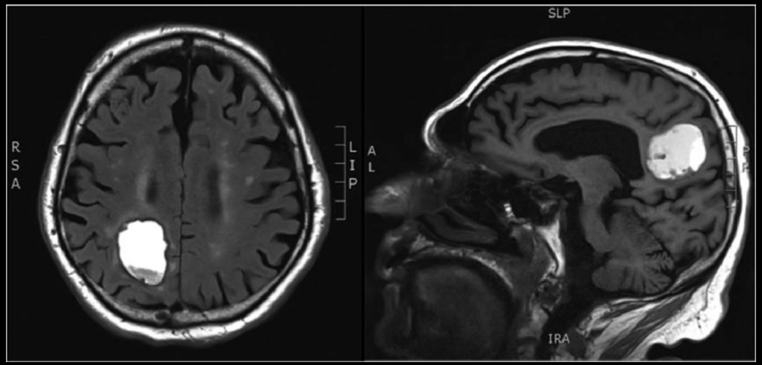
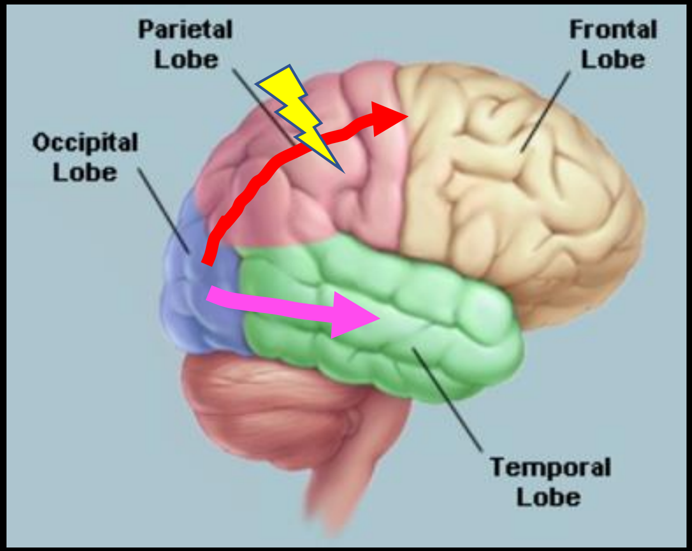
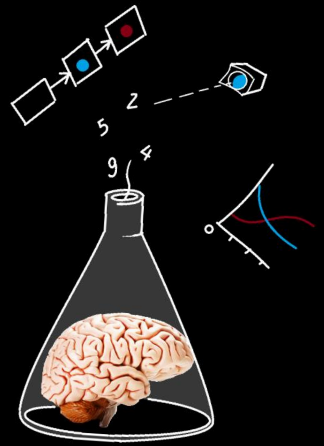






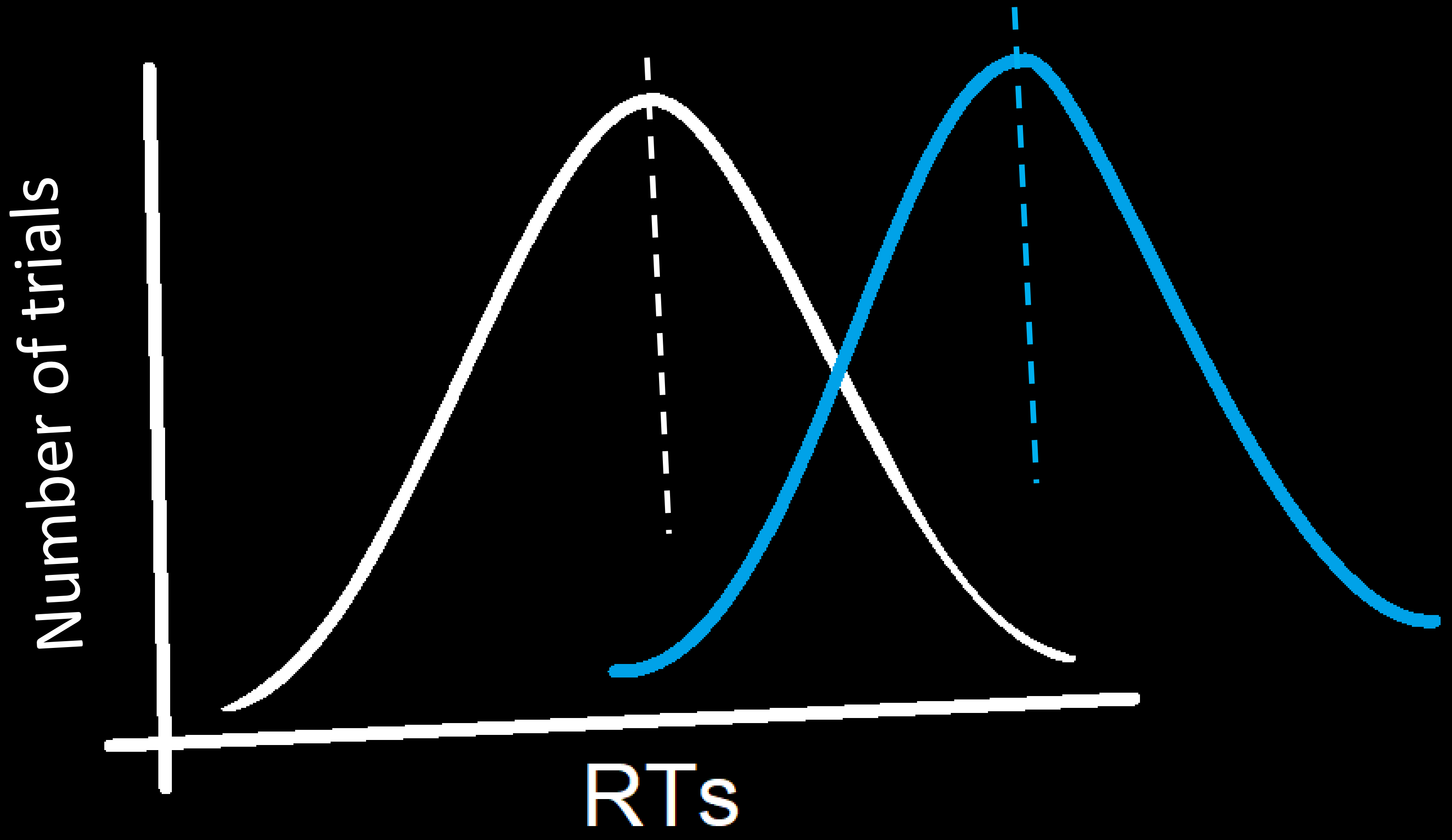
"where"

"what"



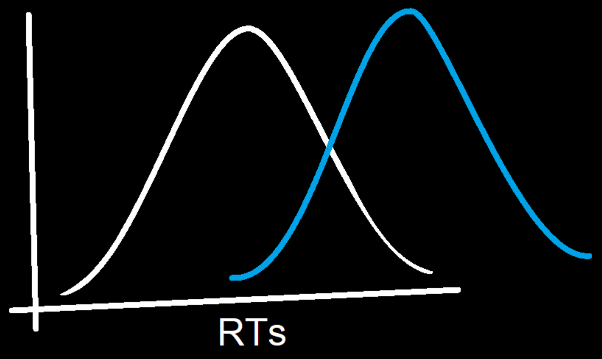
Response times

Certainty that an effect exists depends not just on the means, but on the spread.
→ The extent to which distributions overlap



Response times

Is this all that there is to RTs?



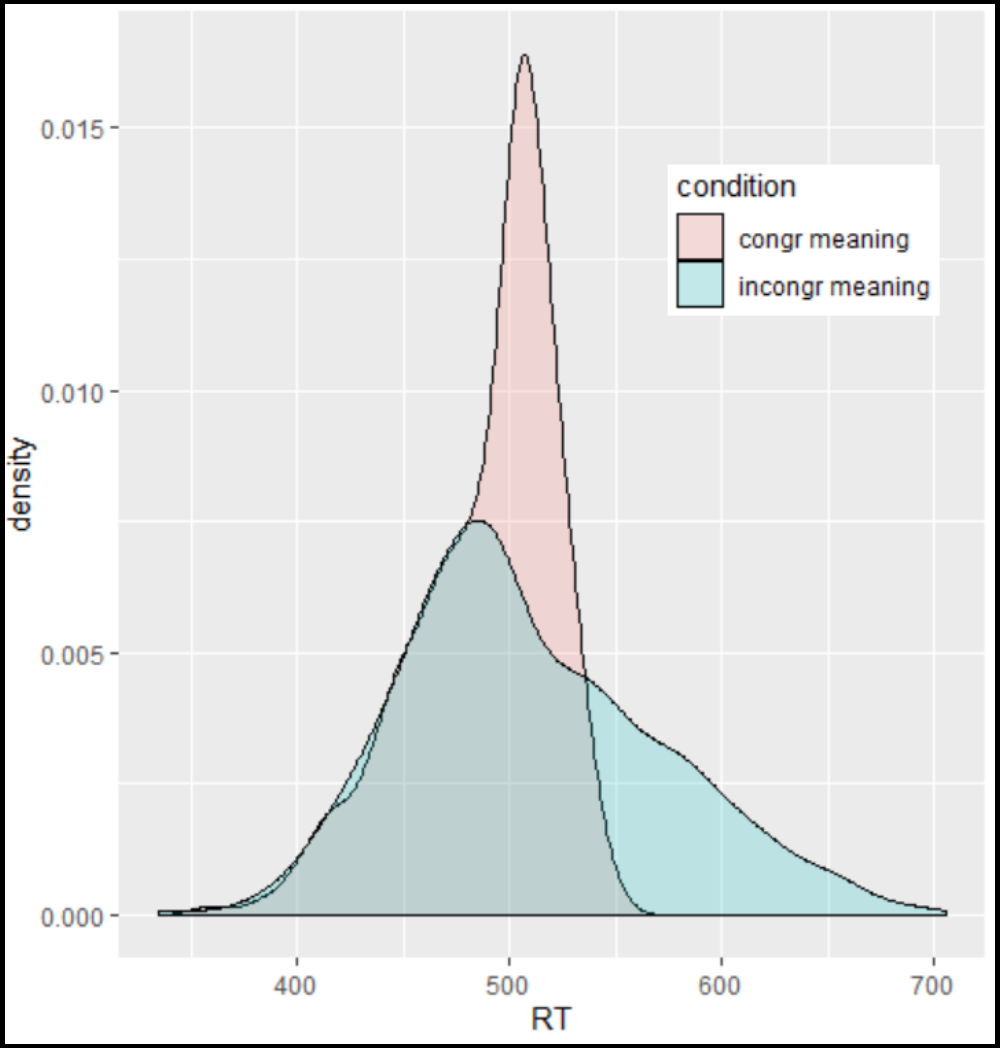
Distributions could reveal more information
→ A difference between two response conditions may be more strongly expressed in the faster portion of RTs than in the slower portion.
(Gomez & Perea, 2020)

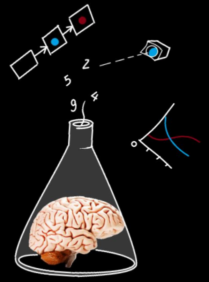
Response times

Early RTs are very similar between conditions, late RTs differ a lot.

…so this effect has a late temporal locus.

Decisions about stimulus color



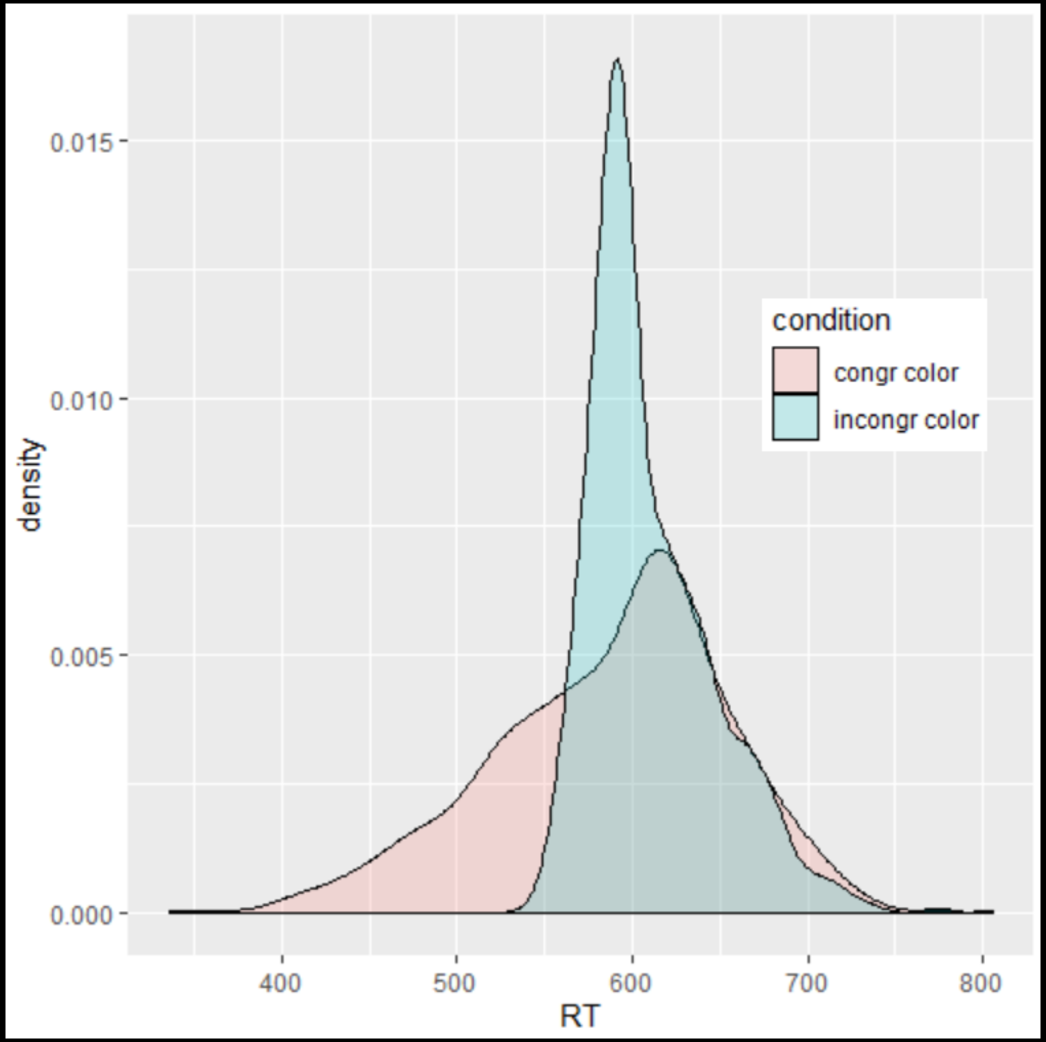


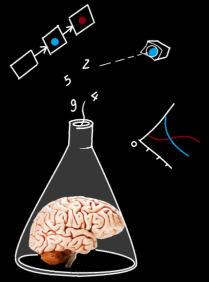
Response times

Late RTs are very similar between conditions, early RTs differ a lot

...so this effect has an early temporal locus.

Decisions about word meaning





Accuracy

Is it problematic if we find an effect in accuracy but not in RTs?
→ No.

Persons A and B are equally fast, but A is more accurate: A performed better

A and B are equally accurate, but A did it quicker: A performed better.

Accuracy

Is it problematic if opposite effects are found in accuracy and RT?
→ Yes.

Person A is better at shooting, but person B is better at skiing. We cannot tell who is the better biathlete.

Combining RTs and accuracy

Inverse efficiency scores

Combining RTs and accuracy into one measure (IES) may allow us to make better direct comparisons.

$$\mathbf{IES = RT / P_{(correct)}}$$

RT = 500 ms, accuracy = 0.90 → IES = 500/0.90 = 556 ms.

RT = 480 ms, accuracy = 0.80 → IES = 480/0.80 = 600 ms.

A deeper look into accuracy
Signal detection theory

A more elaborate measure of accuracy: *Sensitivity*

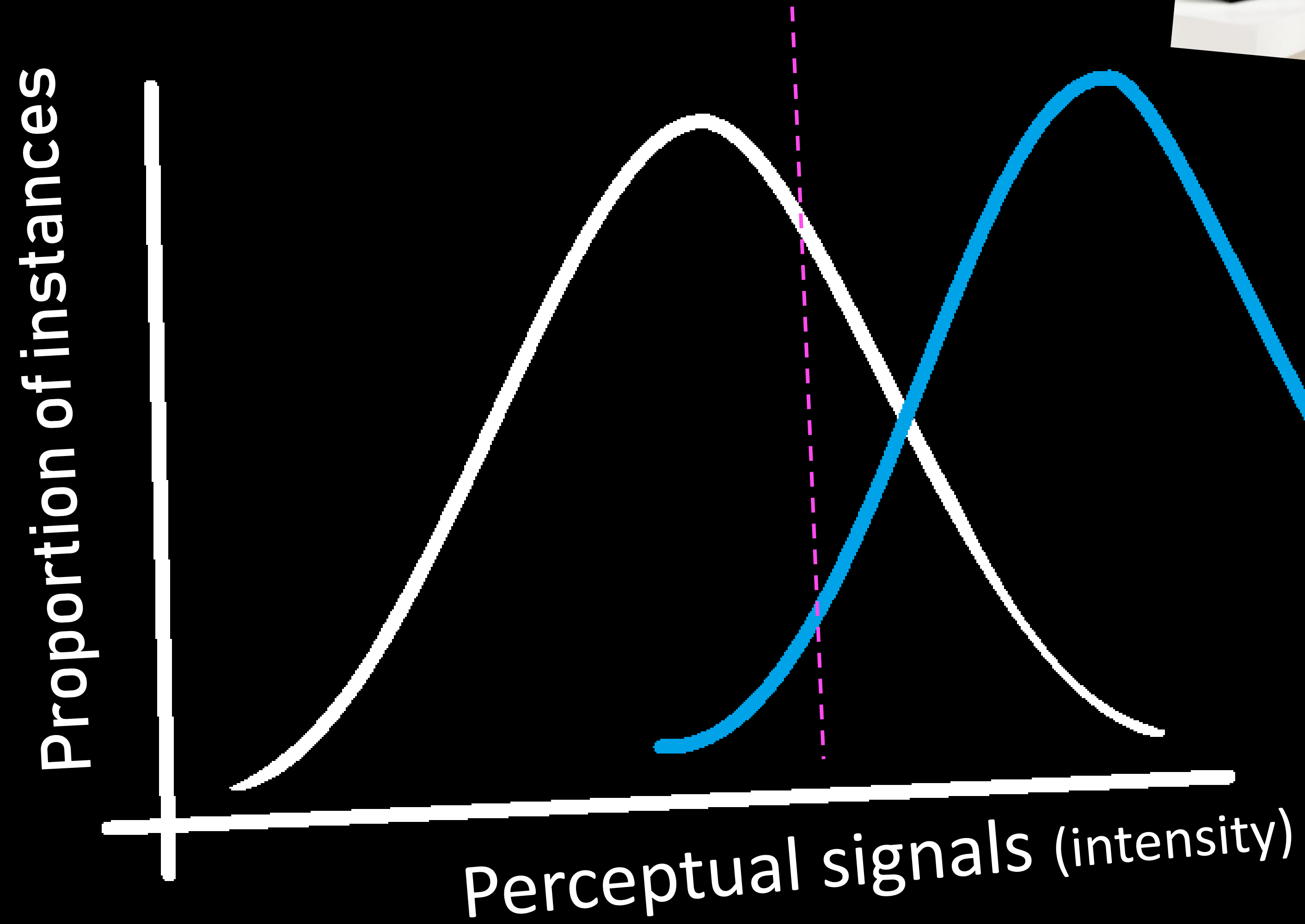
The world around us is noisy

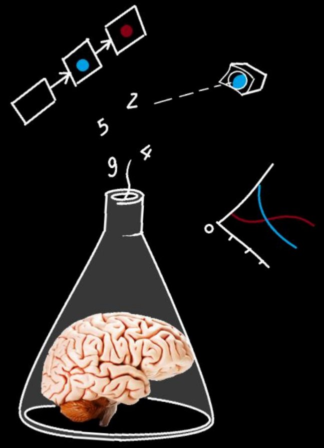
→ How well can we distinguish the relevant from the irrelevant?

Sensitivity doesn't only look at our ability to spot the relevant, but also at our ability to ignore the irrelevant

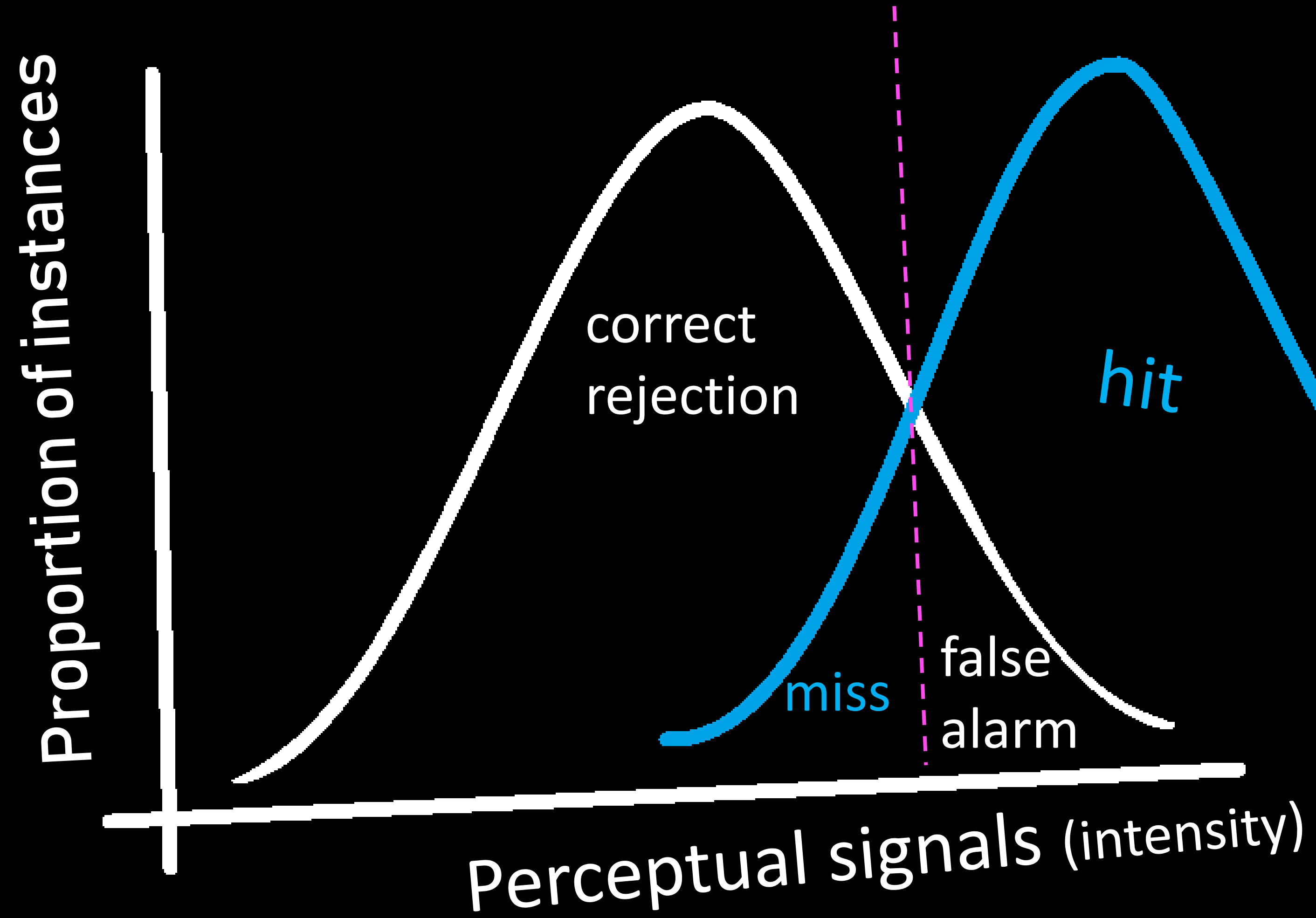
Sound intensity without vs. with alarm

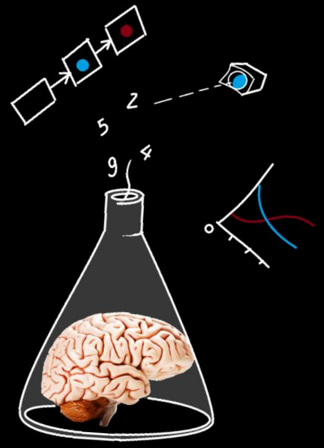
NOISE **SIGNAL**





Cucumber neuron's firing rate when seeing a zuccini vs. a cucumber: *4 outcomes*



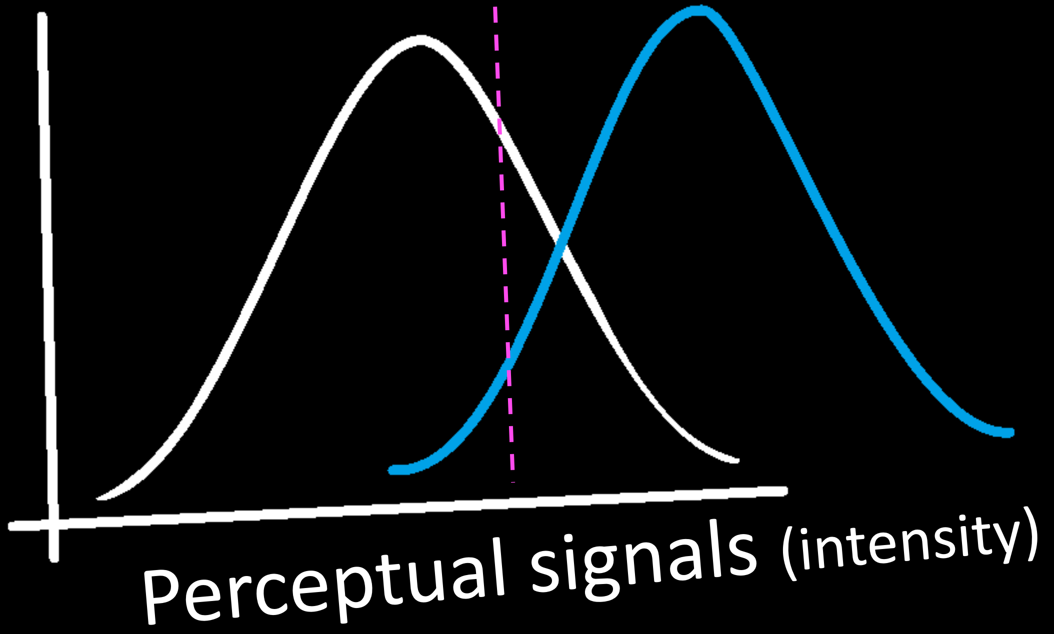


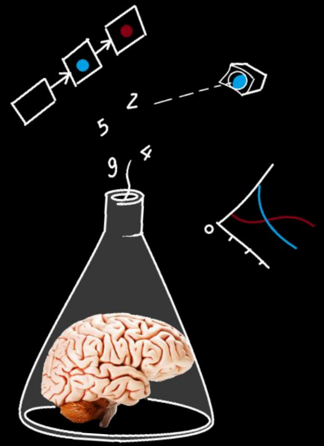
The distance between signal and noise distributions varies among individuals and is called *sensitivity*

(= perceptual skill!)

Not affected by response threshold (criterion)!

z(hits) – z(false alarms) remains same



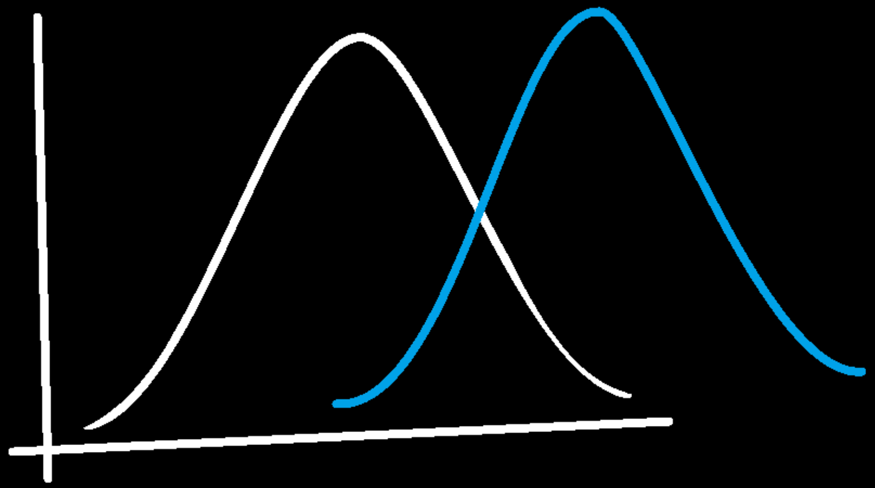


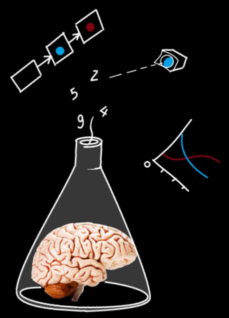
Staircase procedures

a.k.a.: Controlling the subjective distance between the relevant and the irrelevant

→ adjust stimulus intensity, duration, etc., on the basis of incoming responses

→ so that all subjects perform equally

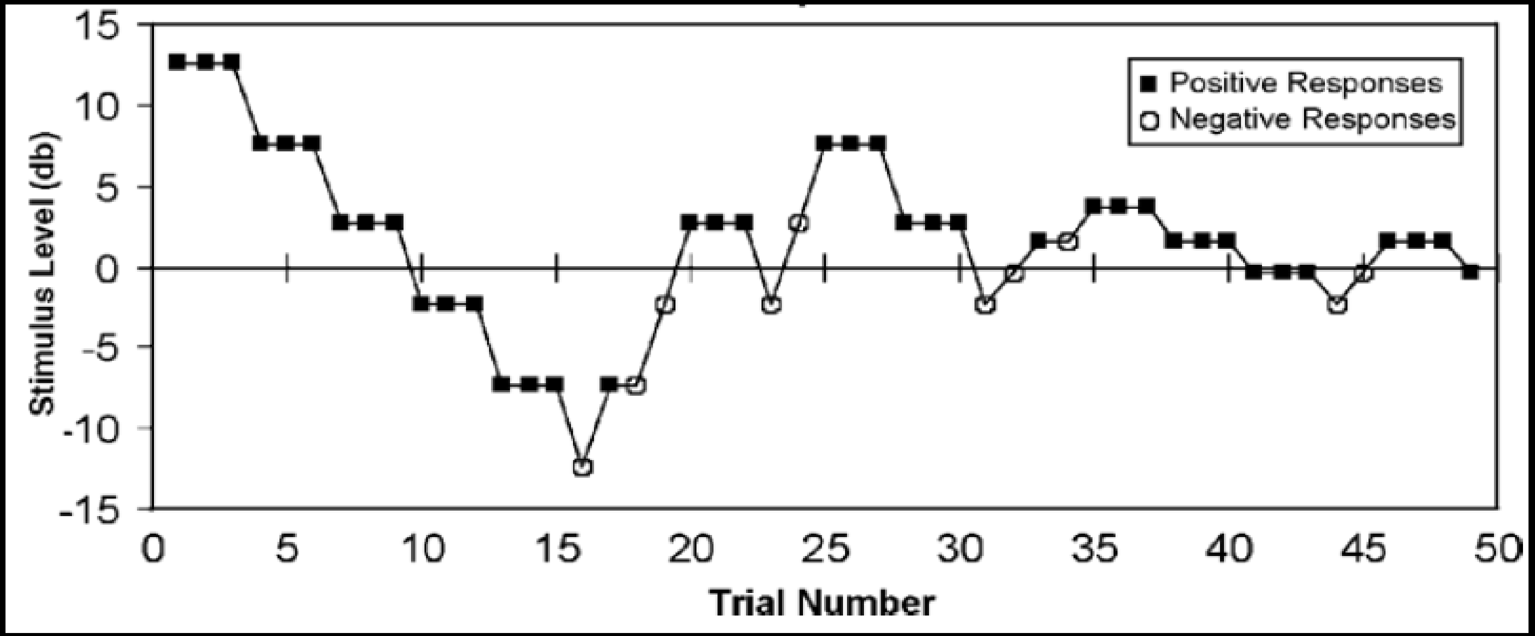


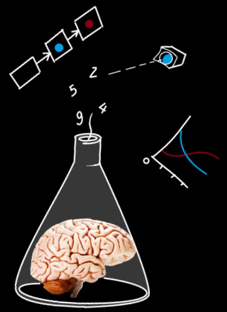


Staircase procedures : example

- After X correct trials, decrease stimulus duration by β
- After Y incorrect trials, increase stimulus duration by β

- After each oscillation, decrease β a bit (until it hits 0)

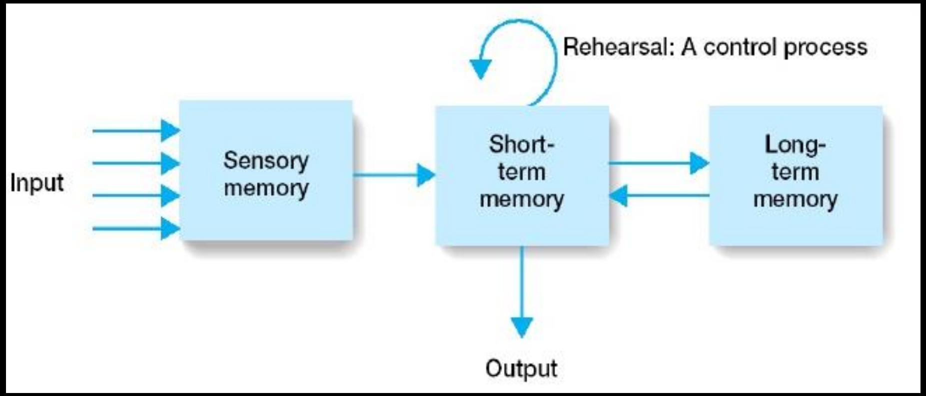




Memory is…

Any way in which a past experience affects future thoughts or behaviors

The Modal Model of Memory – 1968



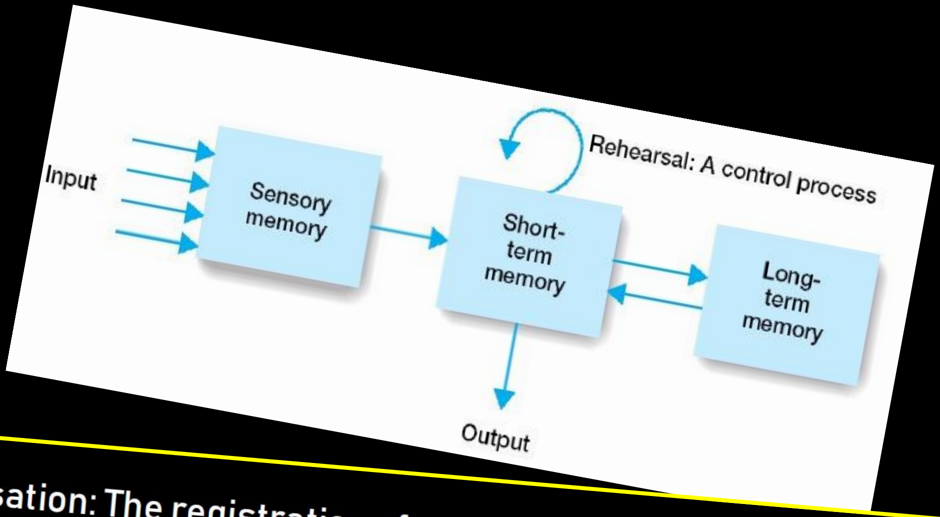
Today, we still conceptualize various stages of memory

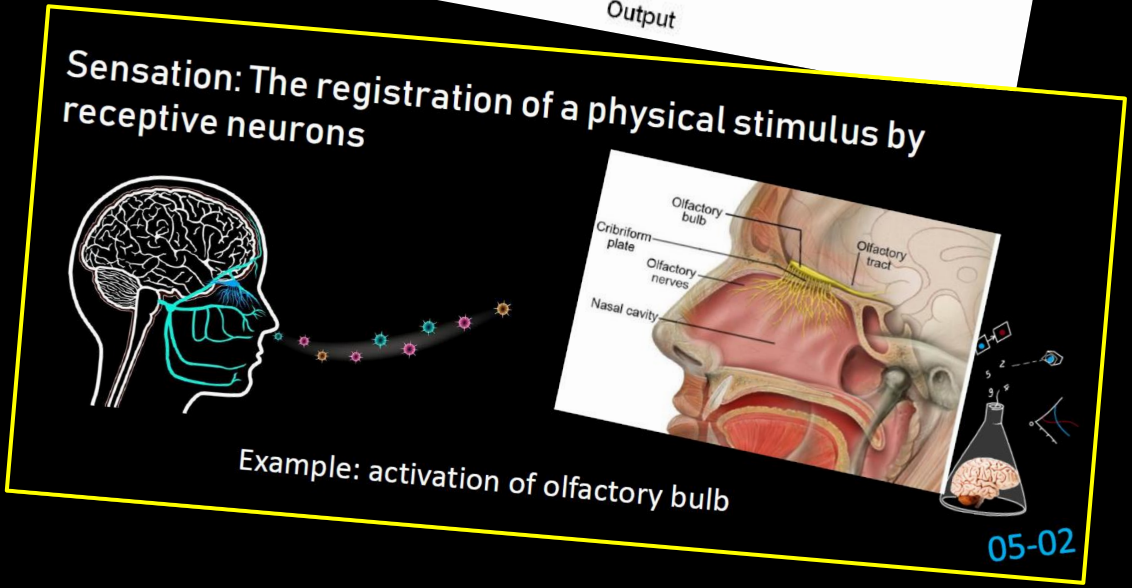
Sensory, STM/WM, LTM

What's the difference between sensory- & short term memory (STM)?

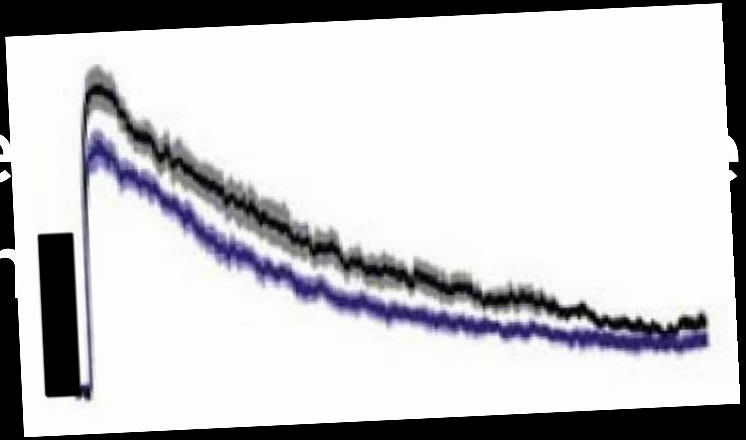
Think back of lecture 3:
sensation vs. *perception*!

Sensation ≈ sensory memory, because neural activity caused by a sensation isn't turned off like a light switch



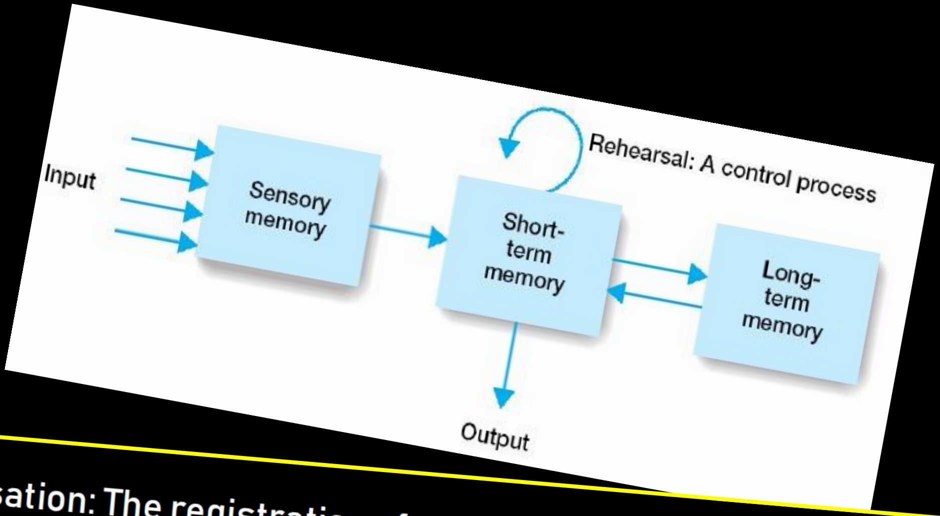


What's the … een sensory- & short term



Think back of lecture 3:

sensation vs. perception!



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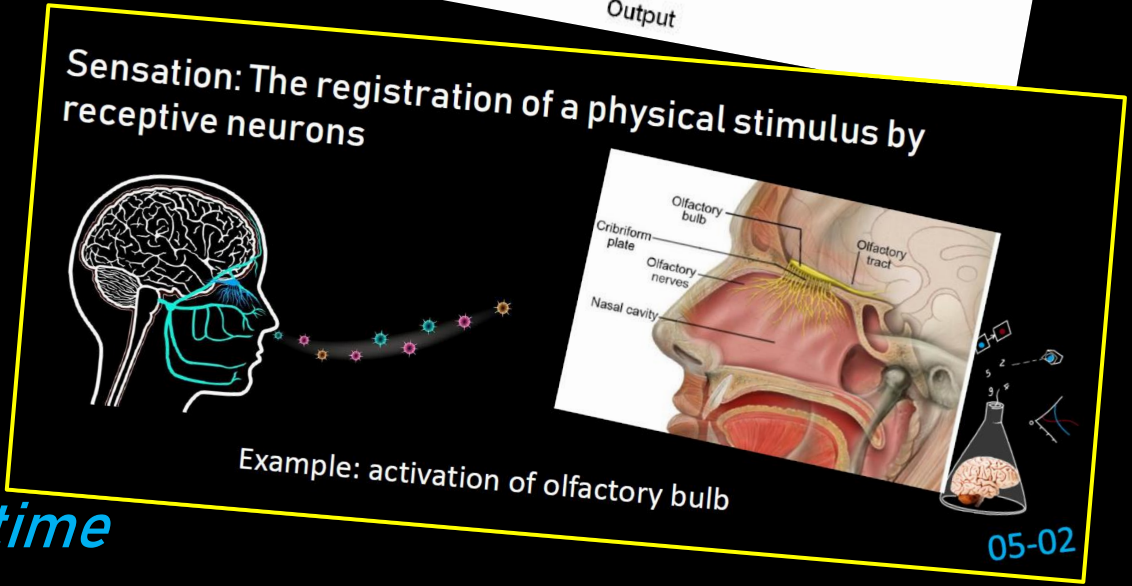


Activity in early regions <u>decays</u> over time

What’s the difference between sensory- & short term memory (STM)?

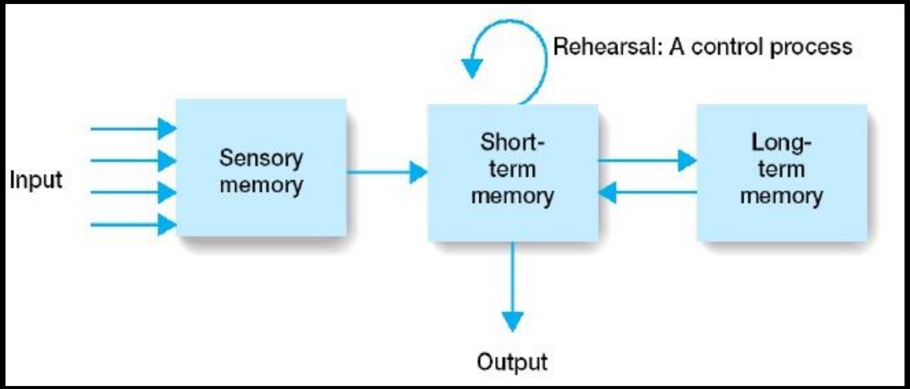
Think back of lecture 3:
sensation vs. *perception*!

Sensory memory examples

What’s the difference between sensory- & short term memory (STM)?

Our senses register a lot of information (e.g. the whole visual field), but only part of it is consciously processed

A.K.A. only part of it enters STM (= attentional orienting!)



STM: what's the limit?

529846731

vs.

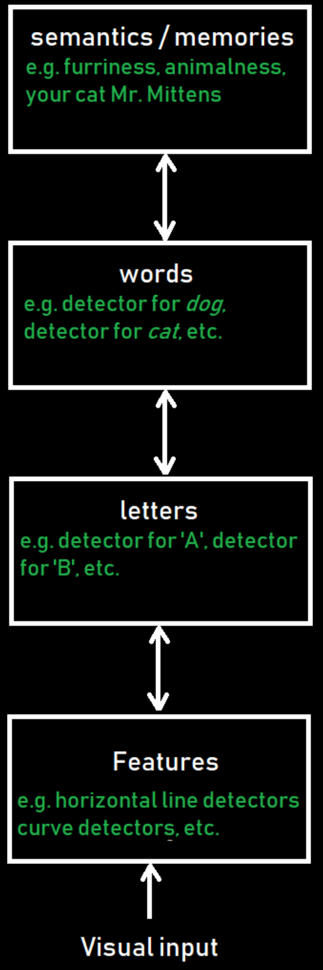
123456789123456789 *chunking*

The learned relationships among objects are a matter of long-term memory

… yet, this knowledge does aid STM

→ interdependence

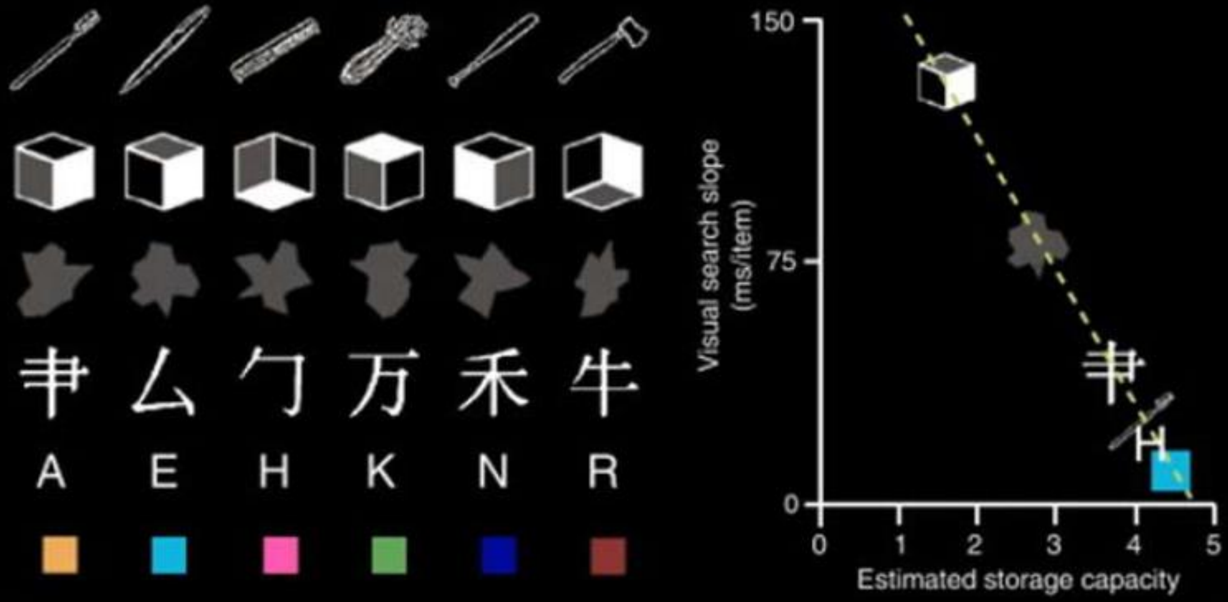
Interaction between top-down & bottom-up (perception lecture) works for memory too!



STM: what's the limit?

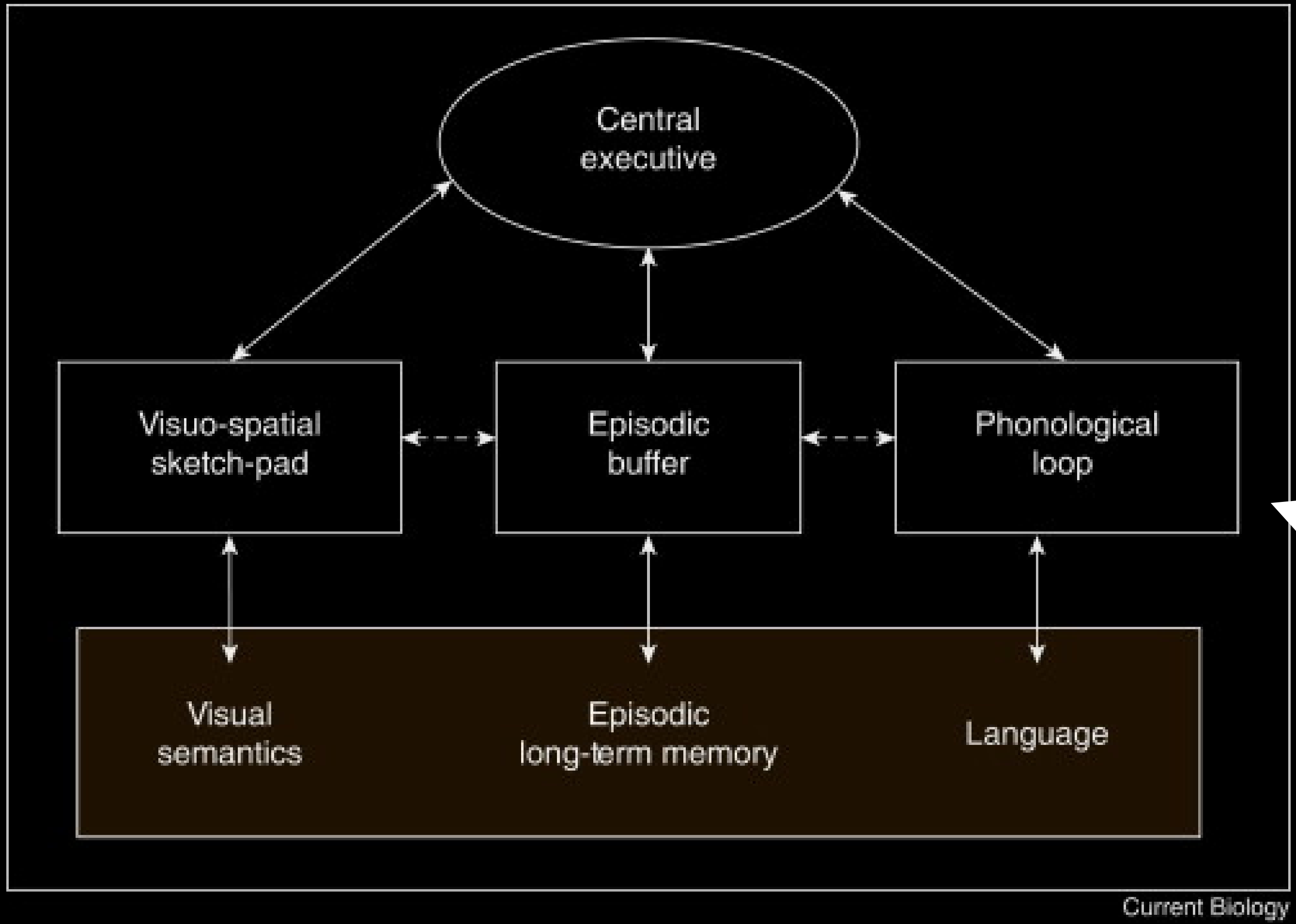
Instead of framing the limit in terms of number of objects, frame it in terms of amount of information.

Some item types are more difficult to remember



Alvarez, G. A., & Cavanagh, P. (2004). The capacity of visual short-term memory is set both by visual information load and by number of objects. *Psychological Science*, *15*(2), 106–111.

Working Memory

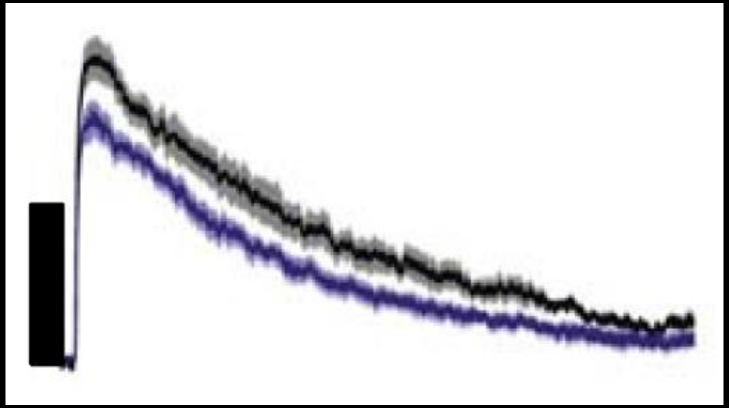


"slave systems"

Working Memory

How does it work in the brain?

Sensory memory is easy: residual activity in early perceptual regions of the brain



WM in the brain

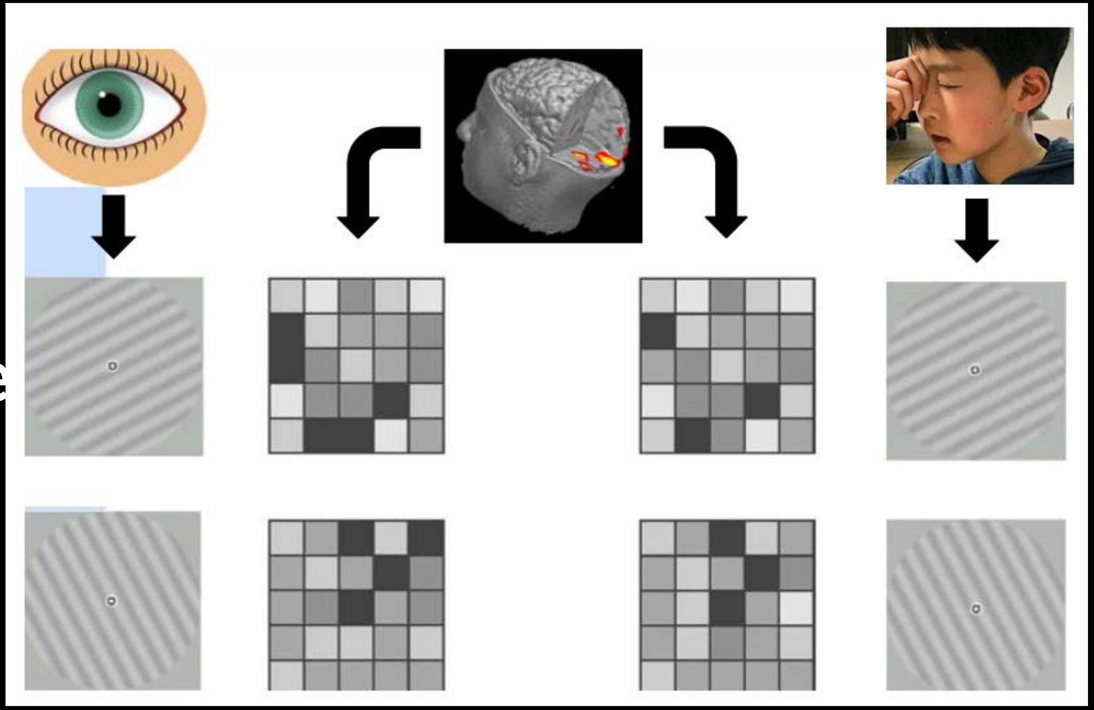
PFC is key… but so are all our perceptual areas

We can 'read minds' by looking at the visual cortex

looking *memorizing*

So memories are 'stored'
- or at least read out -
in the visual cortex too

→ 'Higher' regions like the PFC coordinate activation in perceptual regions during retention



What is LTM?

- LTM is the seemingly infinite archive into which we have stored every experience since our existence

- Though the archive is infinite, stored files may ‘wither’

- Throughout our lives, we are automatically building the archive – for strategic purposes

learning, automatization, bolstering WM

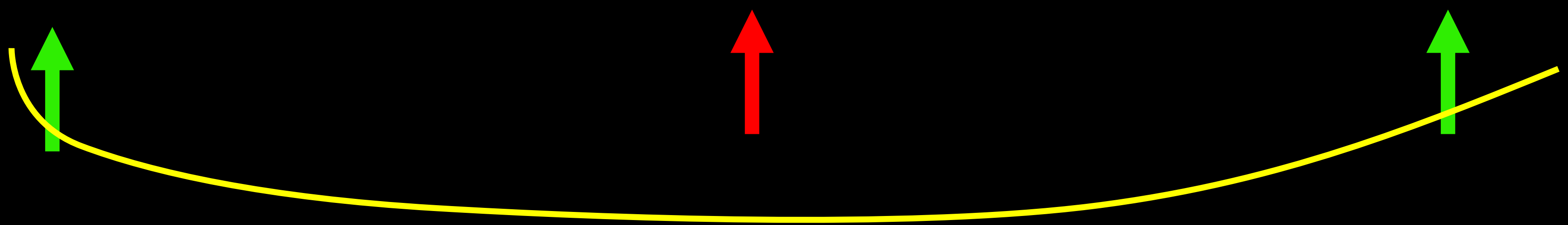
The interaction between WM and LTM

First of all: how do we know that these are really two separate things in the brain?

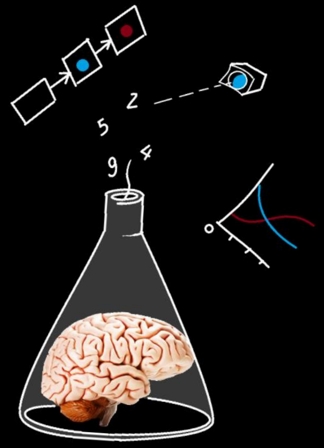
An experiment without patients: *The serial position curve*

briefly presented one-by-one:

tree – laptop – sphinx – earbud – mouse – lamp – pocket



When asked to recall as many words as possible, subjects report the first and last words best



The interaction between WM and LTM

First of all: how do we know that these are really two separate things in the brain?

An experiment without patients: *The serial position curve*

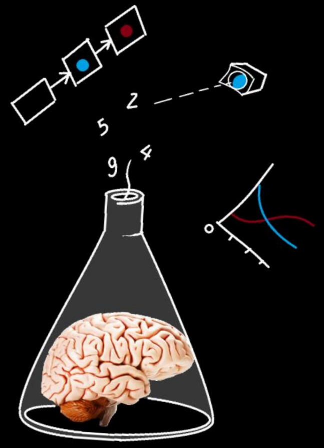
briefly presen

tree – lap

mp – pocket

Neither STM nor LTM can account for both these effects simultaneously; ergo, we need both

When asked to recall as many words as possible, subjects report the first and last words best

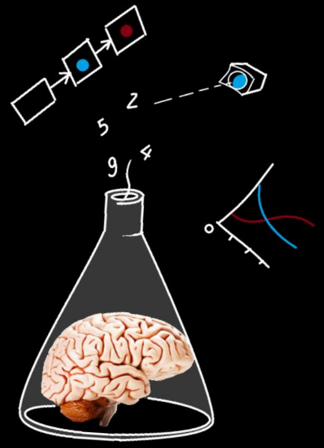


The interaction between WM and LTM

First of all: how do we know that these are really two separate things in the brain?

primacy effect (first word advantage): first words get full attention; STM not occupied by other things, and/or words were rehearsed for a longer amount of time

recency effect (last word advantage): Last words are still in STM

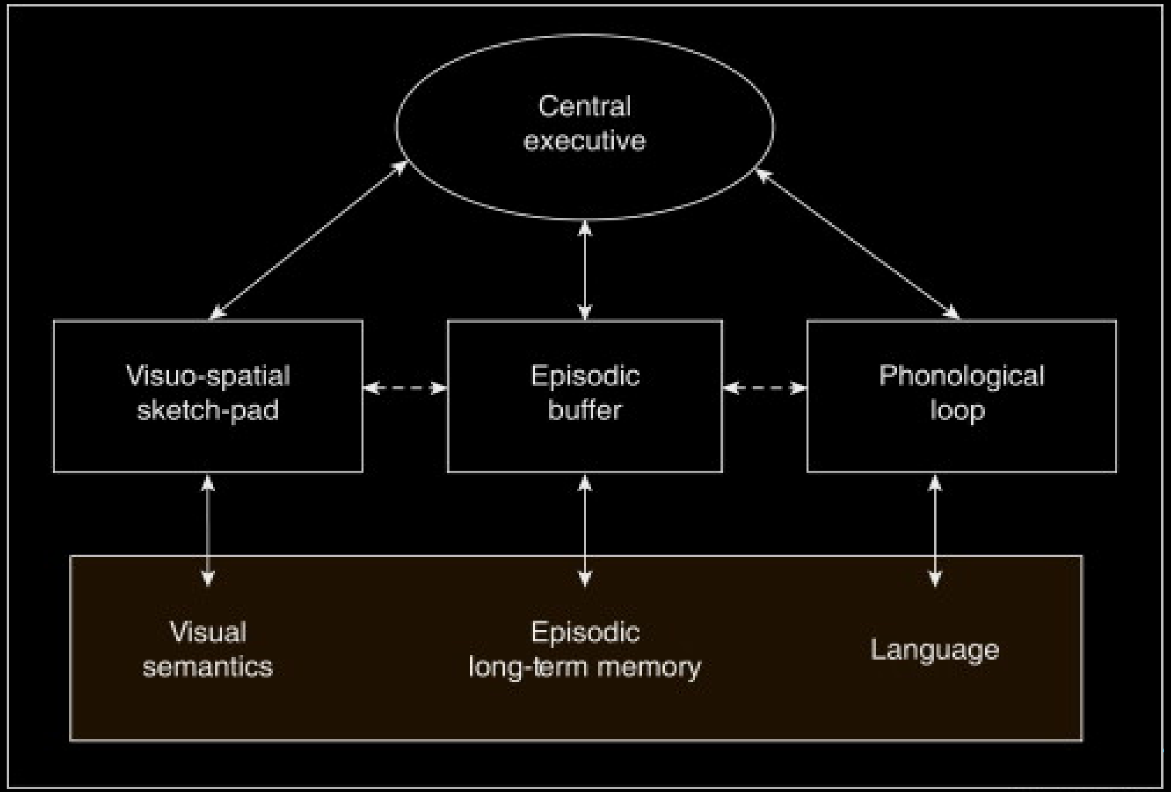


The interaction between WM and LTM

Information in LTM is constantly re-activated by the things that we keep in WM. This information in turn bolsters whatever is kept in WM.

- Meaning of words
- Relevant past events
- Goals

Neural mechanisms later

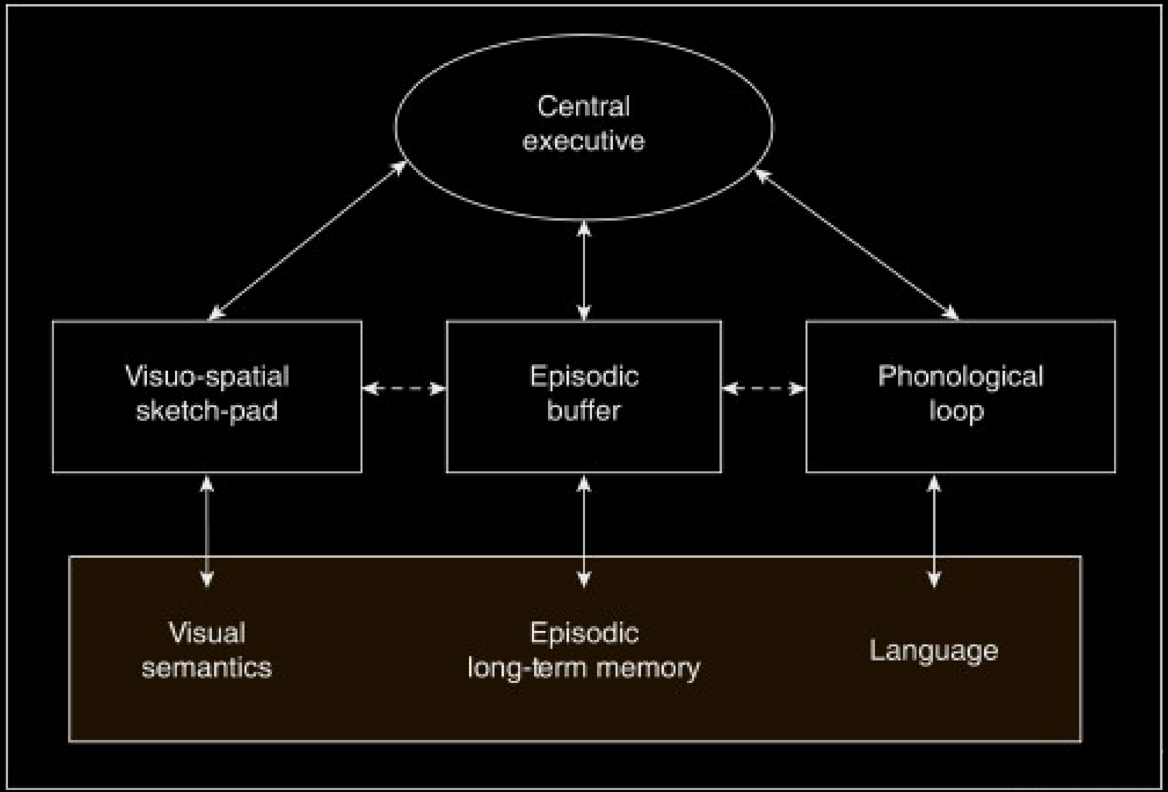


Current Biology

The interaction between WM and LTM

Information in LTM is constantly re-activated by the things that we keep in WM. This information in turn bolsters whatever is kept in WM.

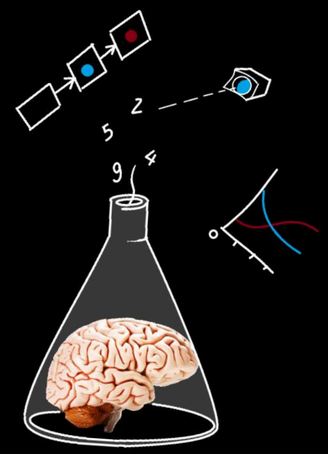
Example:



Current Biology

The various types of LTM

Episodic
Procedural
Implicit vs. explicit
Semantic



What’s the difference between semantic and episodic memory?

Past experiences vs. facts

‘mental time travel’

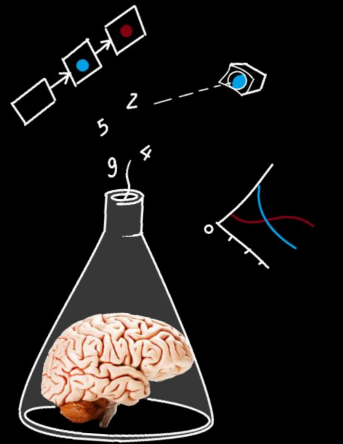
learned relationships

What's the difference between semantic and episodic memory?

A double dissociation: two patients…

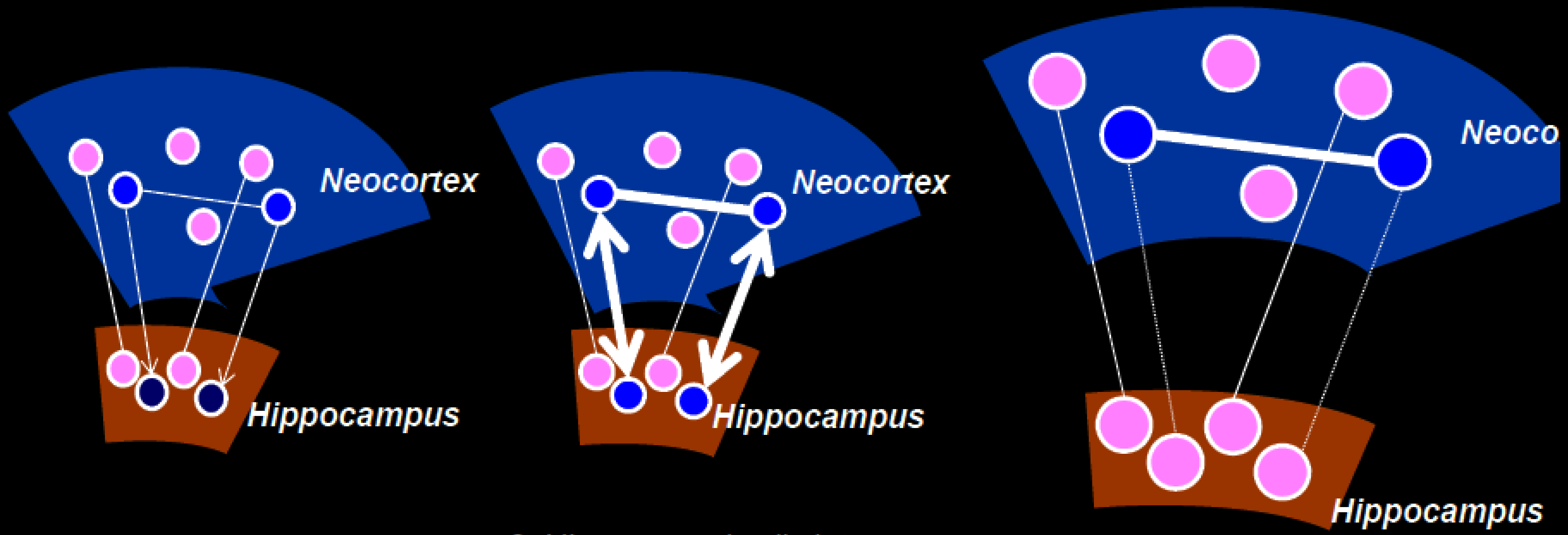
Displayed good knowledge about many things but forgot things that happened 3 minutes prior

Didn't know the meanings of words anymore, didn't recognize close relatives; but could recount the previous day, week, or year



How does LTM work in the brain?

Consolidation



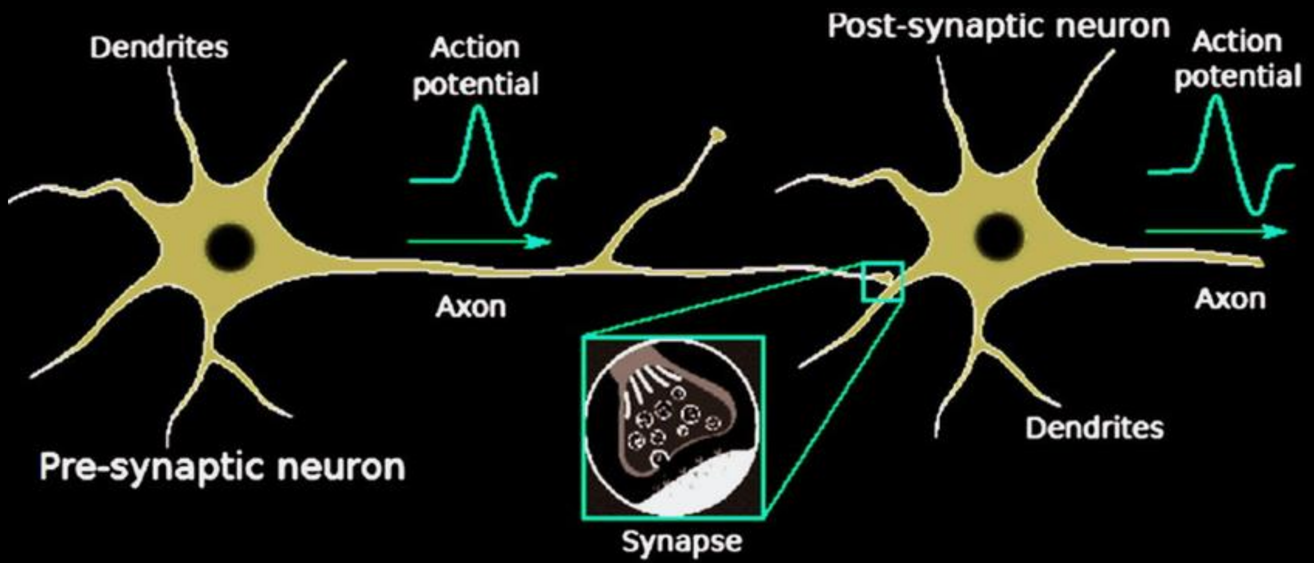
1. Cortical neurons activate associated hippocampal cells

2. Hippocampal cells later on re-activate the cortical cells, allowing the connection in the neocortex to strengthen

3. The cortical assocation is consolidated (LTP), the hippocampal connection is allowed to deteriorate

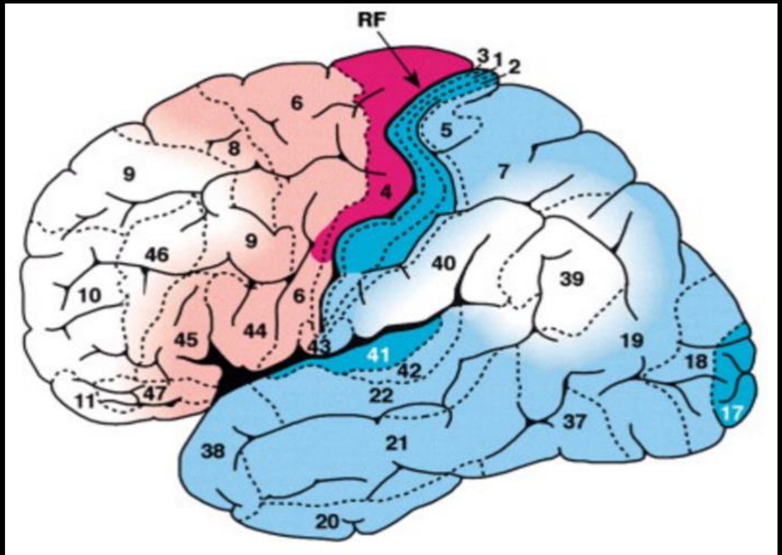
...but what about implicit learning?

Learning at the level of single neurons:
with repeated activation, there is a chemical change at the synapse. The *synaptic transfer* is strengthened
Ergo, faster processing
e.g., stronger connections between letters and words



Decision-making

Perception & Action



Decision-making is the bridge between perception (+memory, emotions, biases, predispositions, etc. etc. etc.) and action

Expected utility theory

“Given knowledge about what the outcomes of various options will be, people choose whatever yields maximum value”

Not true

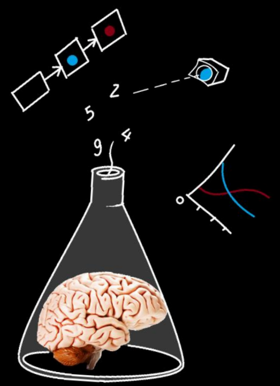
Confirmation biases and overconfidence biases

We give more weight to information that confirms our expectations

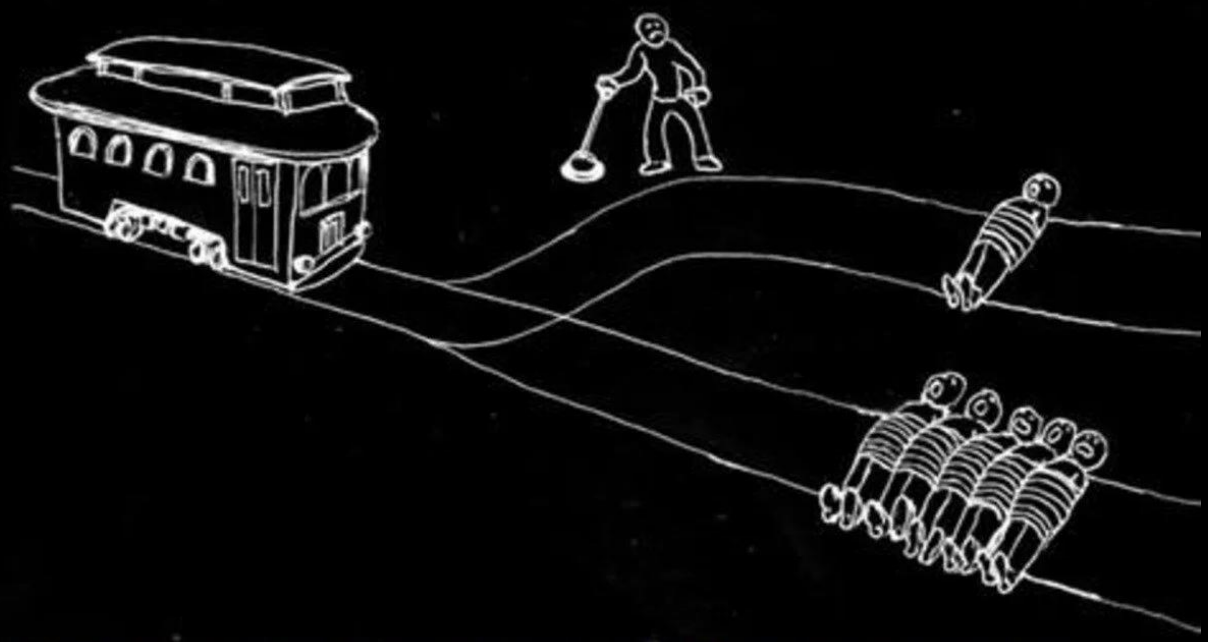
Confirmation biases and overconfidence biases

We trust ourselves more than others

75% of drivers think they belong to the best 25%



Decision-making



You find yourself at a lever. A runaway trolley approaches five people who are tied to a set of tracks. Pulling the lever will divert the trolley to a different set of tracks, where only one person is tied down.

Do you pull the lever?

Decision-making

Expected utility theory: "having all relevant information, people will make a decision that yields the most utility/value/achievement"

Prospect theory: "people act on *predicted* emotions"

How good would I feel if I win?
How bad would I feel if I lose?

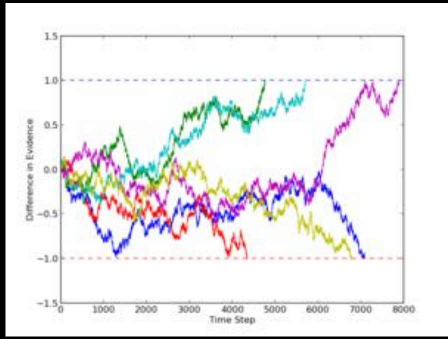
People are often *risk-averse;* but it also depends on how the problem is framed!

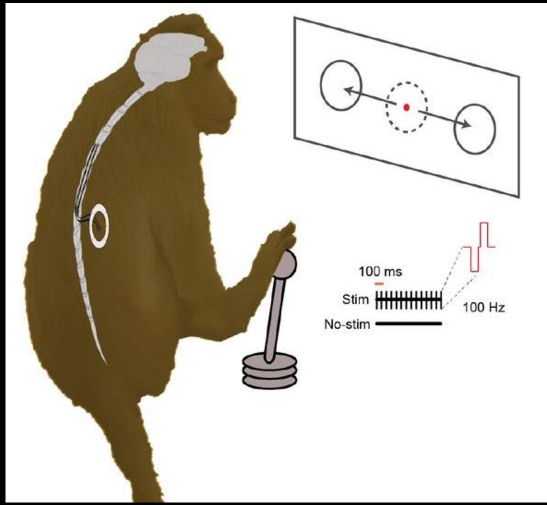
The drift diffusion model

Binary decisions in the brain

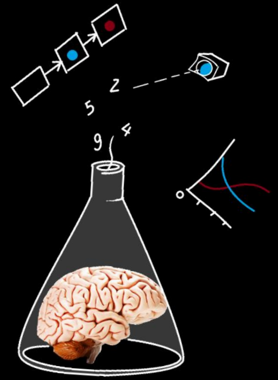
Two competing neuronal clusters, evidence accumulates until one cluster (representing one decision) reaches threshold

Until then:
  doubt



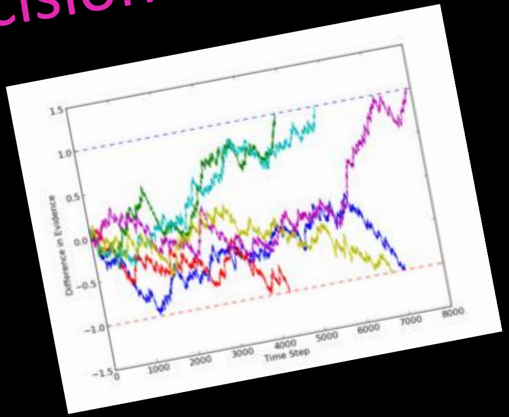


Neural evidence: in Rhesus monkeys, direction-selective neuronal clusters are activated until one cluster's *spike rate* hits threshold

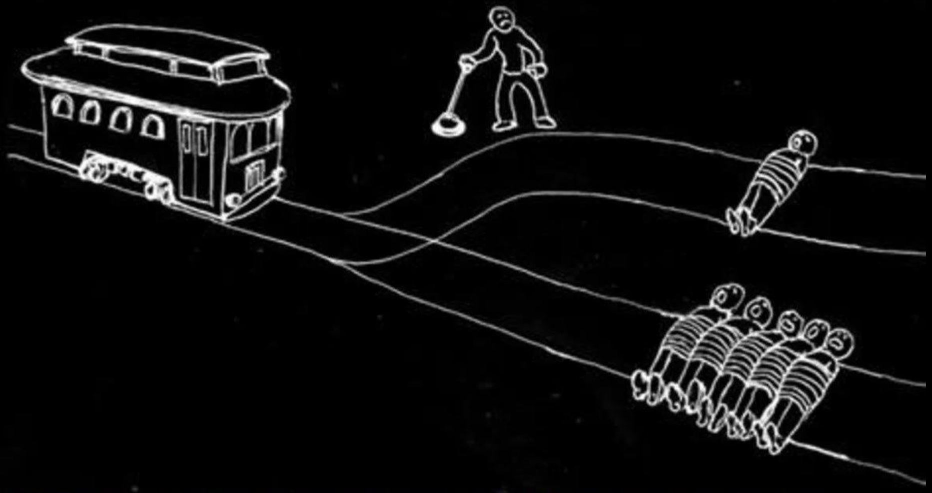


The drift diffusion model

Binary decisions in the brain



Does it hold for more complex decisions?



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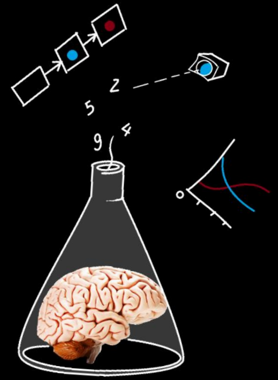
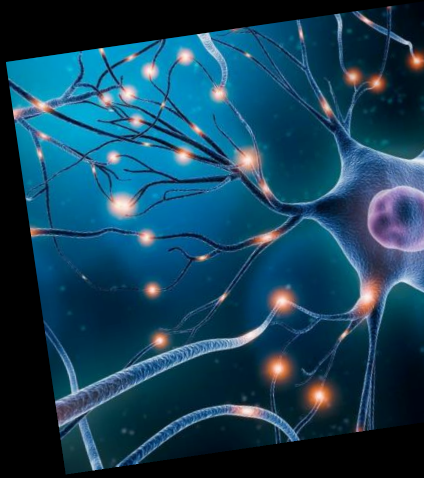


Ultimately, to understand decision-making is to understand the brain entirely...

We have neuronal clusters driving the onset of billions of actions

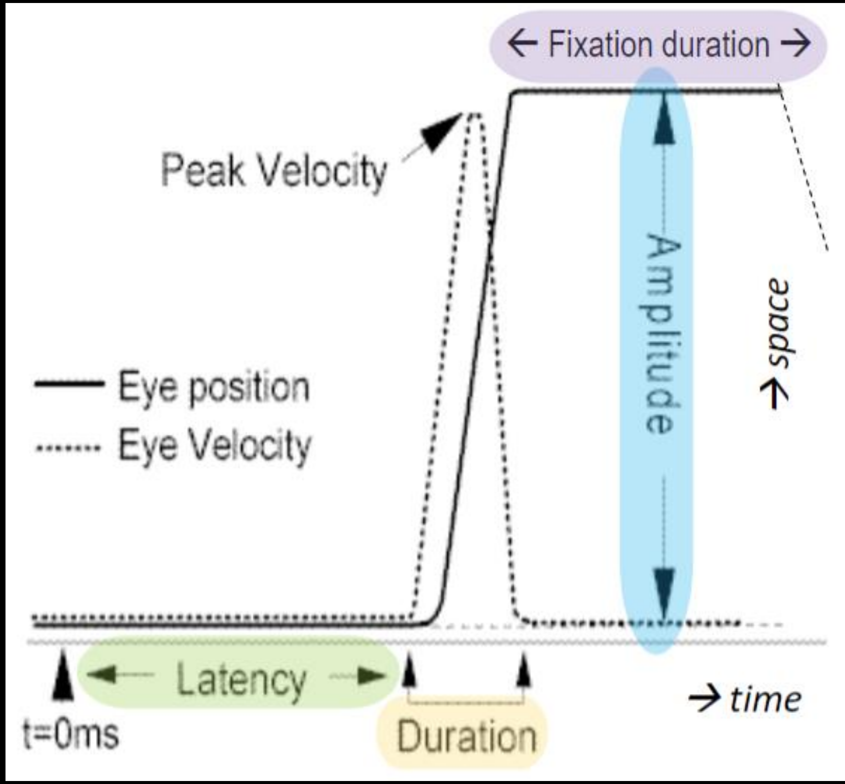
Those clusters are excited in billions of ways

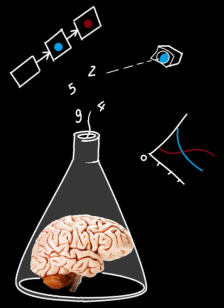


We can predict ‘decisions’ of single neurons and human populations; nothing in between

Terminology

Saccade
Saccadic amplitude
Saccadic latency
Fixation
Fixation duration
Microsaccade





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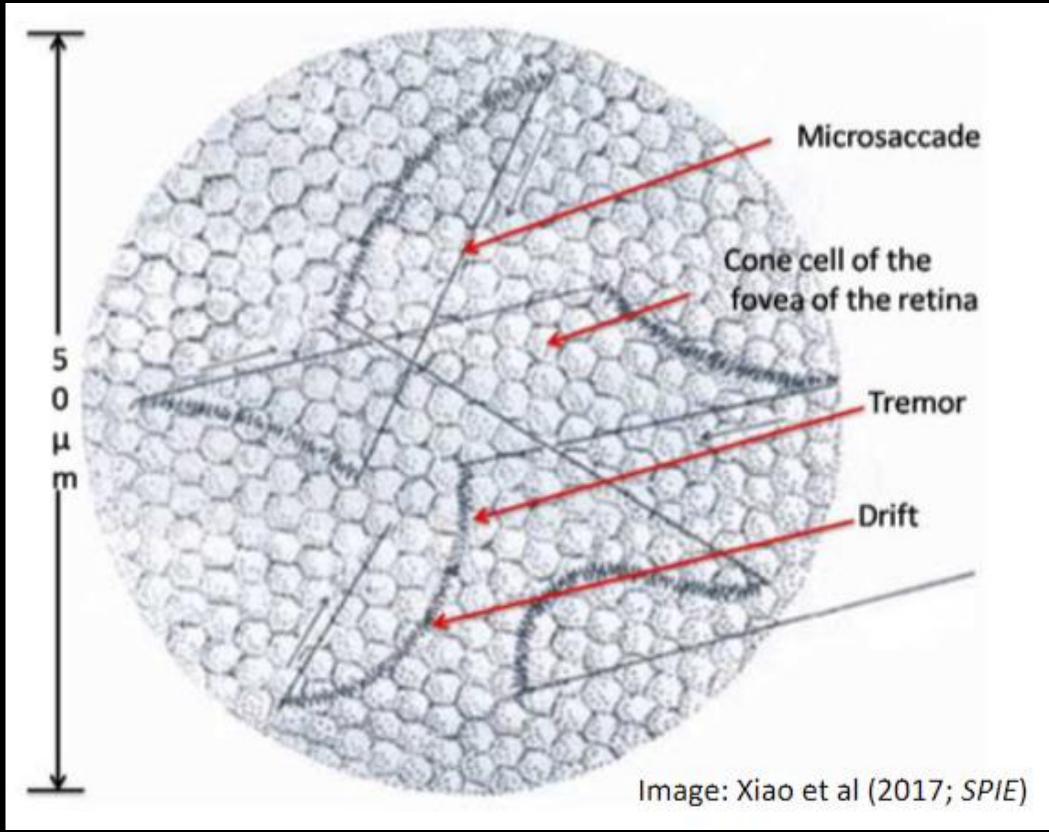
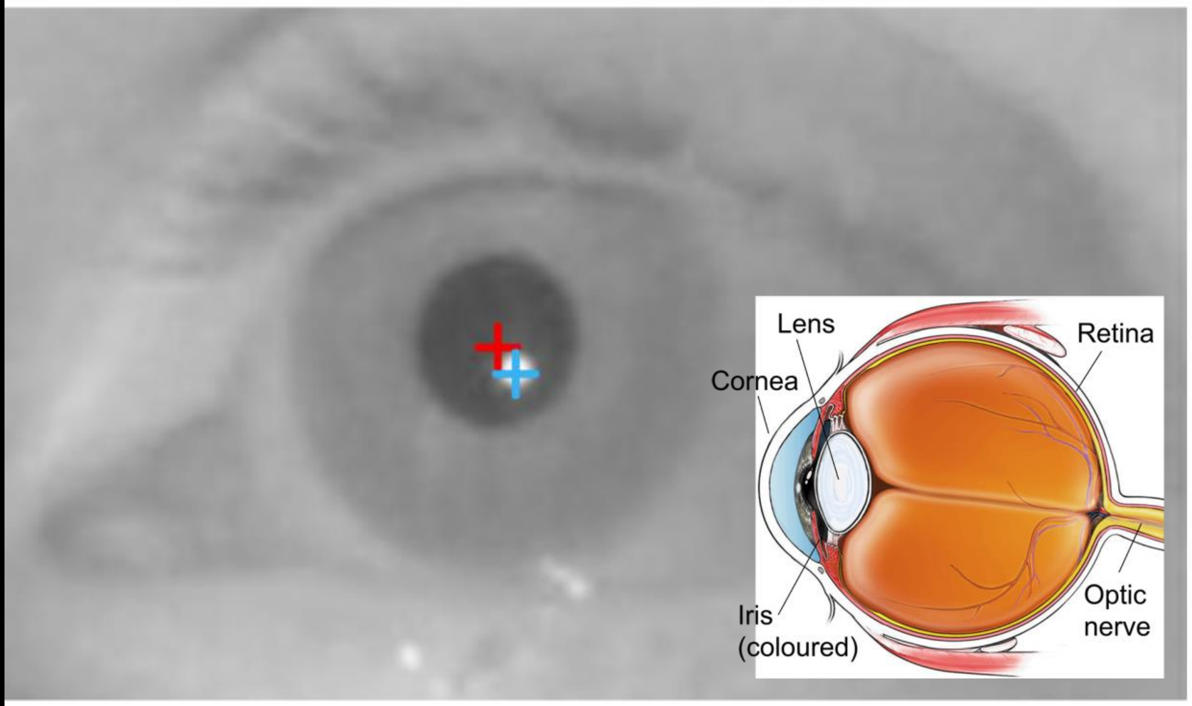
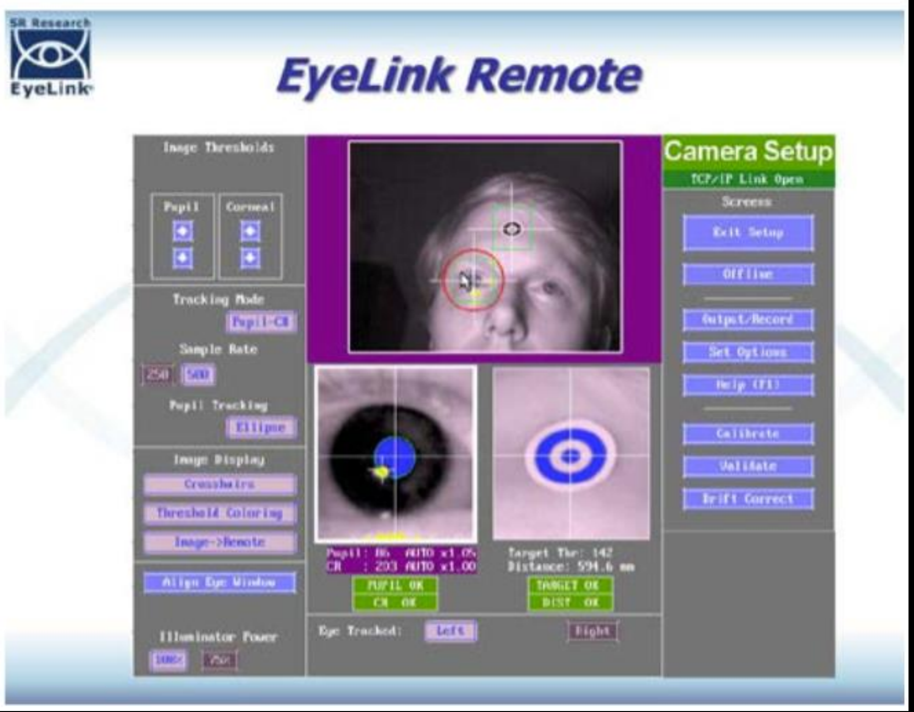


Eye position: two signals

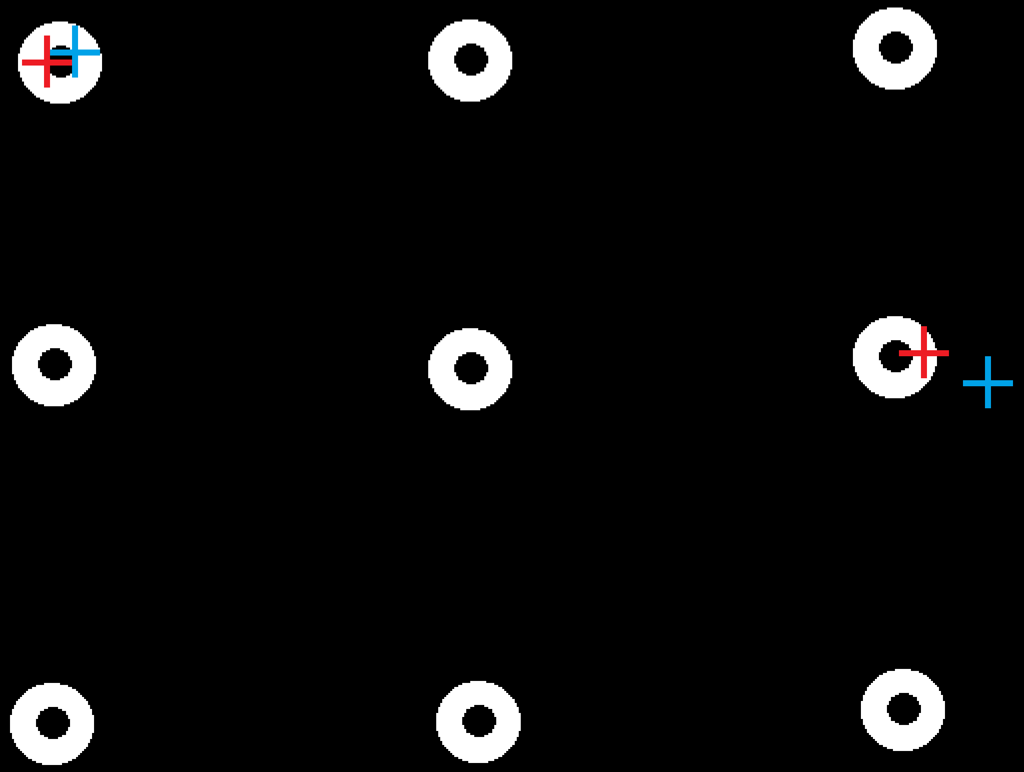




Pupil location

Corneal reflection of (infrared) light sent from camera

Eye position: calibrate



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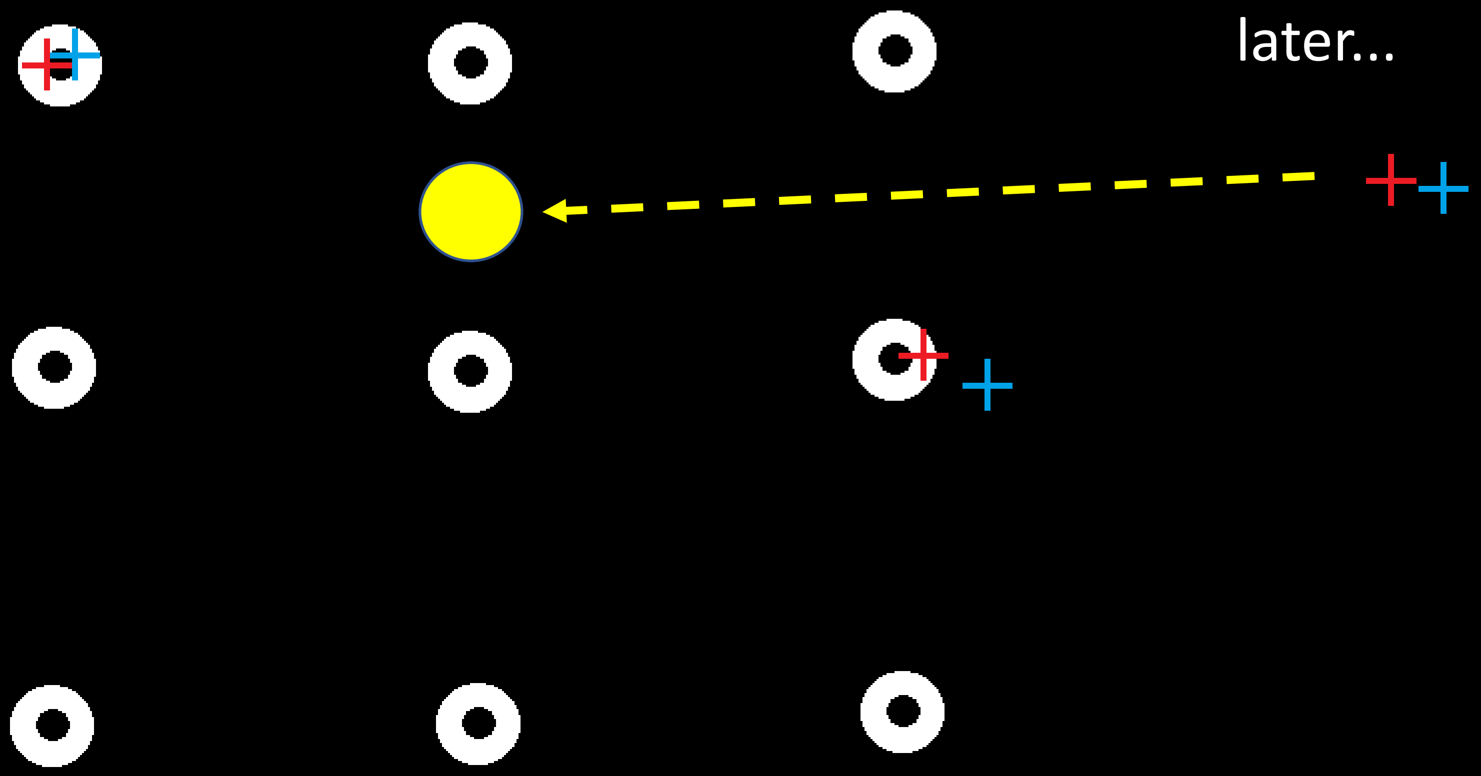
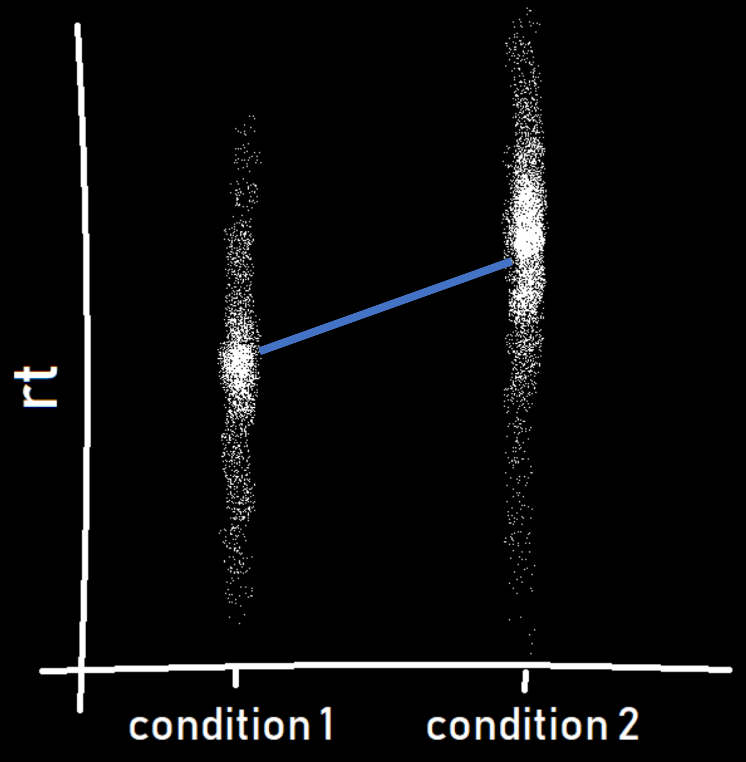


Pupil location

Corneal reflection of (infrared) light sent from camera

The logic of LMMs

Explaining more variance than regular ANOVA's



The logic of LMMs

Fixed effects vs. random effects

Experimental variable (conditions)

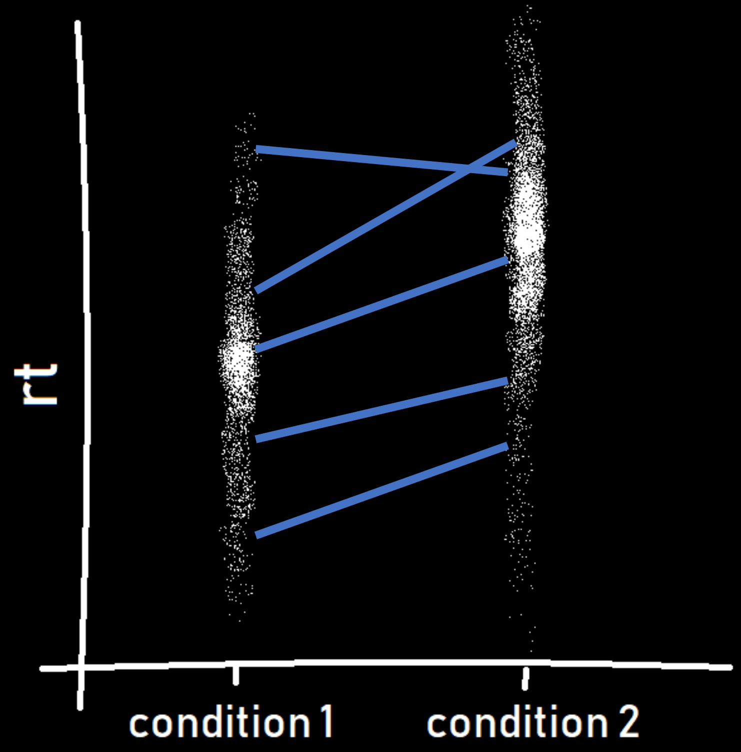
Those things about which we have hypotheses; (a specific direction of effect)

Covariates for which we expect a particular pattern

subjects
items (stimuli)

Those things that we expect may be variable, but for which we do not expect a particular pattern

Both in terms of *intercept* and *slope*, i.e. overall performance and effect strength



An example

Cats, Dogs & Capybaras

Fixed effect: picture-sound congruency (*congruent* vs. *incongruent*)

Random effect: subjects, animal type, animal picture, sound
(both in terms of intercepts as well as slopes)

→ The data will be analyzed on the basis of single trials, rather than averages per condition and participant

But now we want the perfect model!

(1+distraction | subject)

On the right of the vertical line: variable name

On the left: 1 = random intercept

(subjects may on average vary from one another)

'distraction' = random slope

(the effect of distraction may vary across subjects)

We can verify that a model with random slopes explains more variance than a model without random slopes

Likelihood-ratio test

model1 <- lmer *(with random slope)*
model2 <- lmer *(without random slope)*

anova(model1 , model2)

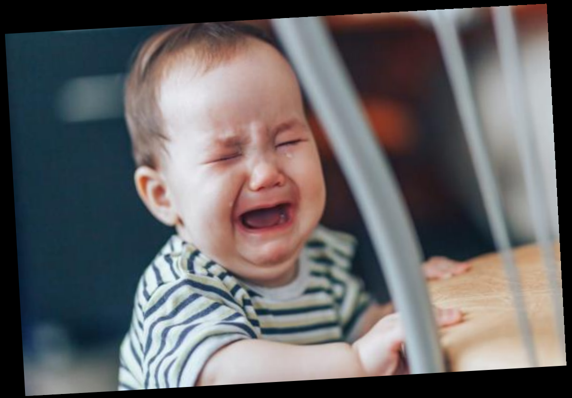
```
model1 <- lmer(
    RT ~ session * distractor  + (1+distractor|subject)
    data=data,)

model2 <- lmer(
    RT ~ session * distractor + (1|subject)+(1|item),
    data=data,)

anova(model1,model2)
```

```
> anova(model1,model2)
refitting model(s) with ML (instead of REML)
Data: data
Models:
model2: RT ~ session * distractor + (1 | subject) + (1 | item)
model1: RT ~ session * distractor + (1 + distractor | subject) + (1 +
model1:     distractor | item)
       npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
model2    7 370113 370170 -185050   370099
model1   11 370121 370210 -185049   370099 0.3737  4     0.9846
```

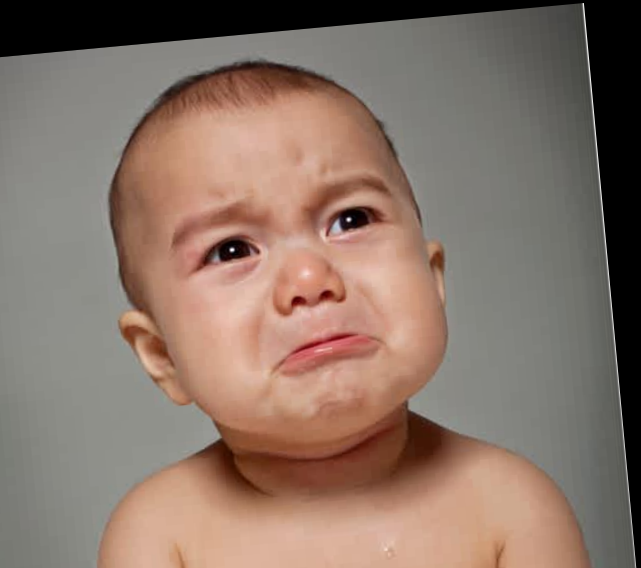
What is language?

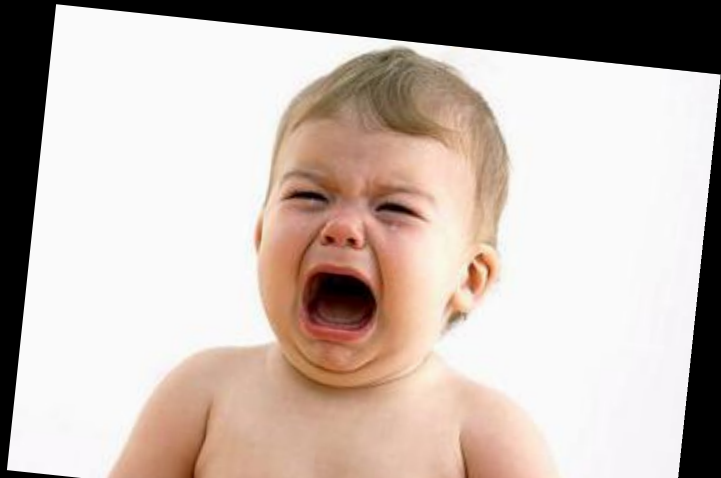


Language vs. communication

Communication: *any* transmittance of any signal
in any perceptual modality

Communication is the overarching thing;
language is but a means to communicate





What is language?

Language is a *hierarchical system*

Comprises *building blocks* that can be combined into building blocks that can be combined into building blocks…

Comprises *rules* about *how to combine* building blocks at each level of the hierarchy…

The set of structures that can be built following the rules is *infinite*

But hold on a sec…

> Aoccdrnig to a rscheearch at Cmabrigde Uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht the frist and lsat ltteer be at the rghit pclae. The rset can be a toatl mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe.

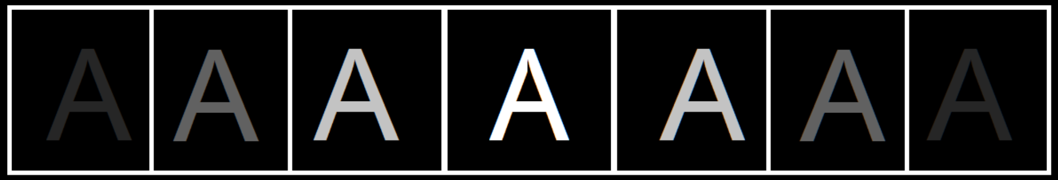
Letters are *flexibly* encoded for their positions

But hold on a sec…

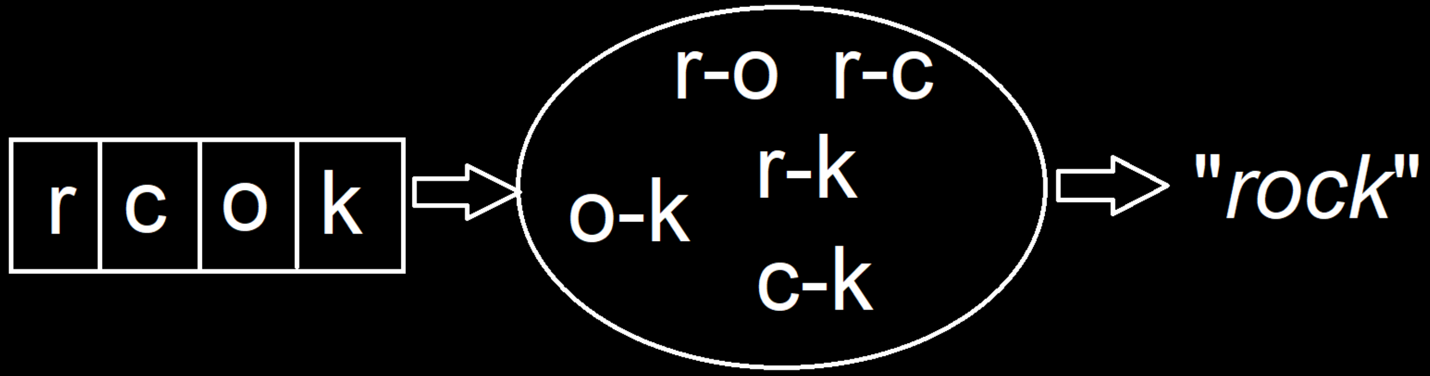
Letters are *flexibly* encoded for their positions!

Potential solutions:

- Positional noise: letters activate not only their slot but also surrounding slots



- Bigram representations: an intermediate layer between letters and words, where (location-invariant) letter combinations are activated

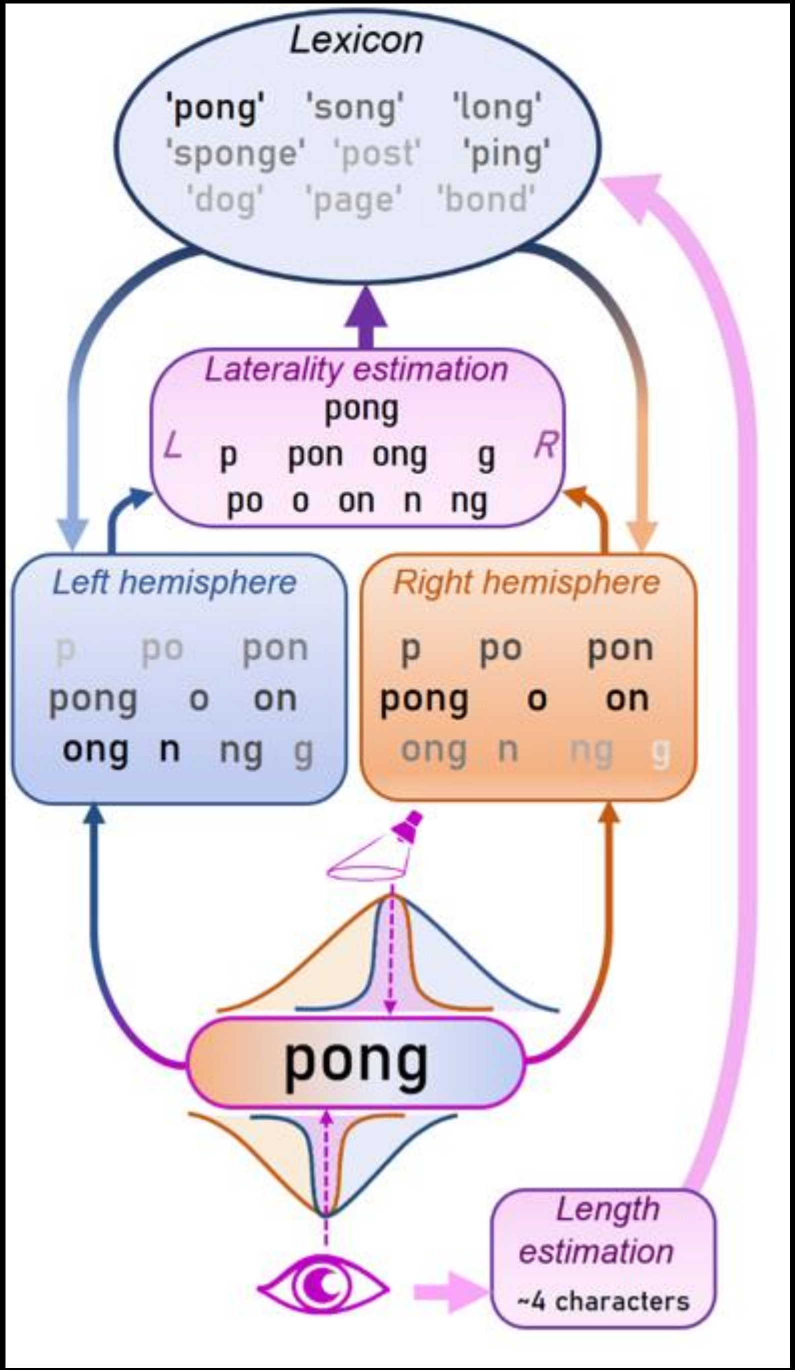


A new theory of orthographic processing…

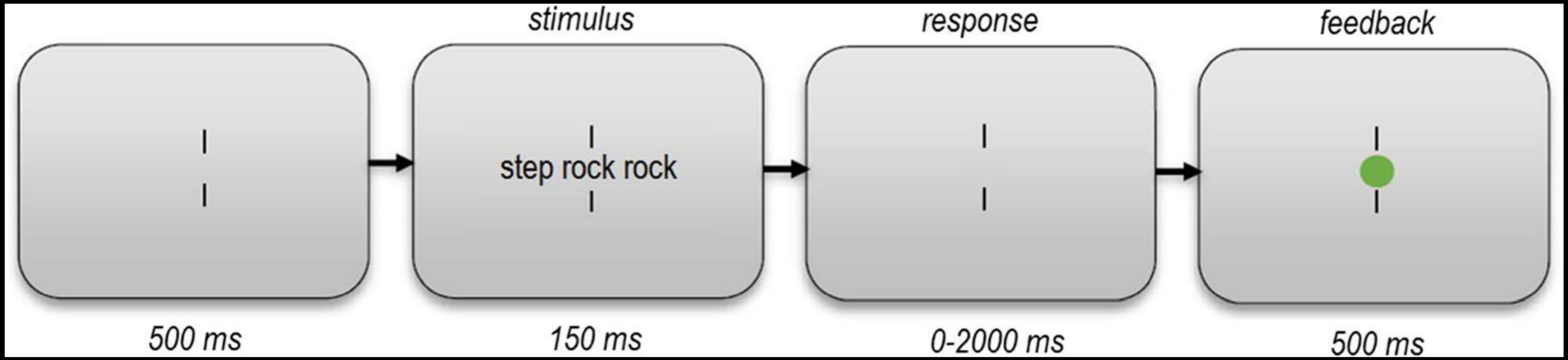
PONG (the *Positional Ordering of N-Grams*)

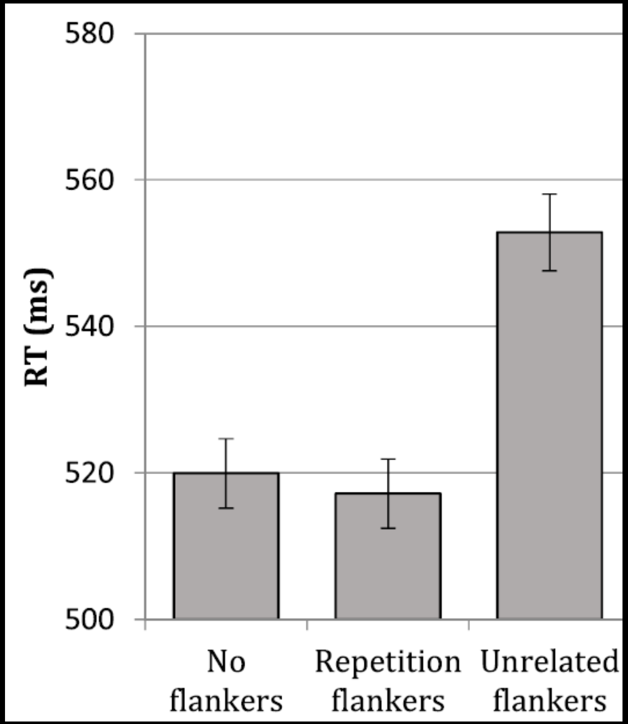
- The brain is a sequence learner
  t, th, the, ther, there, here, ere, re, e

- The brain estimates the laterality of N-grams through bi-hemispheric activation differences



Serial processing of words?





We cannot prevent ourselves from processing the flankers!

Only (sub-lexical) orthographic processing?

Syntax

Do love you me?

You that read wrong

You read that wrong too.

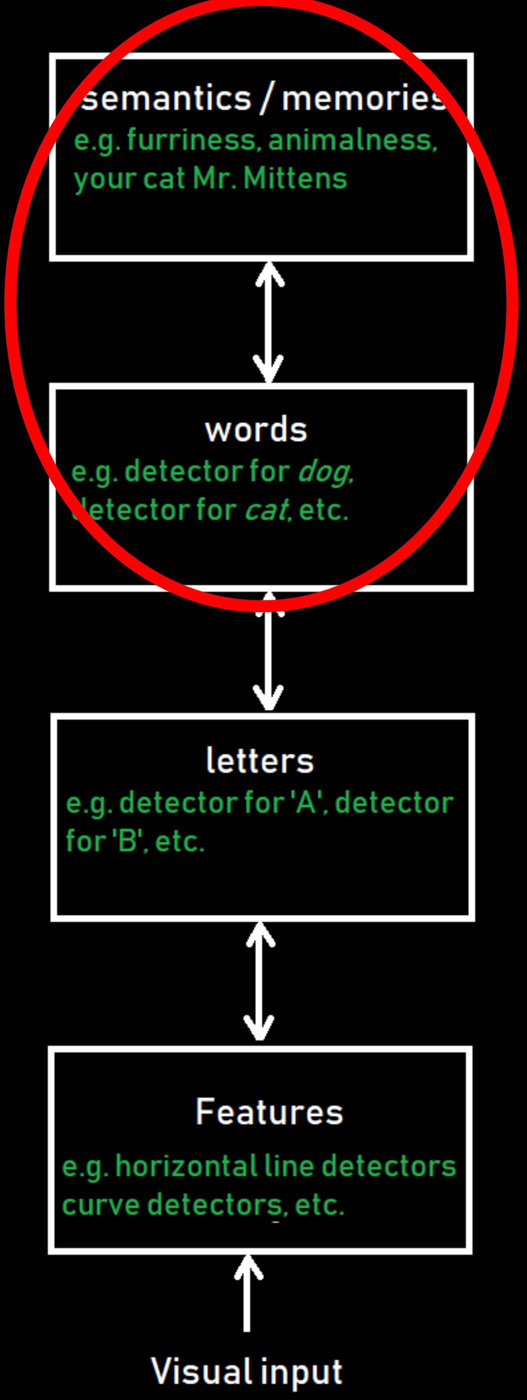
Additional evidence that we’re multiple words in parallel

Syntax →

Do love you me?

You that read wrong

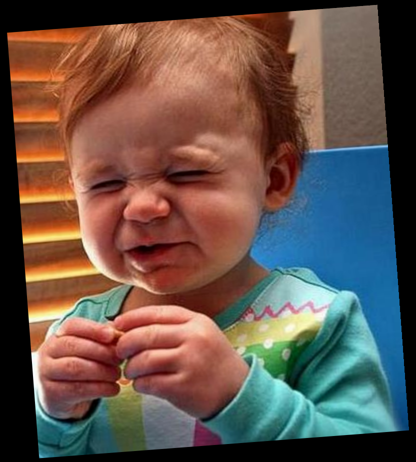
You read that wrong too.



But are we completely flexible?

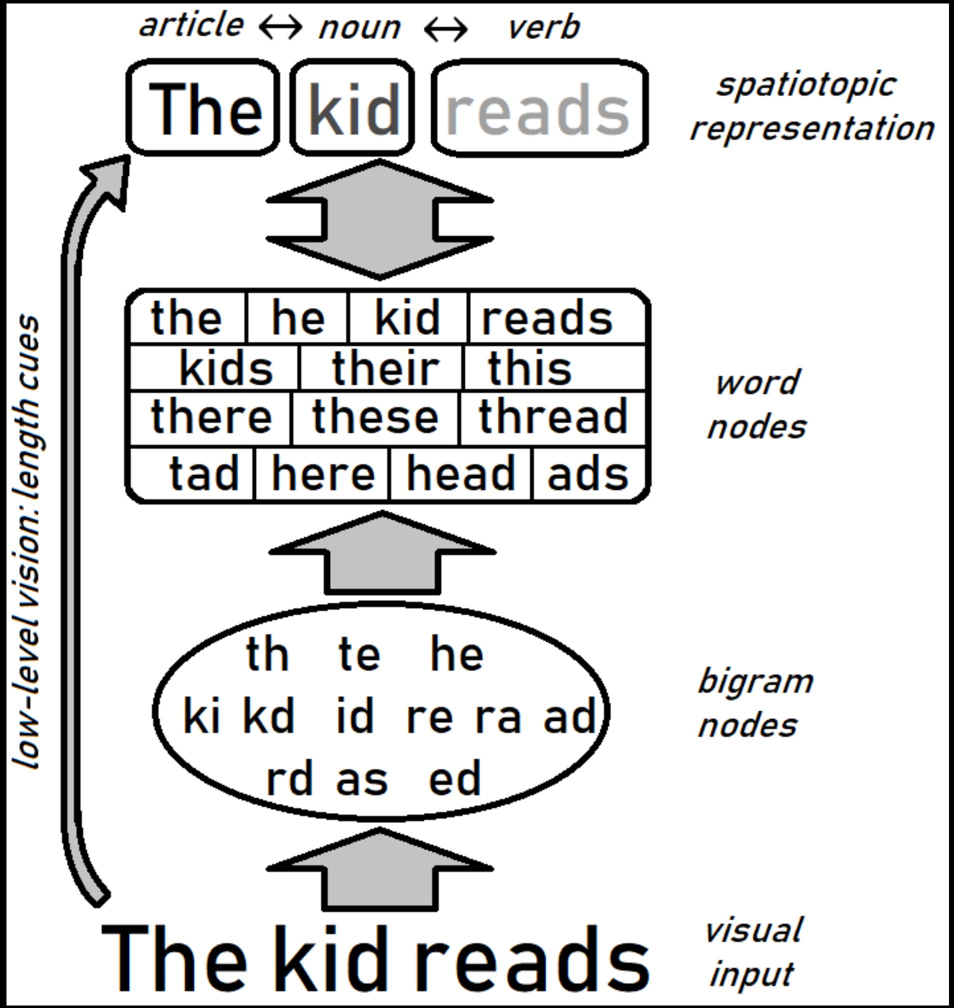
baby dog eats meat

baby eats dog meat



Our expectations constrain the mapping of words onto locations

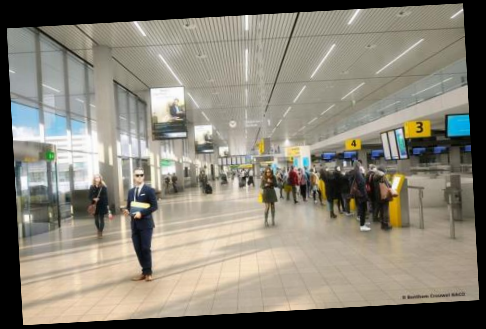
OB1-reader


article ↔ noun ↔ verb
The kid reads
spatiotopic representation
the he kid reads
kids their this
there these thread
tad here head ads
word nodes
th te he
ki kd id re ra ad
rd as ed
bigram nodes
The kid reads
visual input
low-level vision: length cues

Interfaces

All man-made environments are interfaces

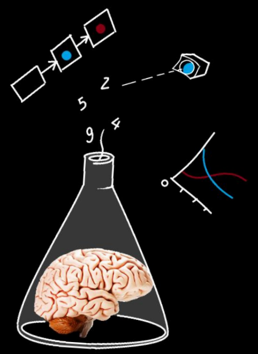
- Design determines how well its users can achieve their goals and tasks
- Environments are interfaces because they provide *information* that guide user decisions



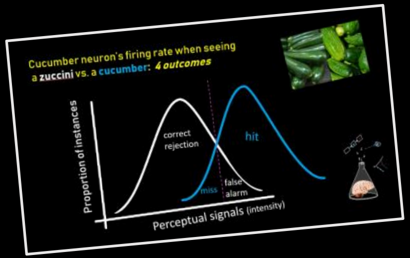
Good design...

considers

perception expectation attention memory

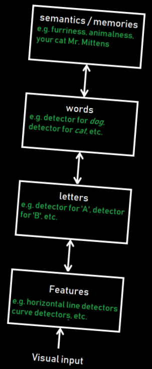


Perception

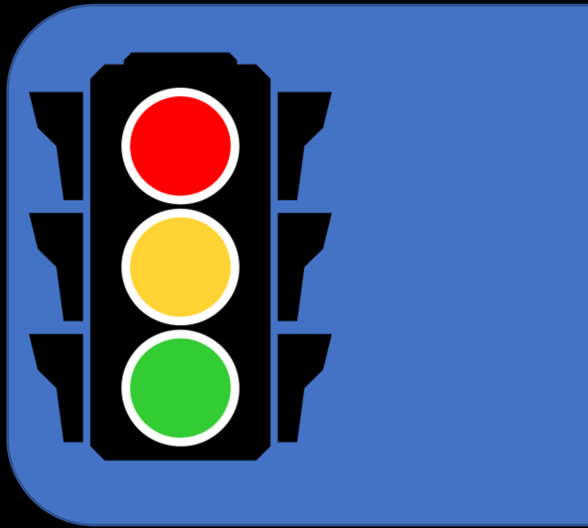


1) Reduce signal-to-noise ratio (SDT!)
   contrast, size, illumination, etc.

2) Don't refer to more than 5 things with a single sensory dimension

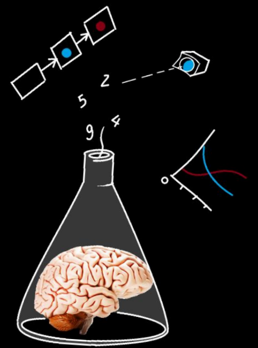


3) Take top-down processing into account



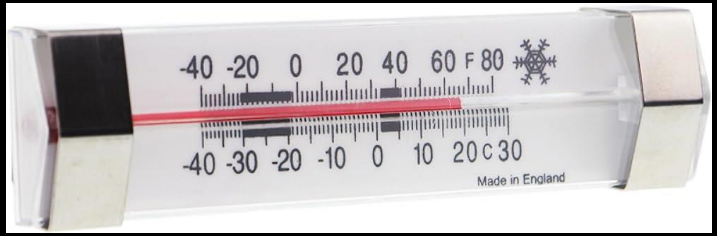
4) Redundancy gain: convey information in multiple ways

5) Make things discriminable



Expectation

6) Realism: display elements should correspond to the real world



7) Realism – moving edition

Attention

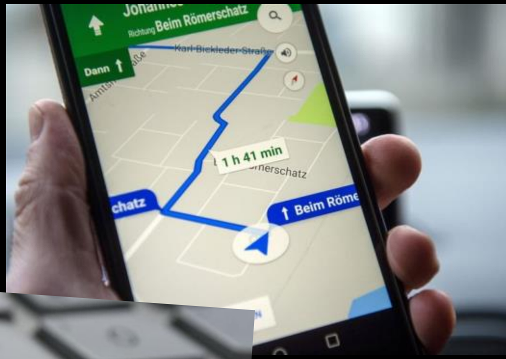
8) Minimize access cost (i.e., navigating from one important location to another shouldn't take effort)

9) Proximity compatibility

10) Divide processing load among the senses

Memory

11) Balance memory and perception: we do not have to memorize what we can see, and vice versa



12) Aid predictions (same as principle 11)

13) Safeguard consistency

Perception

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6 topics

1) Ideal supermarket
2) Touchscreen car dashboards
3) VU entrance
4) Spotify
5) OpenSesame
6) Travel brokers

Questions?

Later questions?

Canvas > Discussions

j.j.snell@vu.nl