Lecture 1 - Introduction

What is Cognitve Psych?

- The study of the (human) brain and behaviour
- Understanding brain & behaviour in tersm of its functions (cognitive processes):
    - Perception
    - attention
    - memory
    - motor control
    - executive functions

Possible project topics?

- **Banknote counterfeit detection** - Can we come up with safer banknote designs?
- **Reading & Dyselxia** - Can we design an interface for better reading in dyslexia?
- **Beach swimming safety** - What do these flags mean anyway? (Capture attention to the right location)
- **Striped dresses** - "Horizontal lines make you look fat" (*Helmholz* Illusion)
- **Intuitive roads** - The influence of road elements
    - How do you react to certain road elements
    - Instead of specifying the speed, build the roads so that the driver wants to drive up to that speed
- **Formula 1 The halo** - Which color works best?
- **Teamsports** - Do teamcolors affect performance?

Lecture 2 - From theory to prediction to experiment

Theory needed?

- No, purely descriptive/observational research can be useful too
- A theory must be *falsiable*

Replication crisis in psychology

- Various causes - publicaiton bias: "life drawer problem"
- Bad practices (un)intentional
- overall pressure to get stuff out
- 3 characteristcs of a good theory:

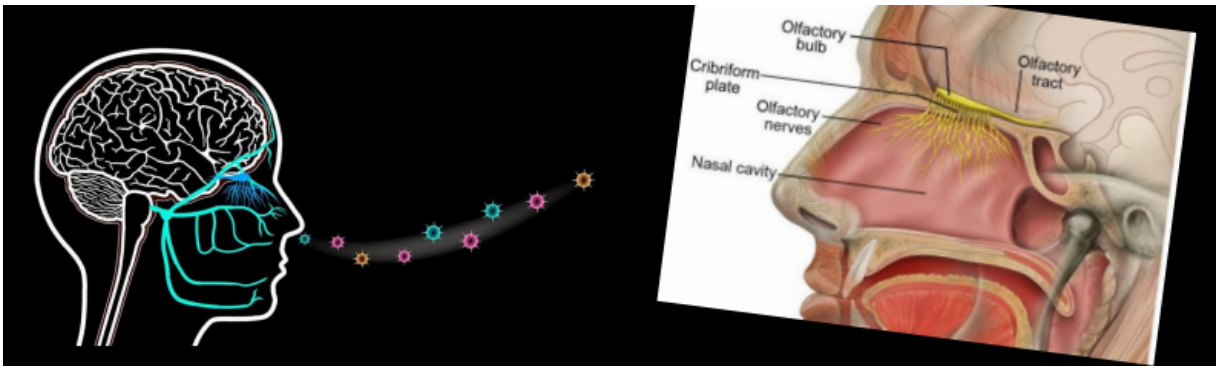
  i. 2.
  3.

-

Perception & Attention

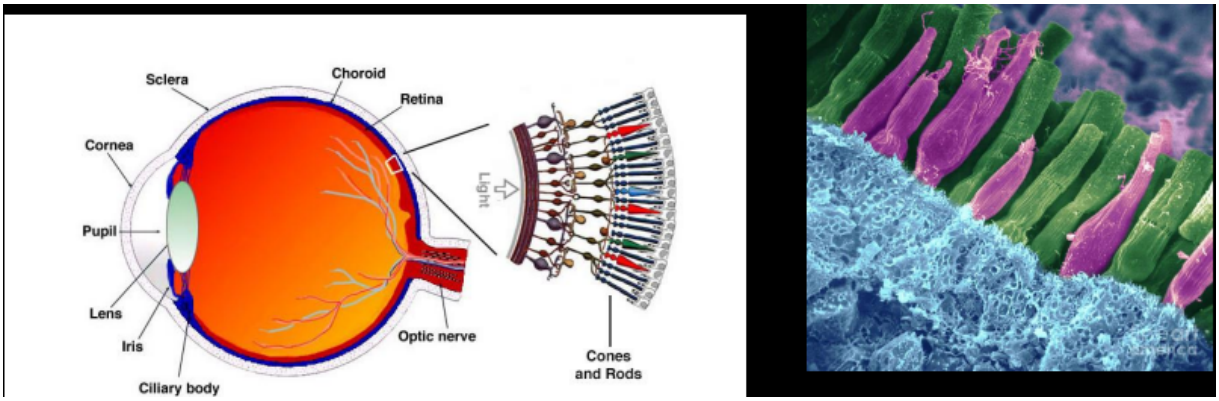
Perception: What is it?

1. Sensation: The registartion of a physical stimulus by receptive neurons



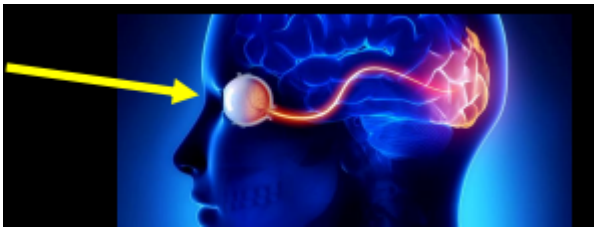
   - Example: activation of olfactory bulb

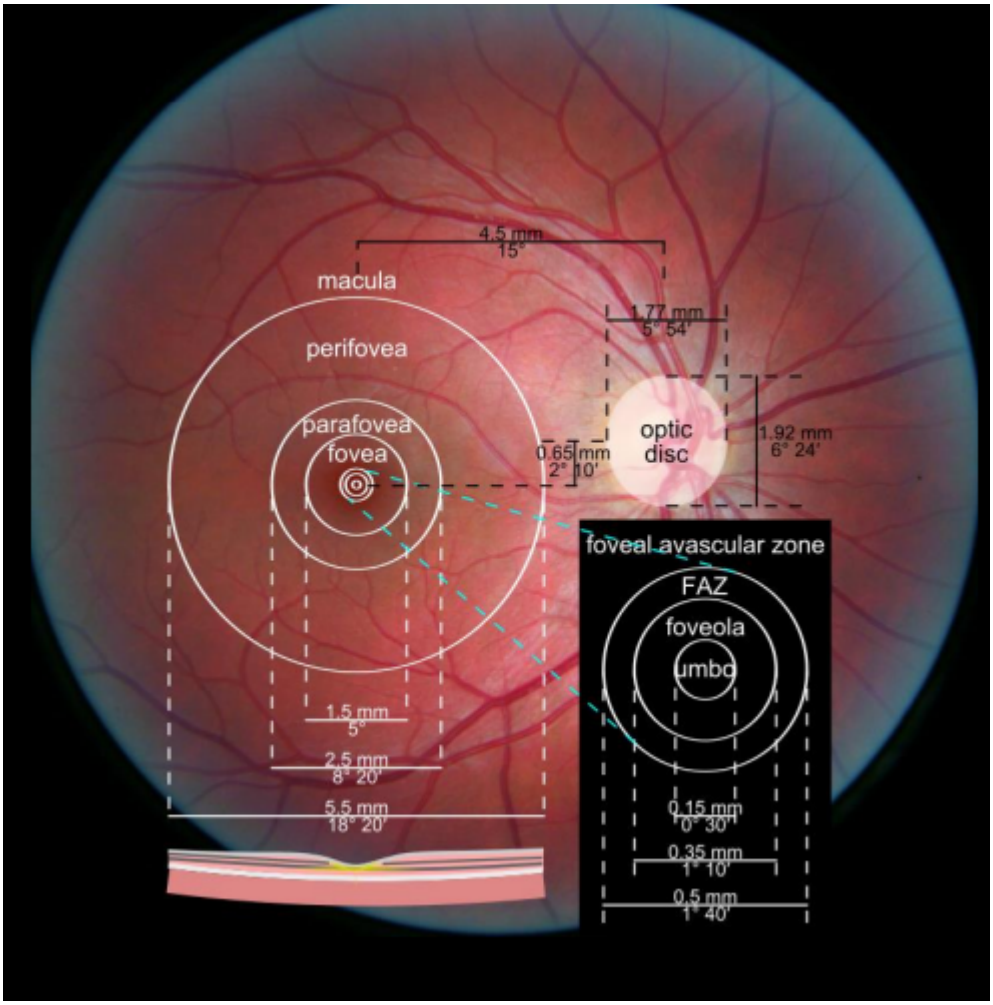
- Sensation: A physical, factual thing, no susceptible to interpretations etc

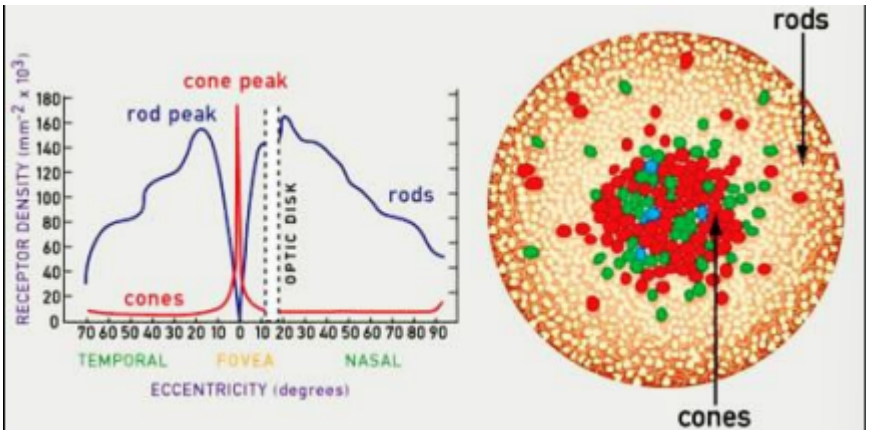


   - Example: activation of visual cortex

1. A physical, factual thing, not susceptible to inerpretatoin

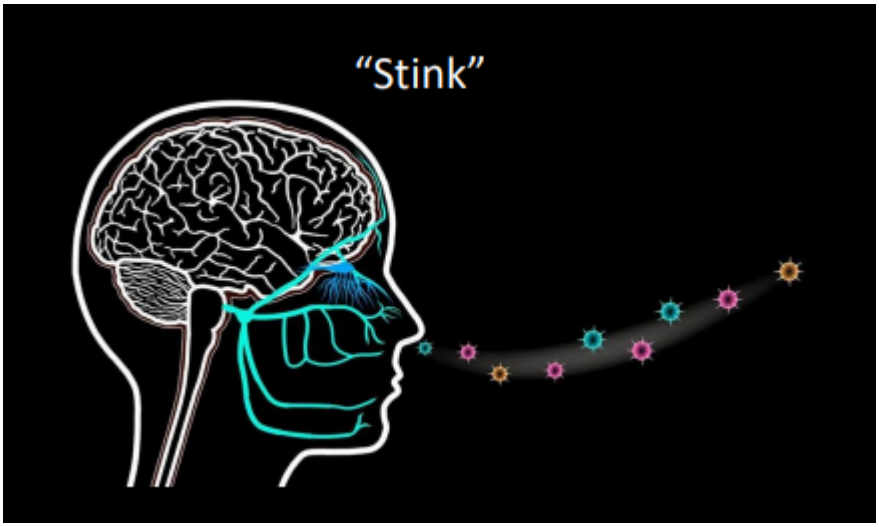






- Example: activation of visual cortex
- Fovea 1: many cones, sharp vision (high acuity), color vision, lower sensitivity
- Parafovea (6-8 degrees): mix of cones androds
- Perifovea (>8 degrees): mostly rods, low acuity, no color vision, more sensitivty

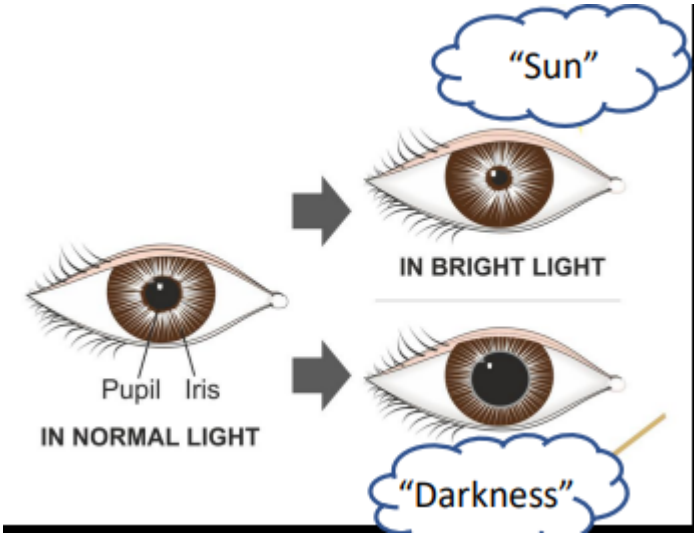
2. The process of *interpreting* sensations

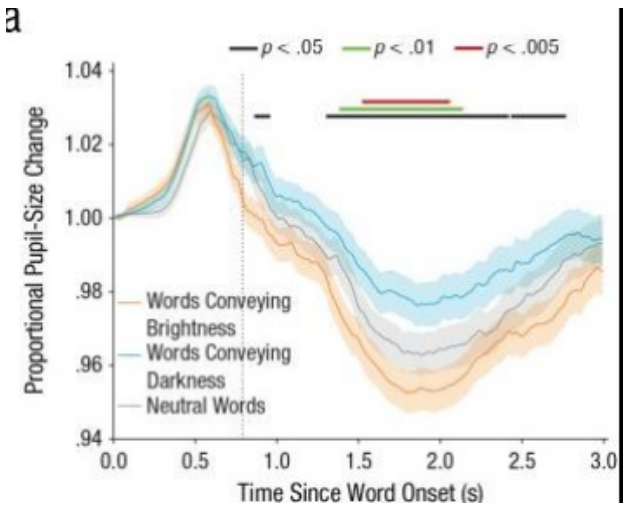


    - Example: smelling

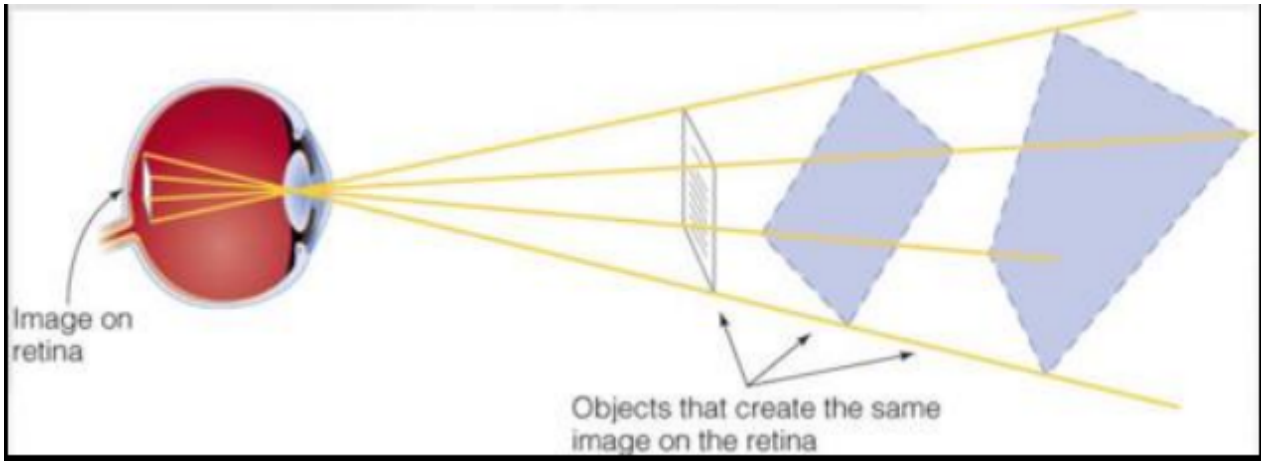
- The goal?
    - Interpreting, recognizing, understanding (what is it?)
    - Interacting with the world (how to respond?)

- A thin line between **sensation** and **perception**…
    - Pupillary light resposne is not just triggered by incoming light… but also by *thinking* about bright objects!





Core challenge in perception: resolve ambiguity

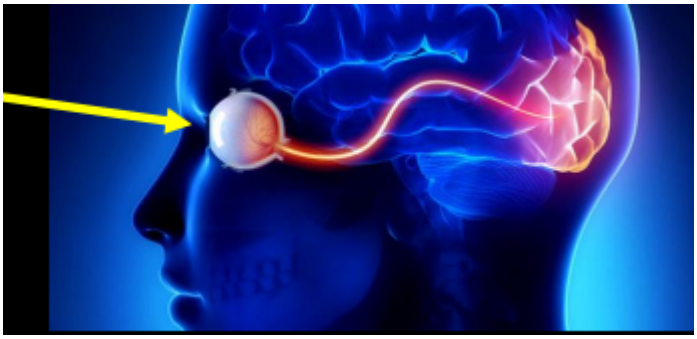
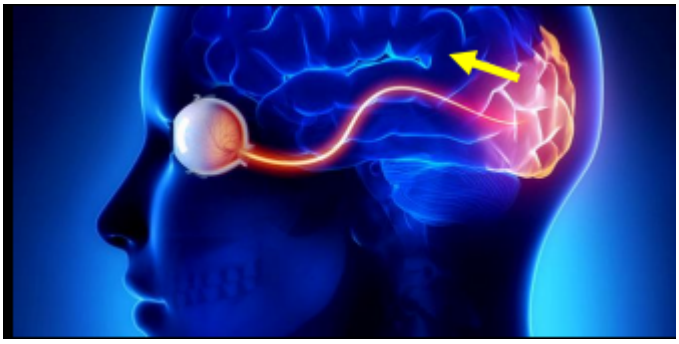
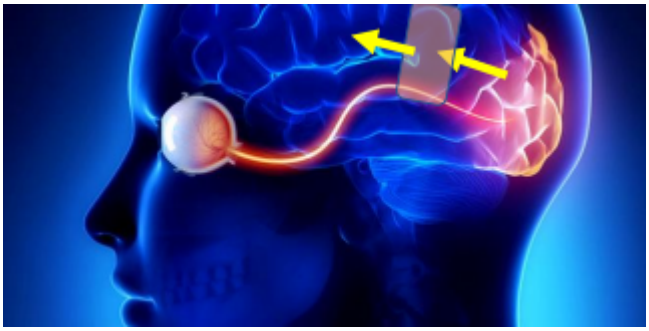
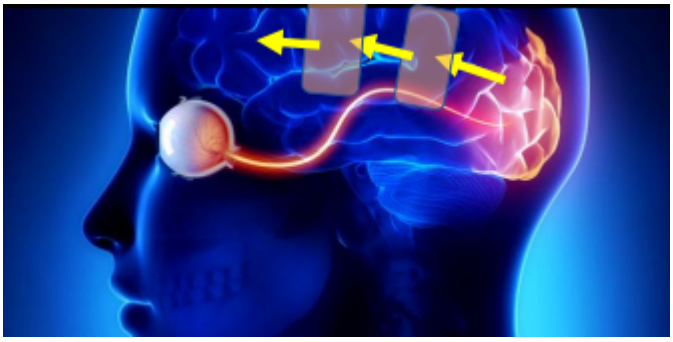
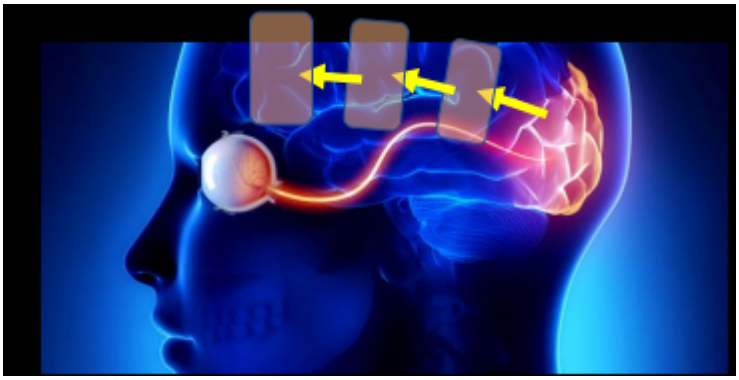


- The inverse projection problem
  -> From sensory processing alone we cannot say anything conclusive aboutthe world!

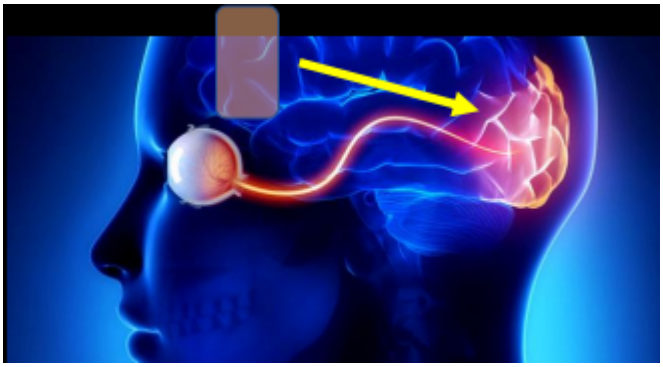
- Example:
  - Auditory, if you focus, you either hear **green needle** or **brainstorm**

Bottom-up vs top-down processing

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

- **top-down**: 'Higher' regions influence activation of 'lower' regions

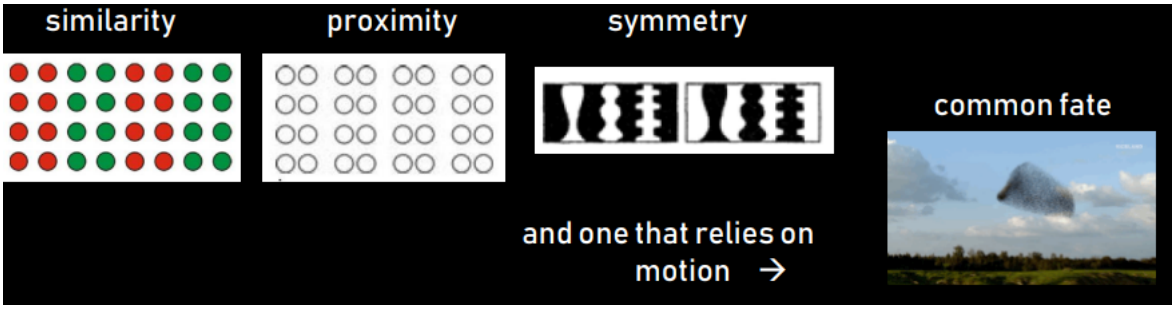


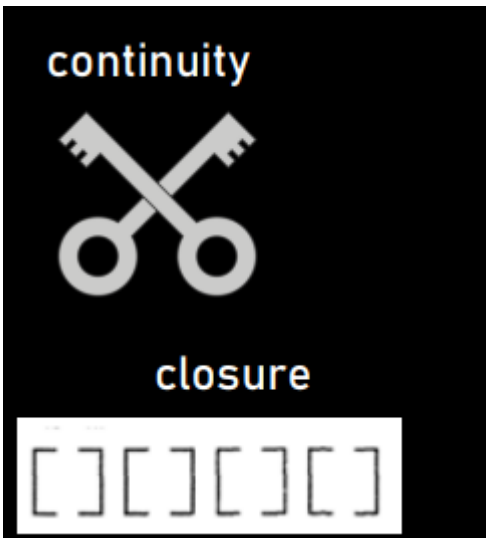
Examples:
sensation = bottom-up
perception = mixture of both

- why is bottom-up processing not just sensation?
    - Grouping of local features into global structures seems to proceed automatically

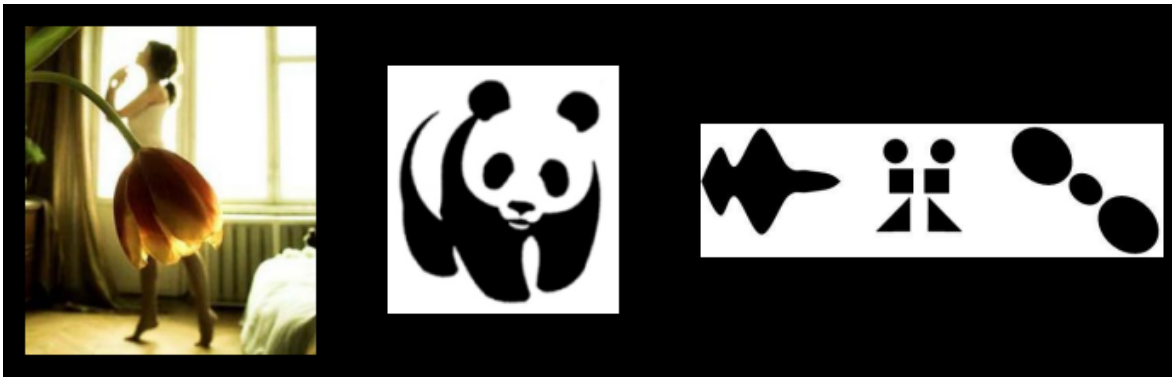
Bottom-up processing: *Gestalt principles*

- A set of assumptions about things that happen in an automatic, bottom-up fashion
    - Similarity: a configuration of red & green dots, depending on how they are aligned
    - Proximity: Dots ordered in a certain configuration
    - Symmetry: How you perceive certain shapes based on colour
    - Closure: mind tends to make a broke line continuous
    - Continuity: mind thinks the object behind is a whole, not 2 separate (the keys)
    - Common fate: Motion -> picture movement illusion





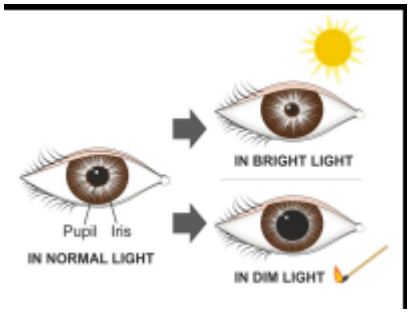
- Examples:
    - Girl with tulip dress -> **proximty**
    - Panda: **closure**
    - Shapes: **symmetry**

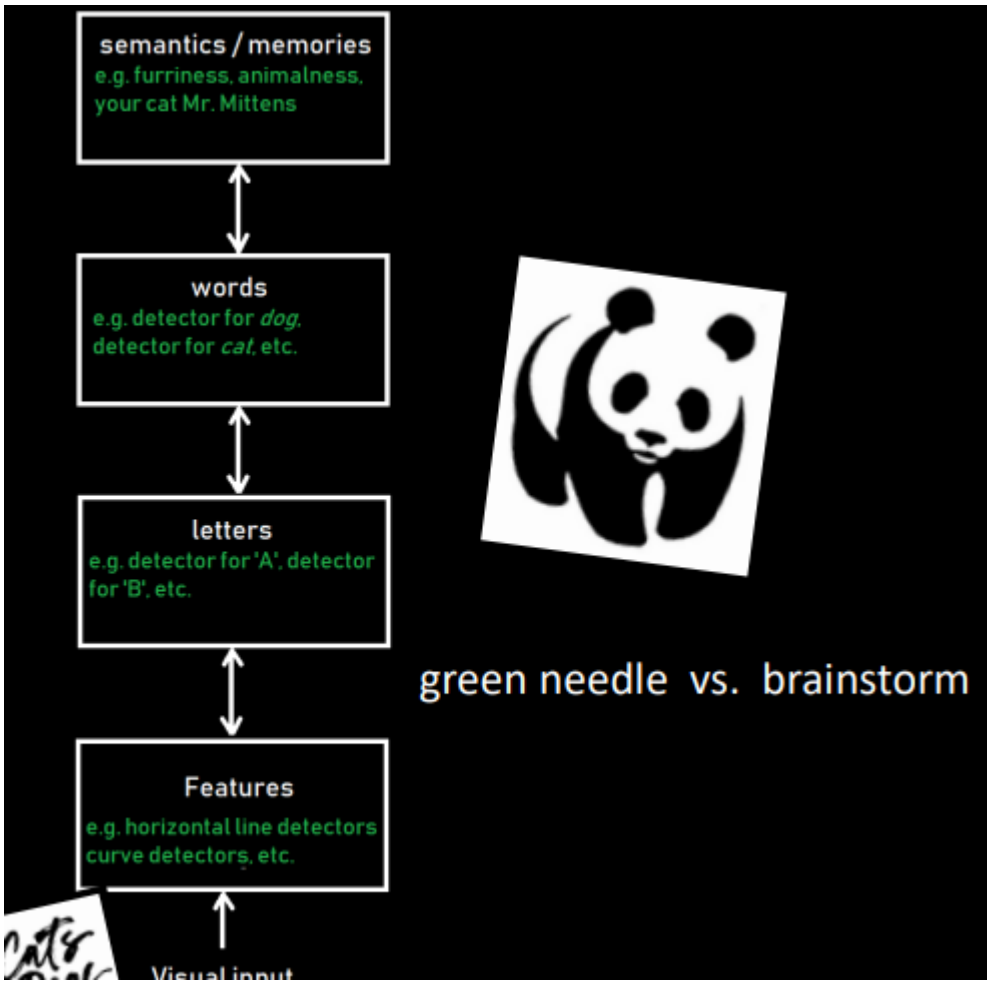


- The principles are *a mere product of the system's architecture*
- But are all these effects really the result of bottom-up processes?
    - Probably not. Our life experiences bolster the expectation that
        - Similar-looking things belong together
        - Objects are most often symmetrical

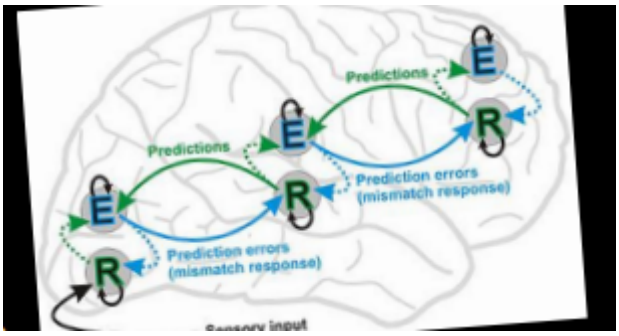
Top-down processing: *Experience*

- This is how we typically conceptualize processing in the brain.
    - **various** levels of processing
    - **interactions** among levels
- Examples:
    - "Sun"
    - Green needle vs.brainstorm
    - James McKeen Cattell, 1886
        - The word-superiority effect: a letter is recognized faster if it is in a word than if it is in a non-sensical string (PLUMP VS PMULP)



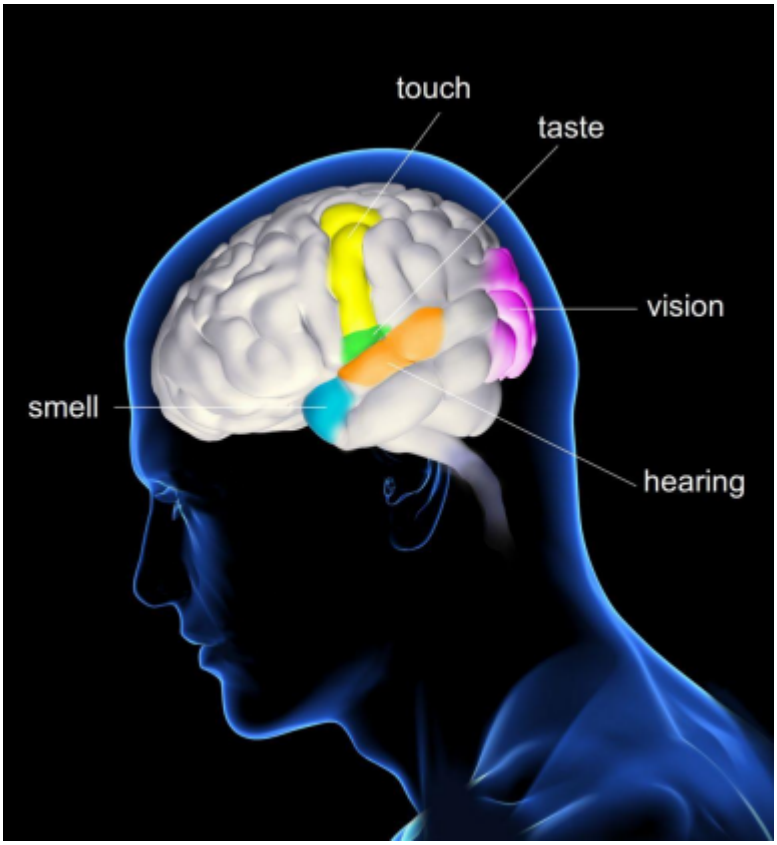


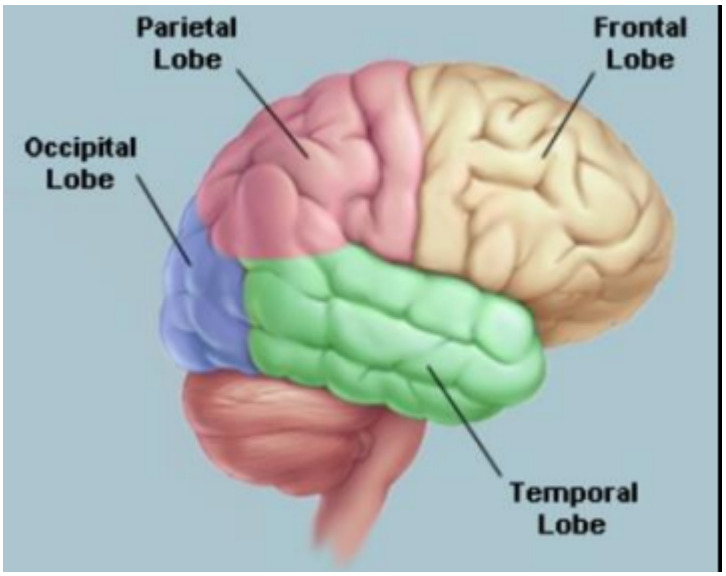
- Another way to frame the interaction between top-down & bottom-up
  - Predictive coding
  - A grand unifying theory of the mind?



Neurophysiology: perception in the brain

- BUT: it's never about isolate brain area's

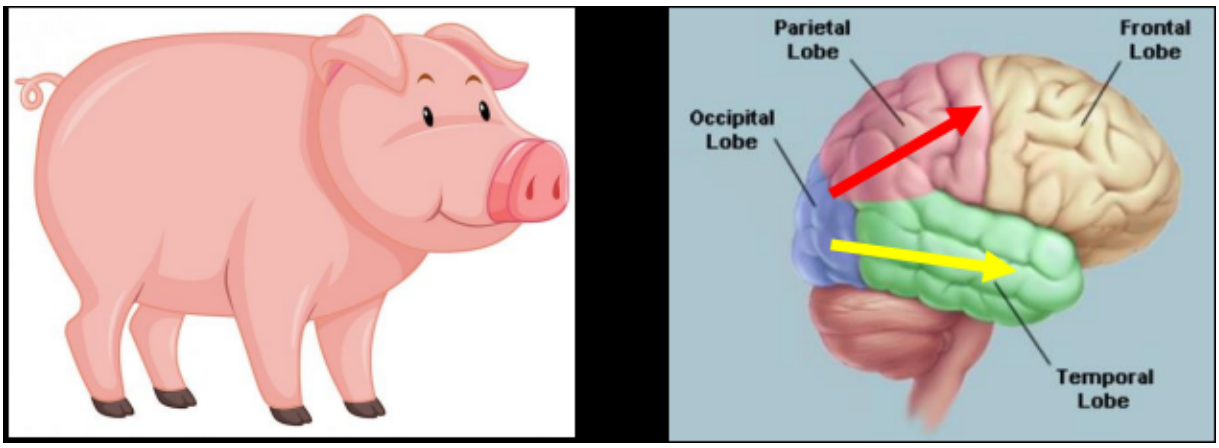




Neurophysiology: Dorsal and Ventral pathways

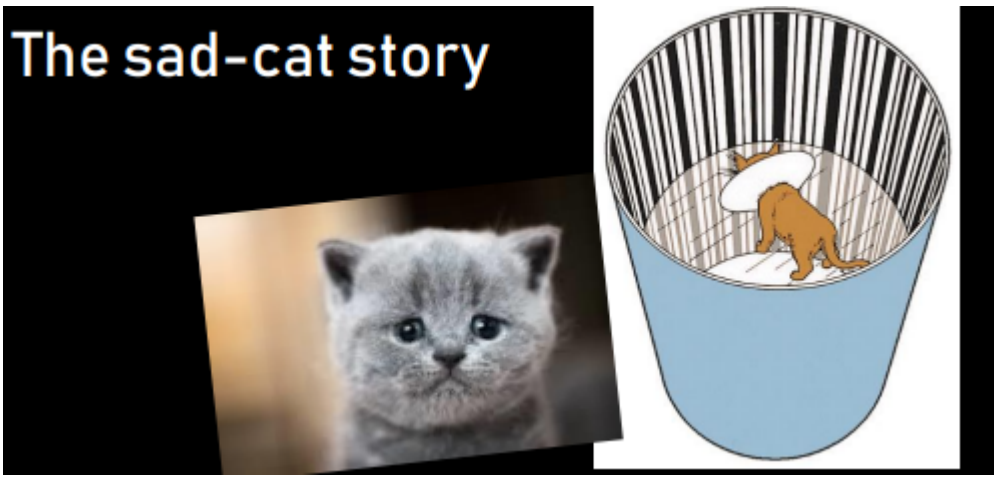
- **Dorsal**= backside: 'where' pathway

- **Ventreal**= belly 'what' pathway



Plasticity in the brain: the brain is flexible

- Where do 'detectors' come from?
    - Our experiences shape the dedicated clusters of neurons
- Example: The sad-cat story



Recap

- Sensation vs. perception: A thin line
- Perception is about interpreting and interacting with the world
- Bottom-up vs. top-down processes
- In vision: from back of brain to front -> from lower to higher levels of cognition
- Neuronal plasticity

Attention: what is it?

- Many psychologists have provided definitions:
    - Attention is the mind's capacity to enhance and surpress sensory input and internal representations
    - also appleis to things that we **keep in the memory**]

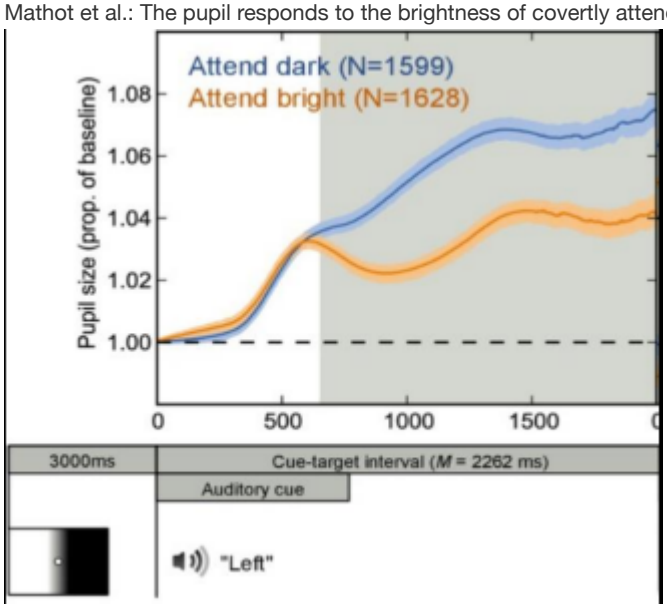
Why do we need attention?

- Tap with your hands on your knees: left left right right left left right right etc. super easy

- Now simultaneory count back from 100 3 by 3
- tapping becomes difficult
- Our brain cannot do an infinite number of computations at once
    - both consciouly and subconsciously
- Computations must be run to compeltion at the expense of other computations
    - both consciouly and subconsciously

Various types of attention:

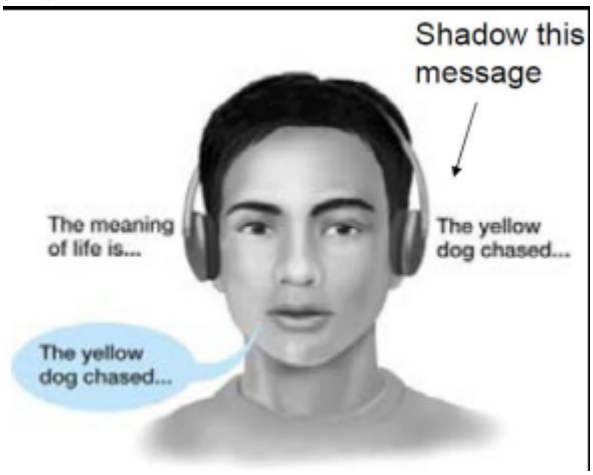
- Within the realm of vision
    i. Overt vs. Covert attention
        - *Overt* is *Obvious* to others: the eyes and head move
        - *Covert* is Concealed to others: the eyes and head do not move
        - Mathot et al.: The pupil responds to the brightness of covertly attended locations



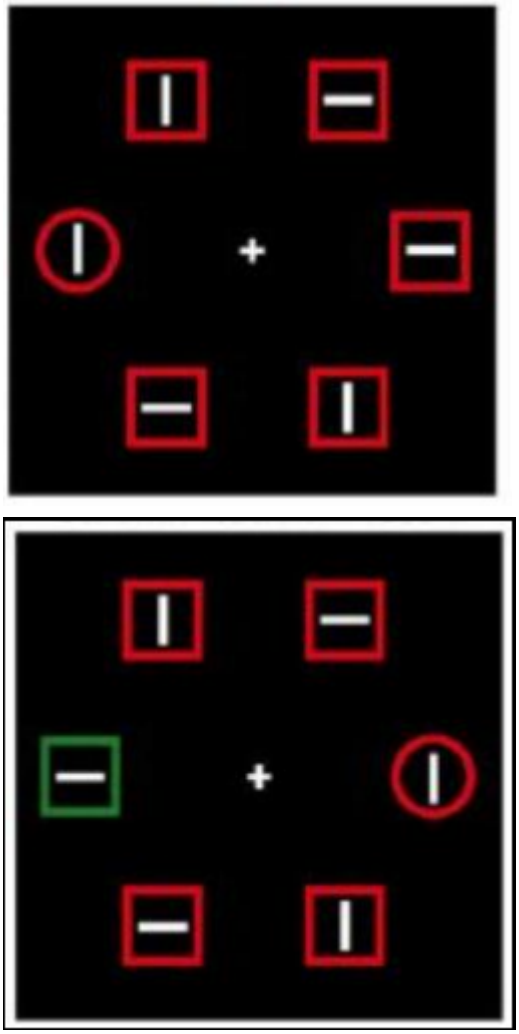
    ii. Spatial vs. feature-based
        - Attentional orienting in vision is often spatial…but you can choose to be more 'sensitive' to apples: we focus in terms of both **where** and **what**

    iii. Endogenous vs. Exogenous
        - Endogenous is internally driven (by ourselves)
        - Exogenous is externally driven (by the world)

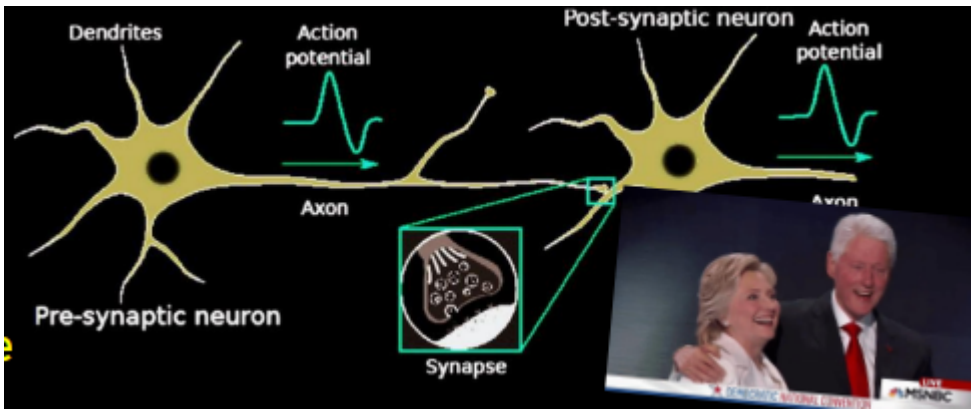
- Research in 1950's: Participants heard 2 messages sim. and focus on one of them and could not report what had been said in the other stream. (**endogenous**)
  - But, when hearing one's own name, attention is automatically drawn to that message (exogenous) -> **cocktail party effect**

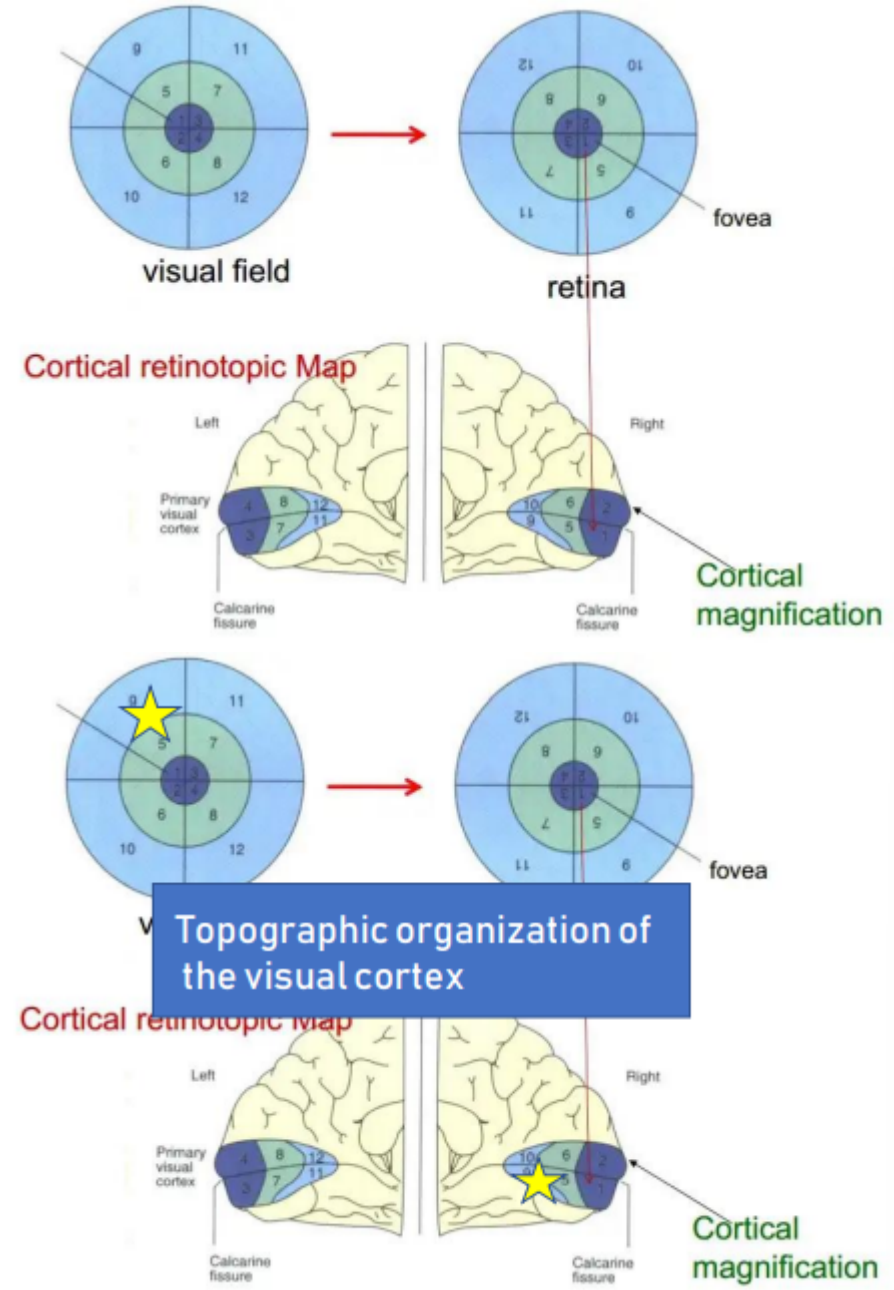


- Singletion paradigm: Participants are asked to focus on a particular feature of a stimulus (endogenous) -> orientation of the line in the red circle
  - But, when a stimulus is presented that is different from the rest, attention is automatically drawn to that stimulus (exogenous) (Red circle vs green square)

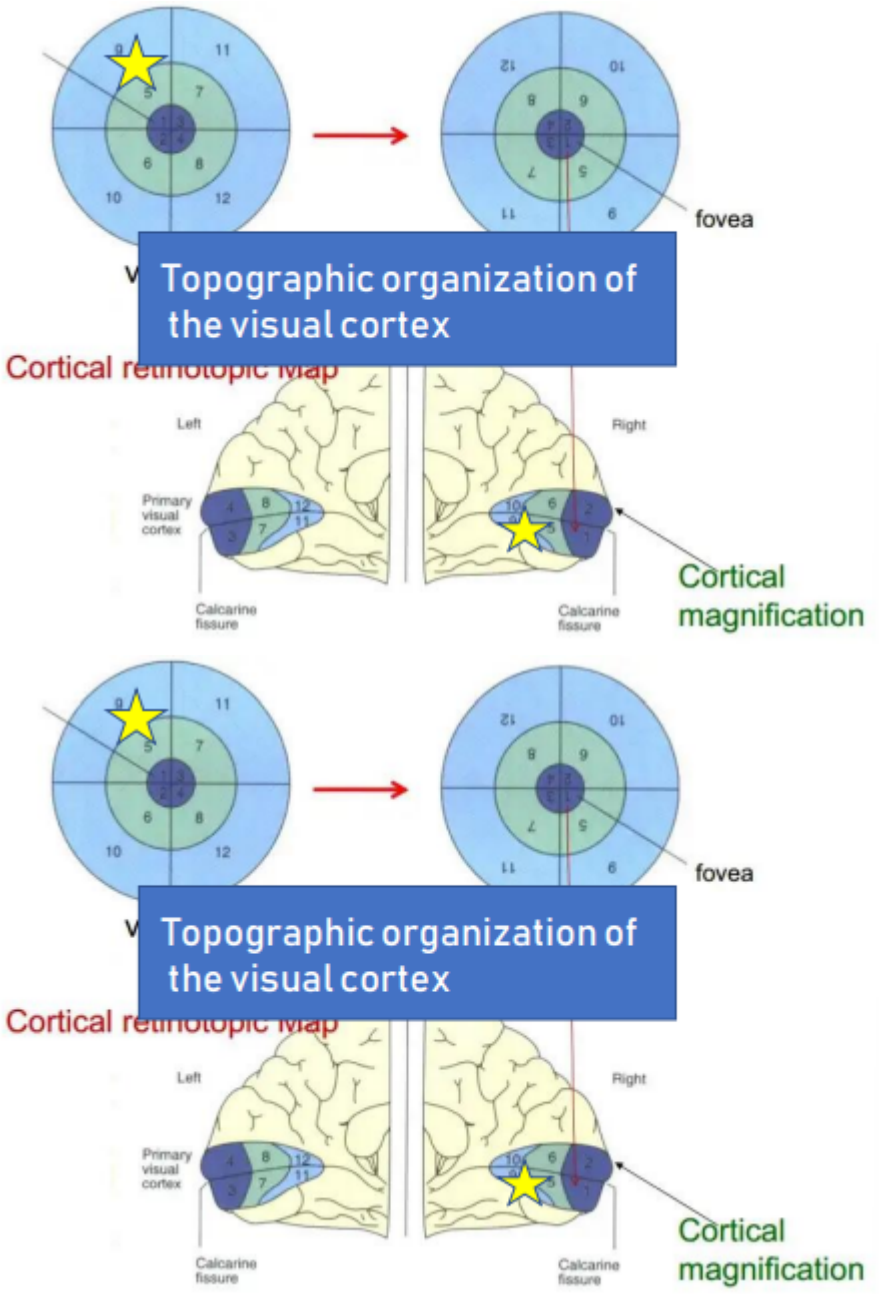


So how does this all work, cognitively? Neurons

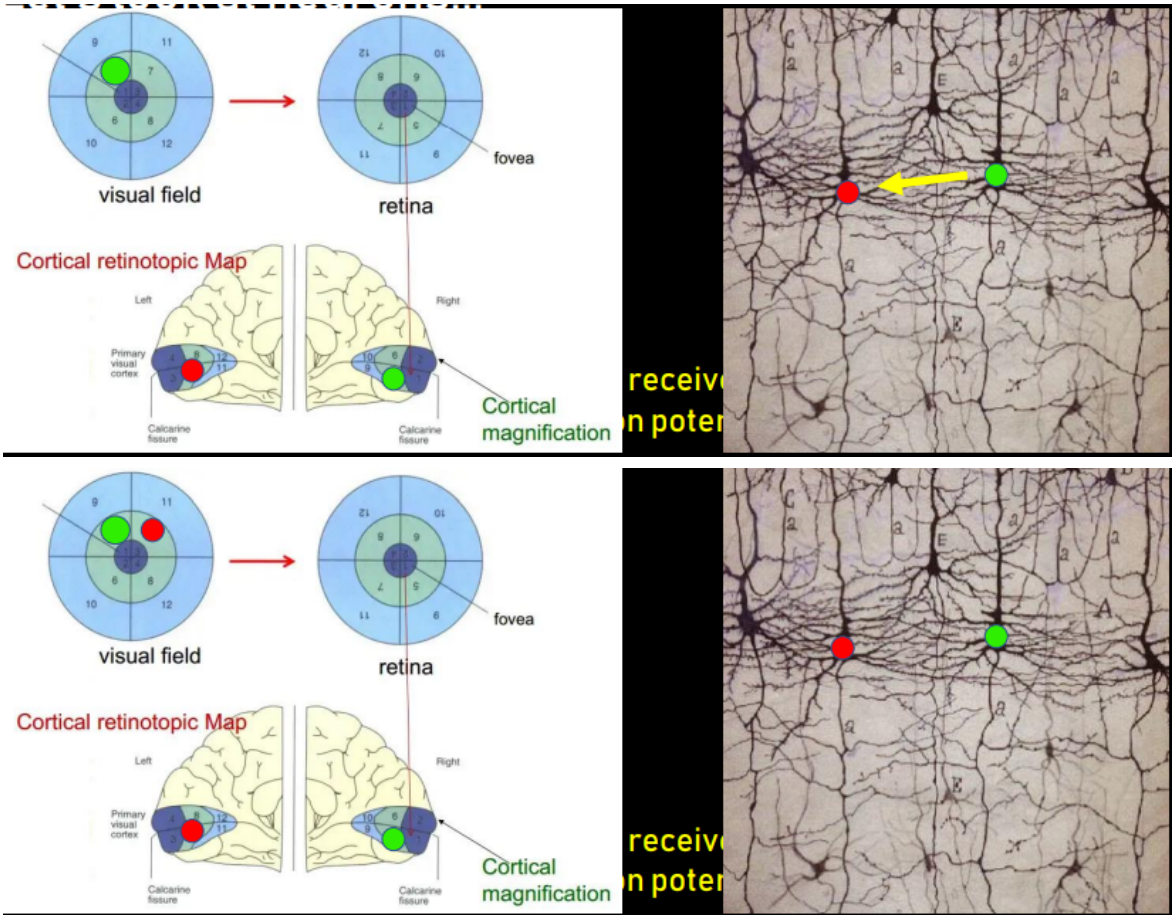




- Neurons have thresholds for when to fire
- The more a neuron is excited (the more input it receives via its dendrites), the more frequently it willfire action potentials



- Some connections are *inhibitory* rather than *excitatory*
    - Neurons coding for Hillary's upper visual field may have surpressed neurons coding for Hillary's lower visual field when 'the thing' happened

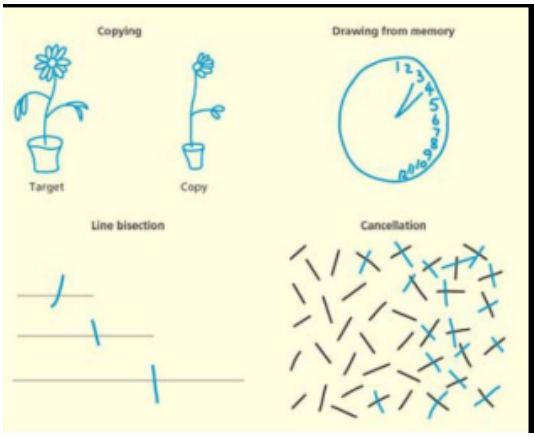


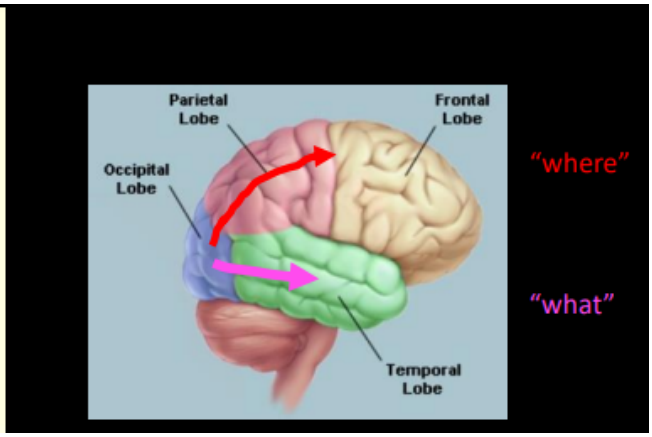
- Signals sent by the upper-visual-field neurons will have entered conscious awarness(frontal brain regions) faster
- Exogenous attention: strong sensory input tips the balance (in terms of 'neuron battle' described on previous slide)
- Endogenous attention: higher-order neurons suppress or excite neurons 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

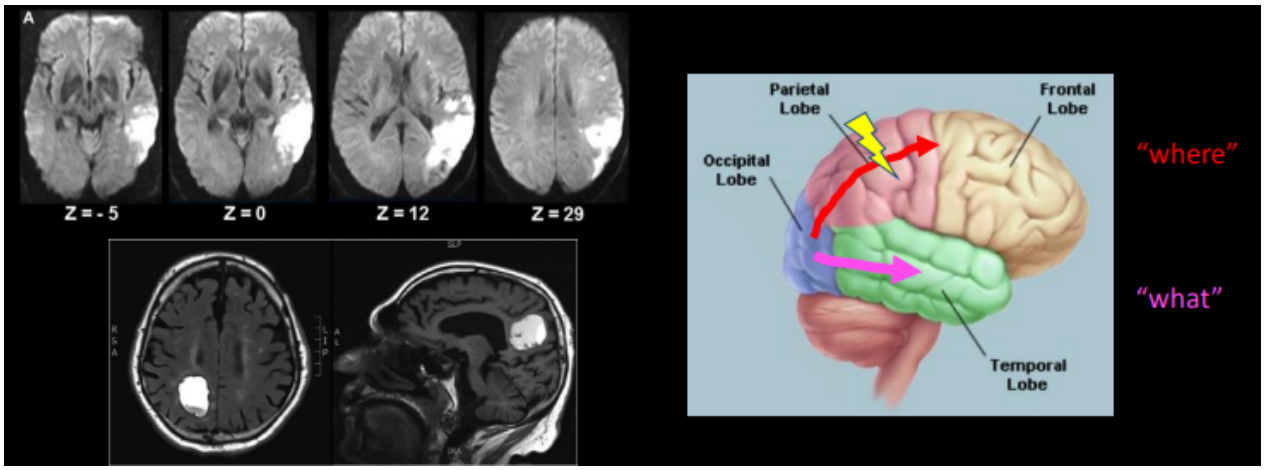
- Hemispatial neglect: Damage to the right parietal lobe
    - Patients ignore the left side of space (one side of the hemifield),even though they can see things in that hemifield when attention is forcefully directed to it

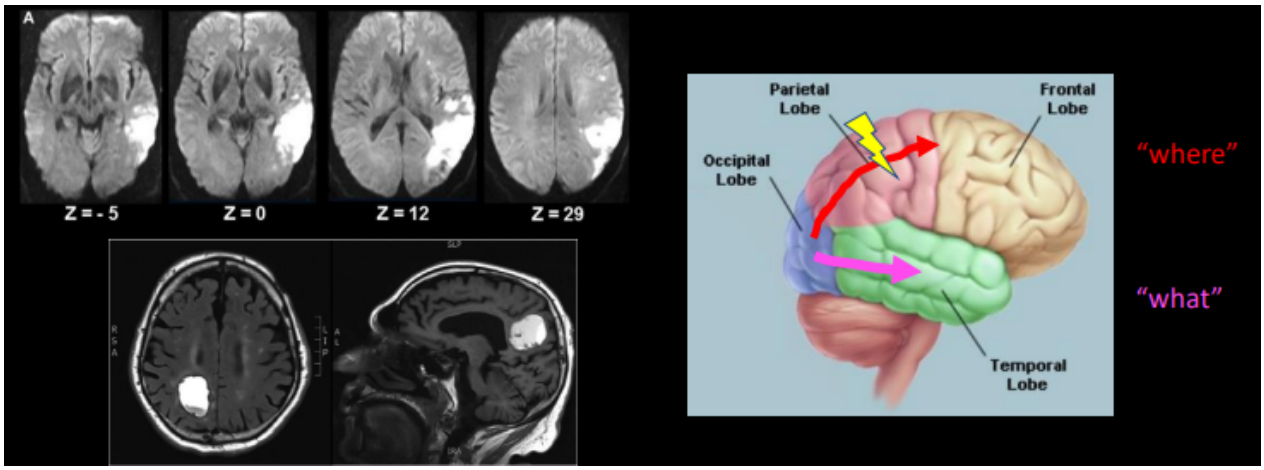
- Example: Drawing a clock, copying a flower, cutting a horizontal line in half





- Where is the lesion?





Recap

- Attention
  - is the mind's capacity to enhance and suppress sensory input and internal representations
  - exists because the brain can only do so many computations at once
- Various types of attention
- Remember the neural dynamis explanation

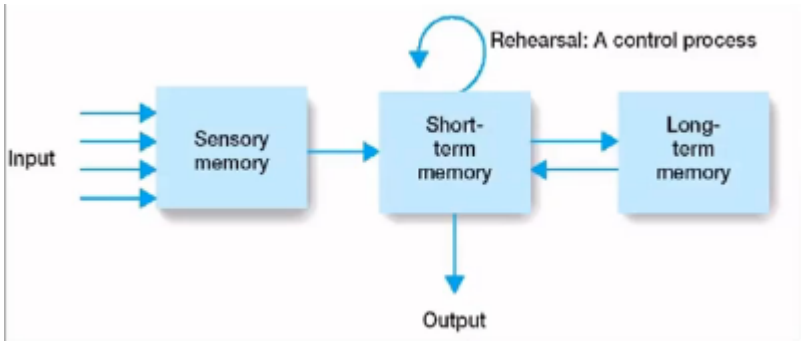
- Hemispatial neglect

Thu Sep 21st - Memory & Decision-making

Memory

- What is it?
  - Any way in which a past experience affects future thoughts or behaviours

The Modal Model of Memory - 1968



What's the difference between sensory- & short term memory (STM)? = Lecture 3 (Sensation vs. Perception)

```
- Sensation approx= sensory memory, because neural activity caused by a sensation isn't turned off like a lig
```

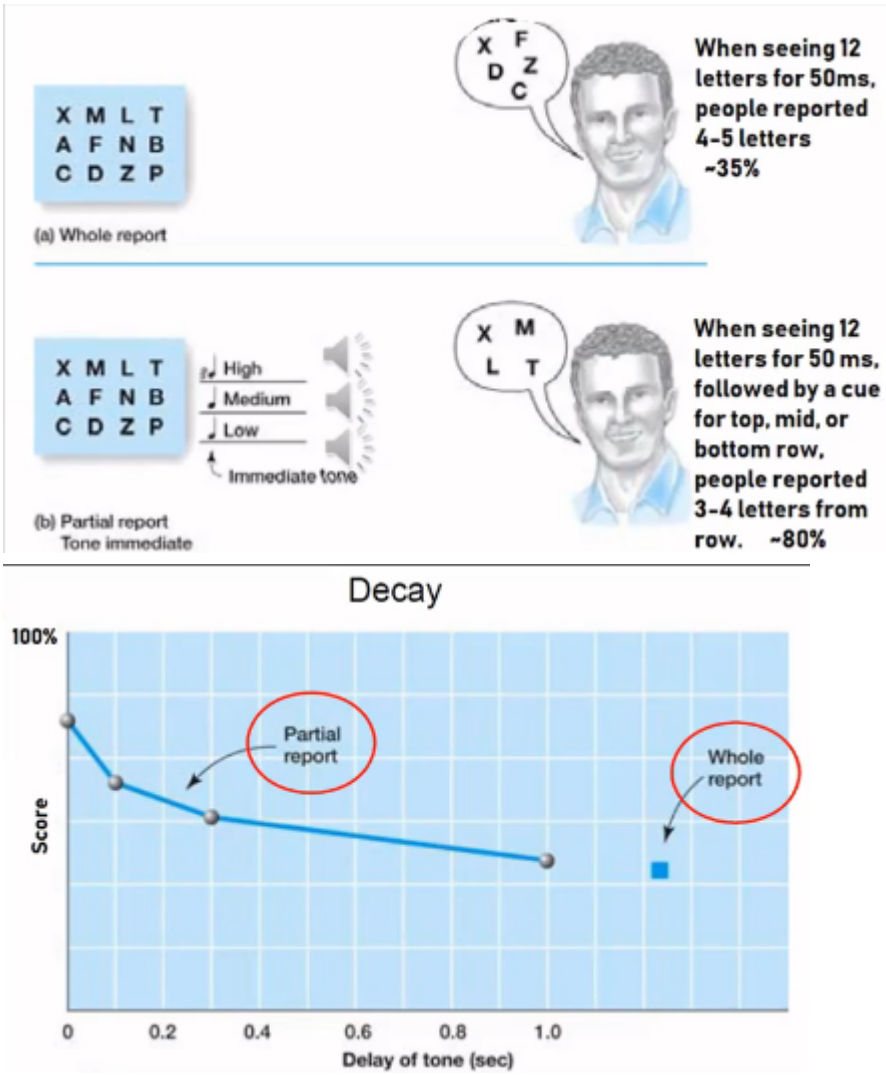
- Examples of sensory memory:

or when you go to the club and just get out

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

AKA only part of it enters STM attentional orienting!

- Experiment by Sperling (1960)(letters diasppear and participant needs to memorize as many as possible)
  - What we can conclude that Short-lived memory registers all or most of the information that hits our visual receptors, but information decays within less than a second
  - It's a very elegant way that there is sensory memory with **high capacity** and short term memory with **low capacity**



> STM is the 1st stage where we can pro-actively retain things

STM: what's the limit?

- Try to memorize the following sequence

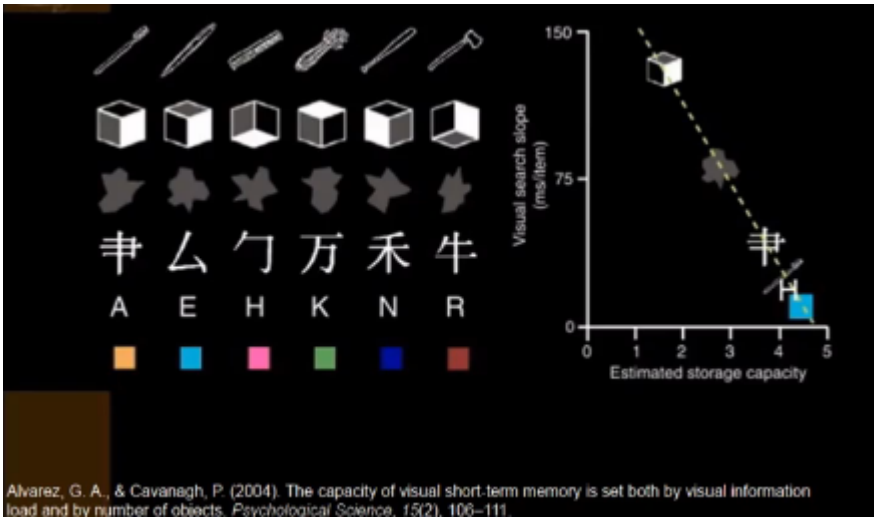
529846731 (random - hard)

123456789123456789 (some logic - easy)

Chunking: The learned relationship 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!
- Instead of framing the limit in terms of number of objects, frame it in terms of amount of information.

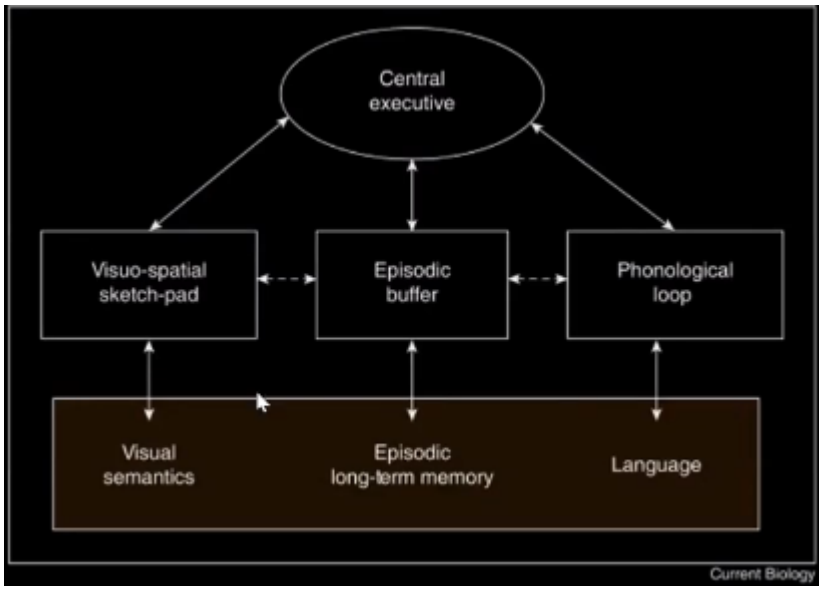
- Some item types are more difficult to remember



(information richenss is more important)

STM: actively memorizing stuff, and…?

- Calculate (3^3)/2 -> This task relied on STM; yet you did more than just memorize.
  - Enter Baddeley & Hitch (1974) working memory.

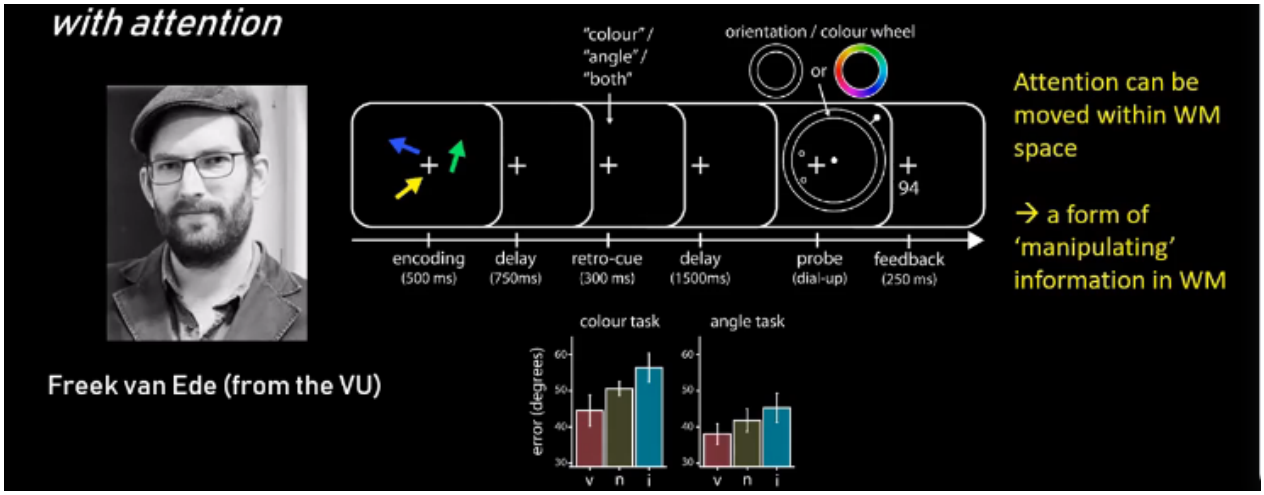


- In the figure, STM middle row ("slave systems")
  - Central executive ("Central processor")
  - Recruit slave systems to encode, maintain and retrieve info
  - Distribute mental resources when multitasking
  - Prevent irrelevant information from entering working memory
  - Coordinate higher cognitive operations (e.g. mental arithmetic)

Working memory

- The visuo-spatial sketchpad: a 'space' to navigate in with attention
  - Freek van Ede (from the VU)
  - Attention can be moved within WM space

- a form of 'manipulating' information in WM
  .

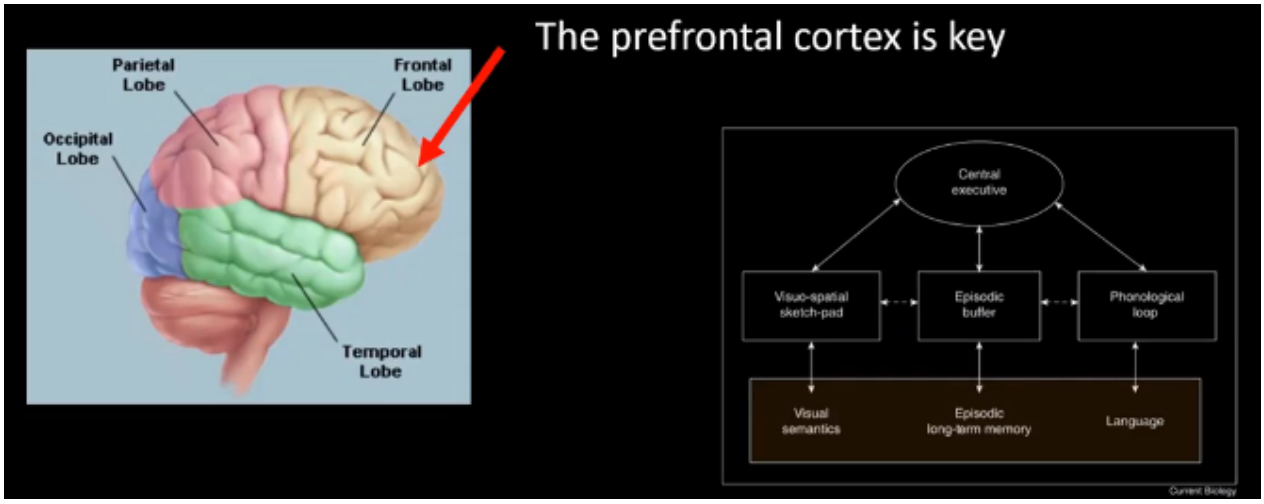


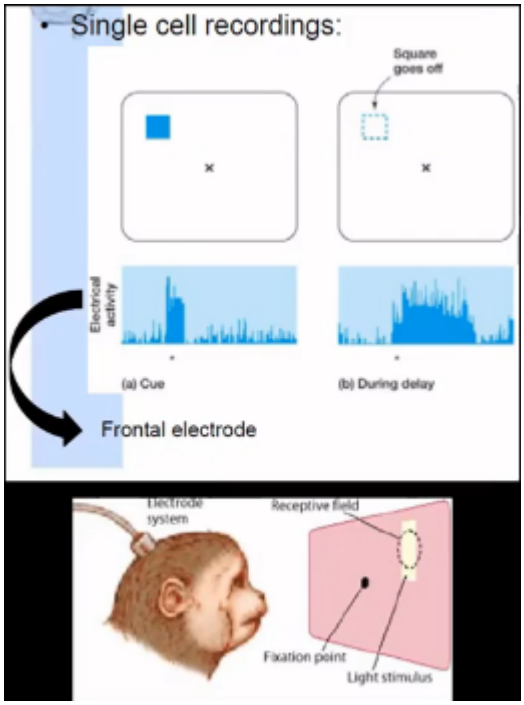
How does this work in the brain?

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

- Car analogy -> when you press the gas pedal the car moves forward, when you release the gas, the car keeps rolling for a bit. (it doesnt stop instantly) Just like the brain

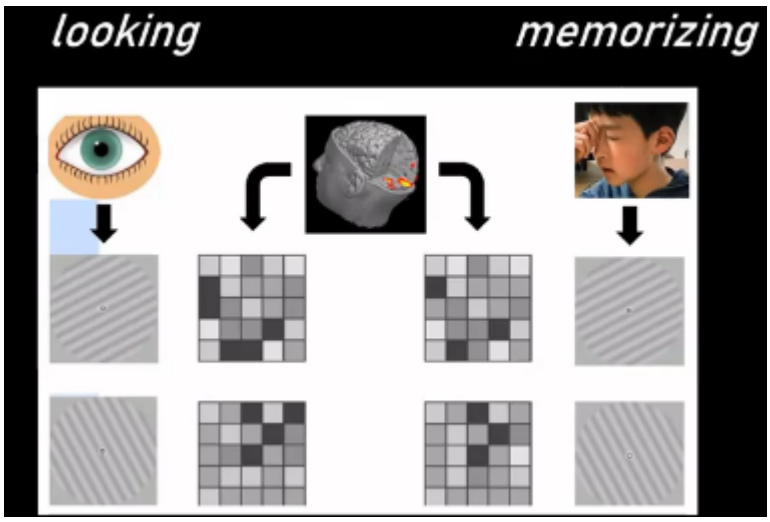
Various regions of the brain have been associated with each of these WM components





WM in the brain

- PFC is key…but so are all our perceptual areas
  - We can't read minds by looking at the visual cortex (Is memorizing the same as perceiving things? Yes. By putting people in an RFMI scanner, you can sort of read their minds)

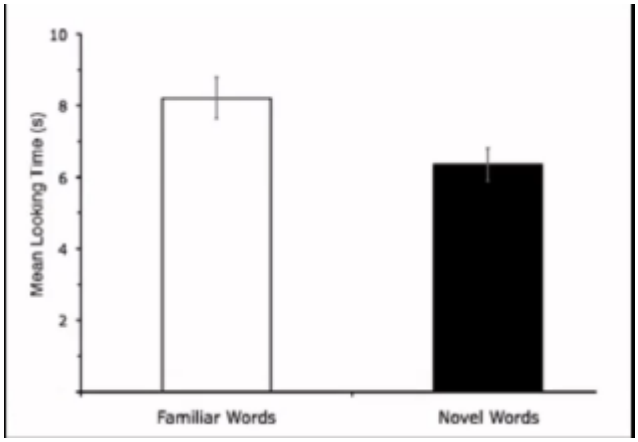


- So memories are 'stored' or at least read out in the visual cortex too
- 'Higher' regions like the PFC coordinate activation in perceptual regions during retention

Long Term Memory

- LTM is the seemingly infinite archive into which we have stored every experience since our existence (Imagine chewing on your desk)
  - Taste and smell are hard-to-describe - but very robust memories

- 8 month old babies depict more attention for familiar words than novel words
  - Test? Pacifier that the baby sucks on (frequency and intensity are modulated by the sounds perceived by the babies)

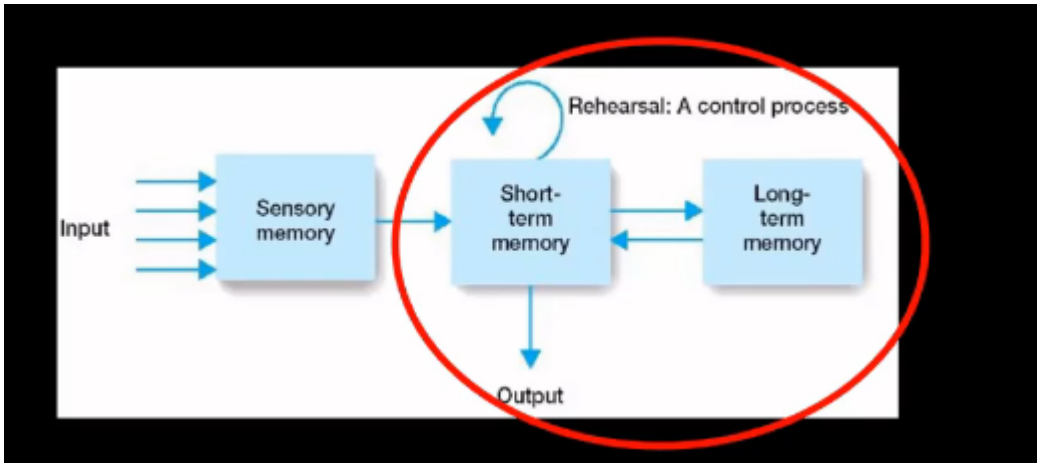


- … But 20 y later, these humans will probably not remember that they took part in that experiment

    - Procedural / implicit memory (statistical learning) vs. episodic memory

- LTM is seemingly infinite archive into which we have stored every experience since our existence
- Through the archive is infinite, stored files may 'wither'
- Throughout our lives, we are automatically building the archive - for strategic purposes (*learning, automatization, boltering WM*)

Interaction between WM and LTM First of all: how do we know that these are really 2 separate things in the brain?



- Clive Wearing: STM 'alright', LTM impaired:
    - Patients with brain damage show preserved memory in 1 type and impaired memory in another type. Clive became ill and that destroyed some brain tissue. He couldn't remember what happened 10 sec ago or more than that. Still has skills, still remembers wife (jumpst happy oh you're back, even though she left just to the kitchen), can still remember jumpscarer
    - Within that 10 sec boundary, STM works fine, but nothing is passed to LTM.
- Patient K.F.: impaired WM but LTM intact
- An experiment without patients: *The serial position curve*
    - Remember sequence of words (as many as possible):
    - briefly presented one by one: tree - laptop - sphinx - earbud - mouse - lamp - pochet
    - When asked to recall as many words as possible, subjects report the first and last word best

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

- Effects:
    - *primacy* effect (first words 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 words advantage): Last words are still in STM

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

- Example: Chess -> memorize chess position (something like chunking)

Various Types of LTM

- Episodic (explicit)
- Procedural (implicit)
- Semantic (explicit) **other words for explicit is declarative**

What's the difference between semantic and episodic memory?

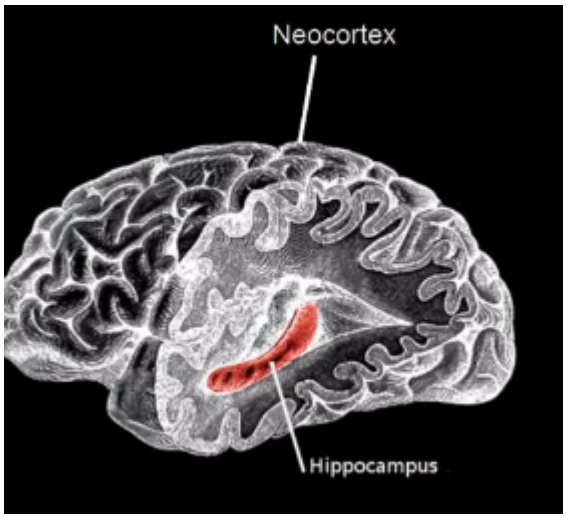
Past experiences ('mental time travel') vs. Facts ('learned relationships')

- Example: I've climbed Mt Everest (you recall both semantic and apisodic memmory)
- A double dissociation: two patients
  - Displayed good knowledge about many things but forgot things that happened 3 minutes prior
  - Didn't know meaning of words anymore, didntrecognise close relatives: but could recount the previous day, week, or year

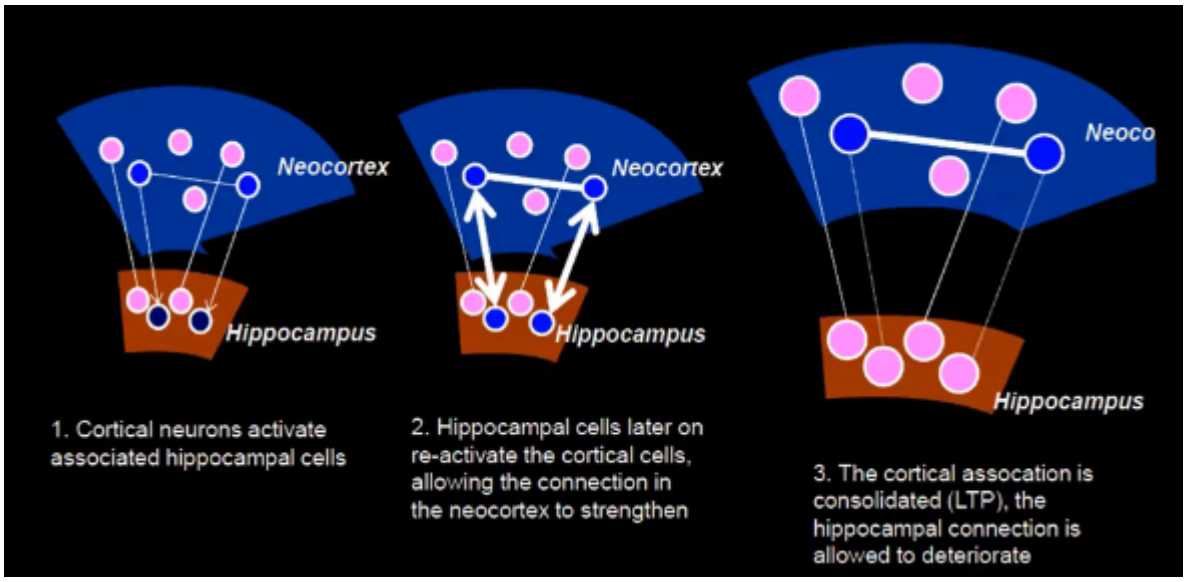
How does LTM work in the brain?

- STM: prefrontal + perceptual regions
- LTM: *Hippocampus* in the medial temporal lobe strongly involved in memory tasks

- When depriving people of sleep, memories don't stick as well



Consolidation



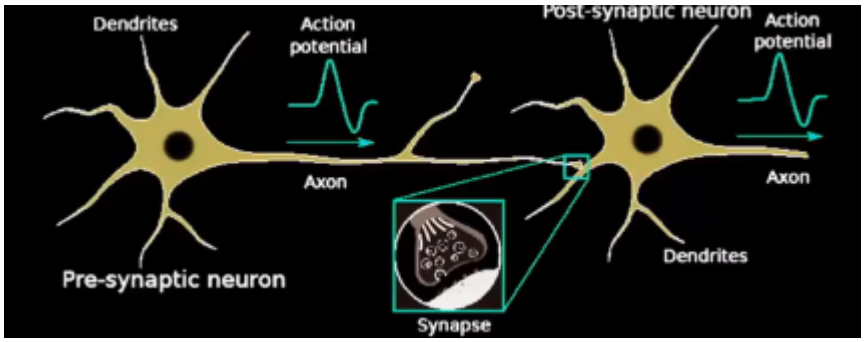
(in cortycal regions, neurons are flying all over the place)

- The hippocampus reactivates teh cortical regions, which strengthens the connecitons between the cortycal neurons,so that they can be active again (recall of memory) whereas the connections between the cortical neurons & hyppocampus die.

- LTM & STM work similarly in the sense that perceptual regions of the brain are involved (memorizing a visual = 'simulating' seeing somethiing…but what about implicit learning?

- **Learning at the level of single neurons:** with repeated activation, there is a chemical change in the synapse. The **synaptic transfer** is strengthened

e.g. stronger connections between letters and words



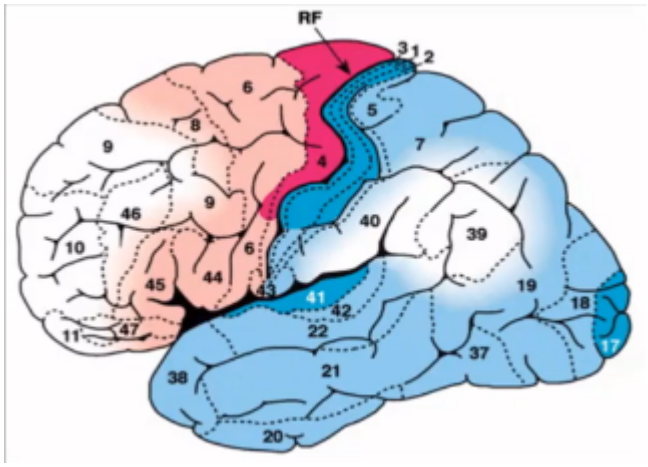
Recap

- Memory: any way in which a past experience impacts present/future thoughts or behaviours
- Several memory stages: sensory memory, STM/WM, LTM
- Sensory memory = trace (residula) activity: high capacity
- STM = active maintenance (due to attentiona focus), but low capacity
- WM = STM whereby info is not just memorized, but also manipulated
- Prefrontal cortex is key, but in cadence with perceptual regions ('slave systems')
- LTM = seemingly infinite archive into which we stow files that may wither over time
- Closer interactions between WN & LTM: LTM is activated by the things kept in WM, and this info in turn bolsters WM content
- Evidence for separate systems: patients, serial position curve
- Understand the vartious types of LTM: semantic, episodic, impilicti vs, declarative, procedural, statistical learning/priming
- Episodic/declarative memory: interaction hippocampus and cortex
- Implicit learning can also be explained at the level of single neurons

Decision-making

- *Do we make decisions?* (free will endless debate)
  - Decision implies multiple options
  - But decisions can always be expllained -> if we've completelyfigured out the brain, can we fully predict human beaviour?
    -

Perception & Action



Decision-making is the bridge between perception (+memory, emotions, biases, predispotions) 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.

- Example: Messi is one of the greatest football players of all time. This is enhanced by an action that he does -> Confirmation bias

Overconfidence biases

- We trust ourselves more than others
  - Example: 75% of drivers think they belong to the besty 25%

- The Small Trolley Problem

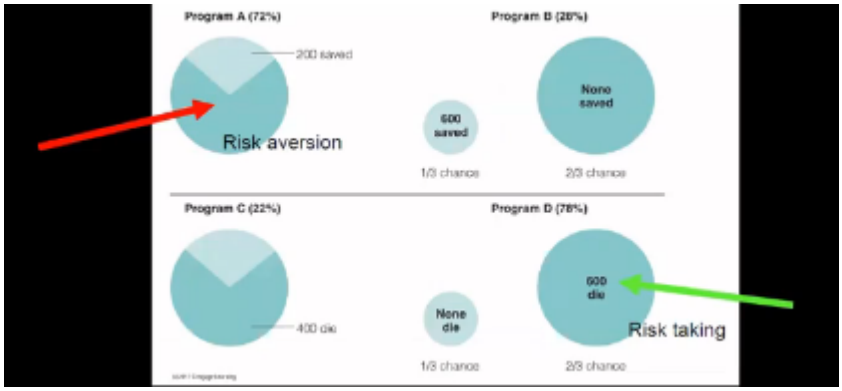
- Expected utility theory: "having all relevant information, people will make a decision that yields the most utility/value/achievement"
- Prospect theory: "people act on predicted emotions"
  - *How good would I feel if I win?*
  - *How bad would I feel if I lose?* - disproportionally more than the above
  - People are often risk-averse: but it also depends on how the problem is framed

- Example: Dutch AD, people are tempted to participate in the lottery (of course, they show people who are winning -> prine the idea of winning, to reduce the risk aversion -> "Imagine if you win")

- Framing: when emphasizing gains, people become more risk-averse, but when emphasizing losses, poeeple become more risk-taking

> "Imagine that the United States is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume that the exact scientific estimates of the consequences of the programs are as follows:...."

A: 200 are saved
B: 1/3 chance that 600 are saved, 2/3 that none are saved
C: 400 will die
D: 1/3 chance that none die. 2/3 chance that 600 die



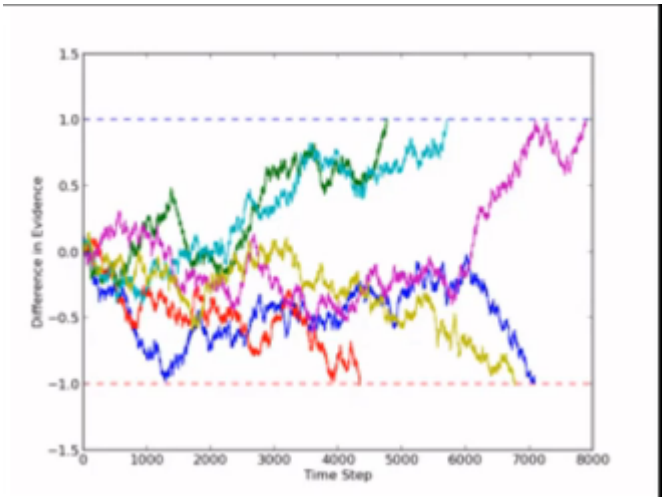
- It's never about calculating the expected value, just the context
- Judges are animals too
  - Are inspired by low level things
  - Are more leninent in their verdict if its made after lunch (otherwise, the punishment tends to be more severe)

Decisions in the brain

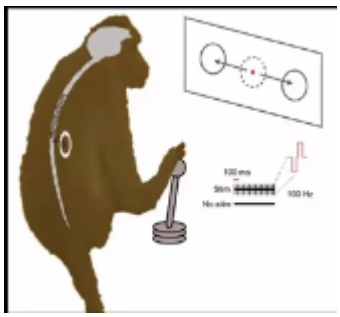
- An 'unfairness' region in the brain: the anterior insular cortex
  - Higher activity -> less likely to accept an unfair offer
  - 'We have 10$, I give you 3$ and keep 7$ myself' (if high activity, will not accept)

The drift diffusion model (Binary decisions in the brain)

- 2 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 activated until 1 cluster's spike rate hits threshold

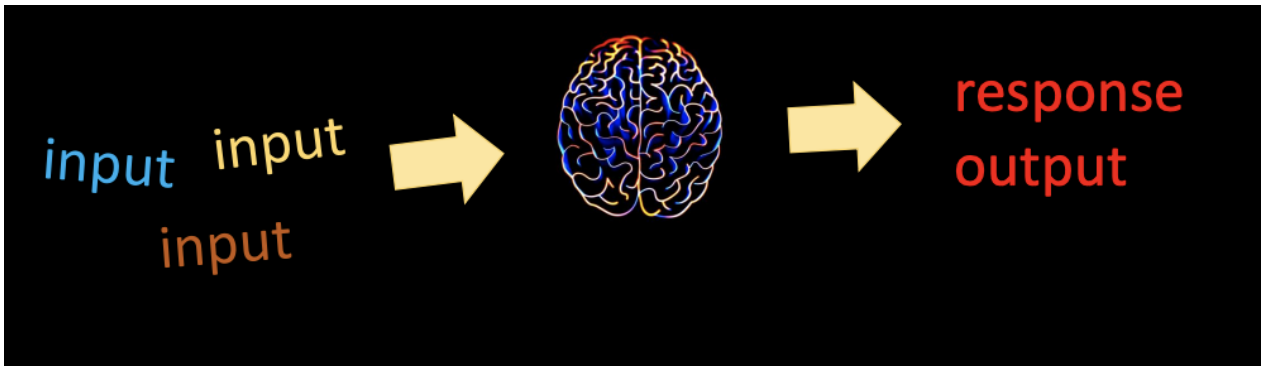


- Does it hold for more compelx decisions?
  - Trolley problem? problably not -> influences by numerous factors, need more compelx models

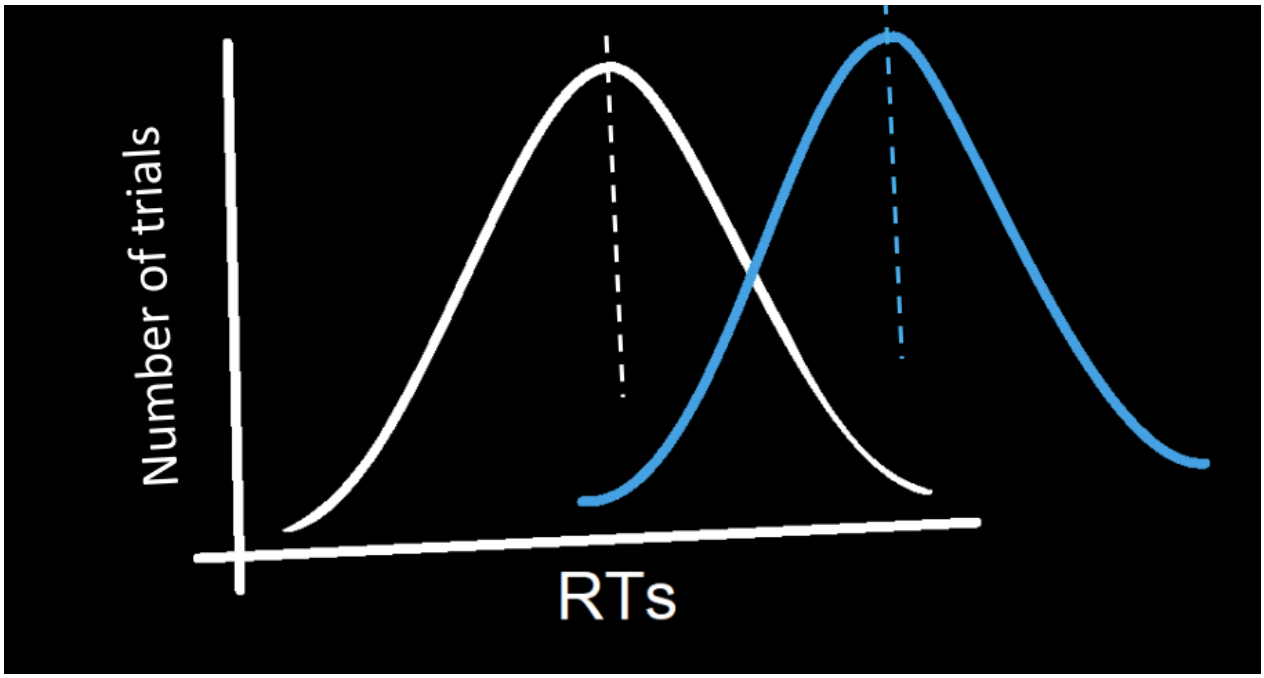
> Ultiomately, to understand decision-making is to understand the brain entirely.
> We have neuronal clusters driving the onset of billions of actions.
> Those clusters are excited in billions of ways.
> We can predict 'decisions' of single neurons and human populations: nothing in between

Response time, accuracy & signal detection theory

Response times



- Certainly that an effect exists depends not just on the means, but on the spread -> The extent to which distibutions overlap



- What we typically do in processing RTs:
  - exclude incorrectly answered trials
  - exclude very atypical trials (i.e. trials with RT beyond several SDs from the mean)
- Distrubutions in R could reveal more infomration
  - 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

A case study on response times

the Stroop task (Stroop, 1935)

- Word meaning impacts processing of the world's print color - and vise versa

RED RED

BLUEBLUE

- Participants saw the words RED & BLUE, in red or blue print. In one block, they responded the meaning of the word. In another block, they responded the print colour of the word.

H: slower responses when the meaning and color don't match

- When calculating the mean response tiems (RTs) in each condition, we indeed see effects of meaning/print congruency:

meaning decision:

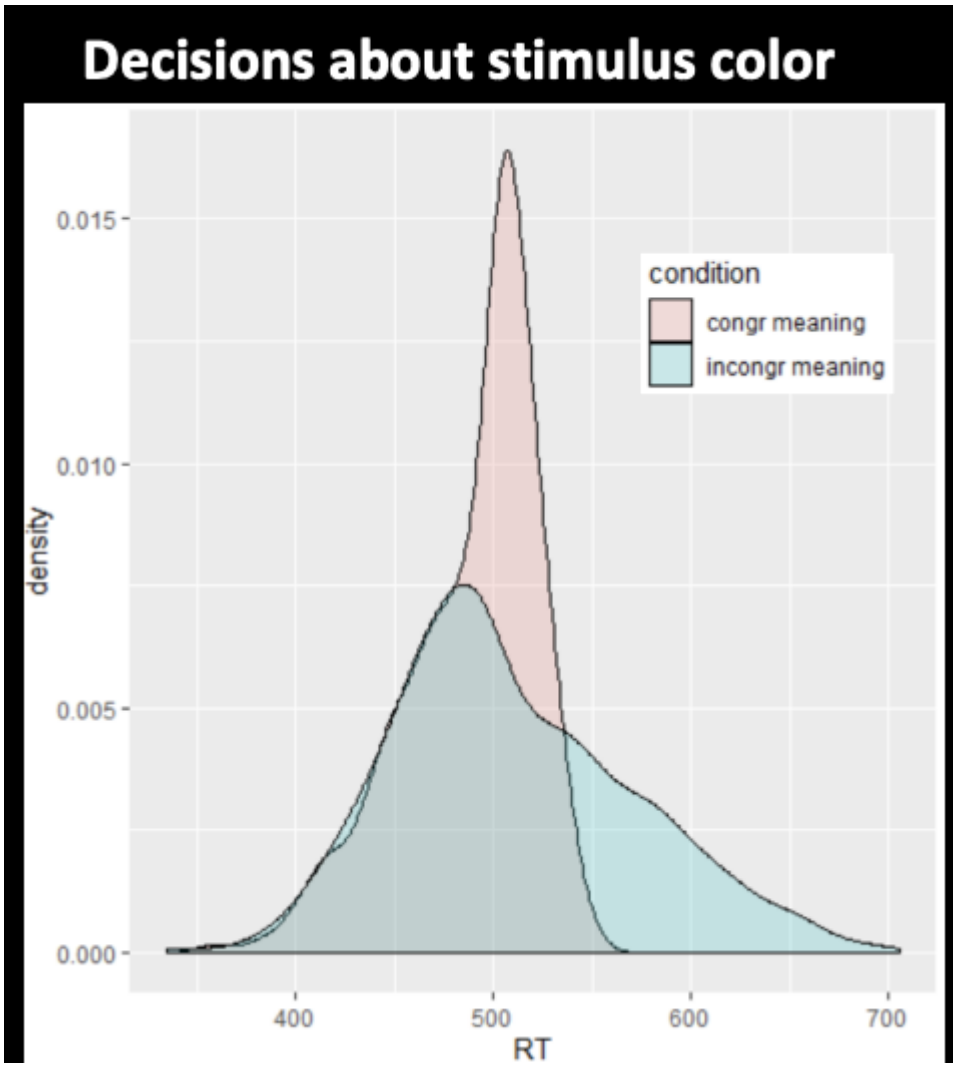
congruent: 587ms
incongruent: 611ms

print decision:

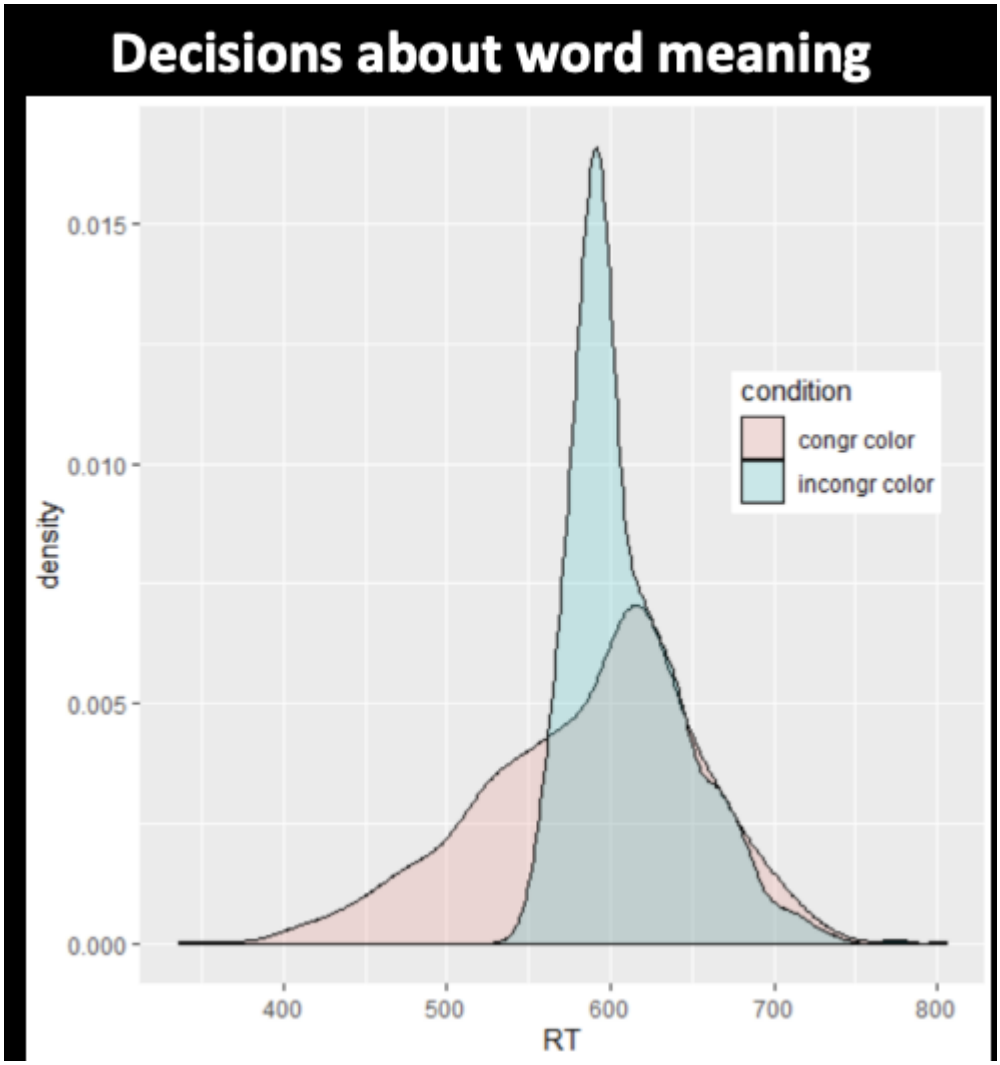
congruent: 489ms
incongruent: 510ms

Are these 2 effects the same thing, cognitively speaking?

- Early RTs are very similar between conditions, later RTs differ a lot so this effect has a late temporal focus



- Late RTs are very similar between conditions, early RTs differ a lot so this effect has an early temporal focus



Accuracy

- Anlayses of accuracy are often regarded as being interchangeable with analyses of RT. (better performance shorter RTs and fewer erros)
- In most behavioural task, both are regarded. More measures -> broader pciture
- We only look at one measure, at times. (e.g. many lines in memory research)

Is it problematic if we find an effect in accuracy but not in RTs? -> No
Persons A & B are equally fast, but A is more accurate: A performed bettter
A & B are equally accurate, but A did it quicker: A performed better.

- Sport analogy

Is it problematic if opposite effects are found in accuracy and RTs? -> Yes

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

Combining RTs & accuracy *Inverse efficiency socres*

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

IES = RT/P(correct)

RT = 500ms, accuracy = 0.9 -> IES = 500/0.9 = 555ms
RT = 480ms, accuracy = 0.8 -> IES = 480/0.8 = 600ms

- IES is a measure of how much time it takes to produce a correct response. It is a measure of efficiency.

A deeper look into accuracy *Signal detection theory*

- Only applicable in the context of binary decisions

A more elaborate measure of accuracy: Sensitivity

- The world around us is nosy. We are constantly bombarded with sensory information. We need to decide what is relevant and what is not.
- Sensitivity doesn't only look at our ability to spot the relevant information, but also at our ability to ignore the irrelevant information.

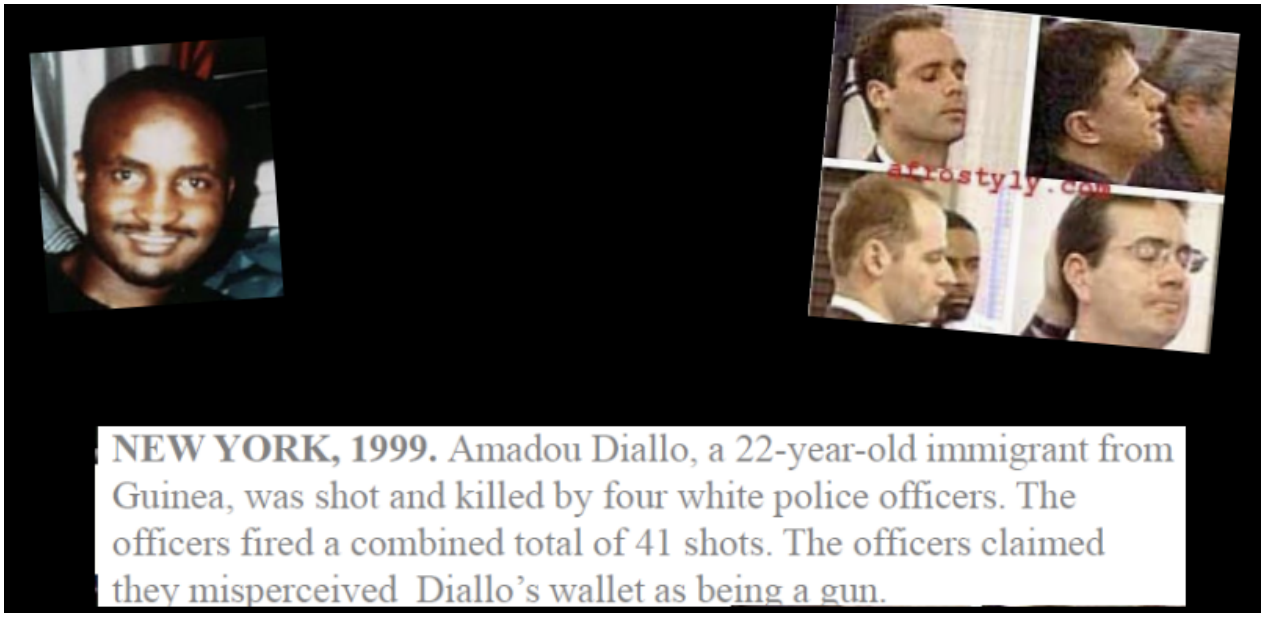
> What is the key challenge in perception?

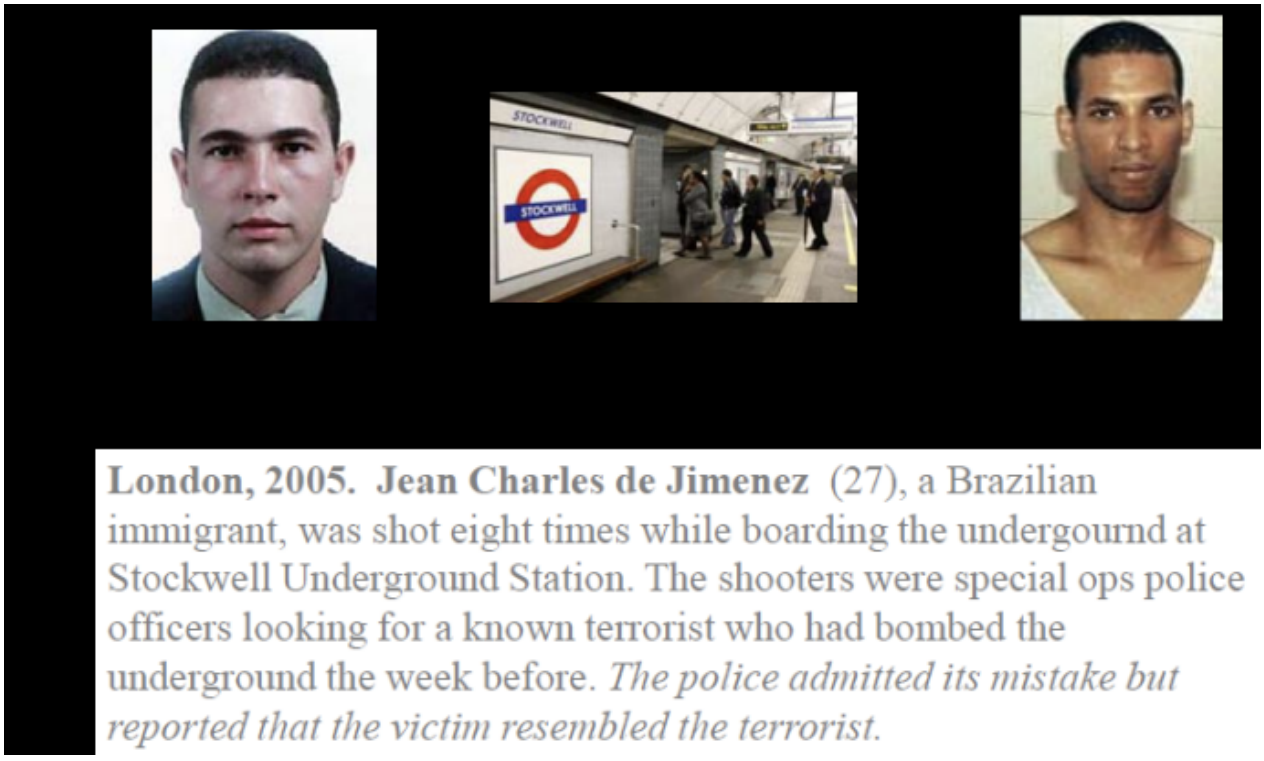
- To resolve the ambiguity in the sensory input; and to distinguish the relevant from the irrelevant information.

- pisica sau caine?

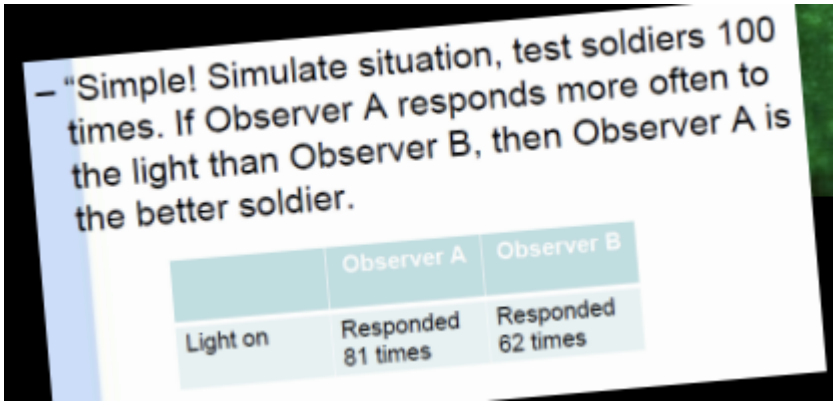
Signal Detection Theory: A way to quantify perceptual skills

> Why do we need to do this?

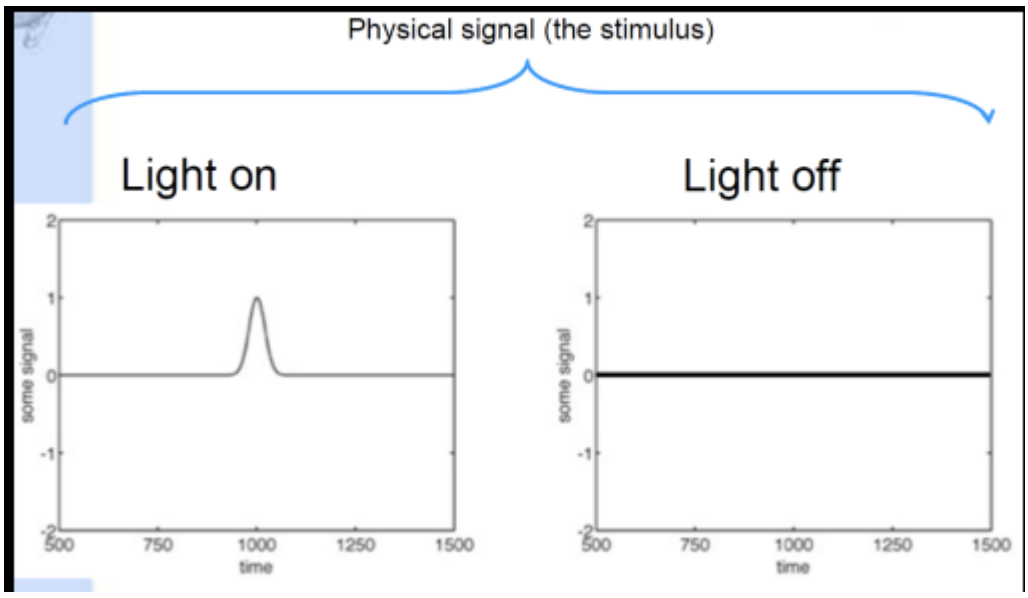


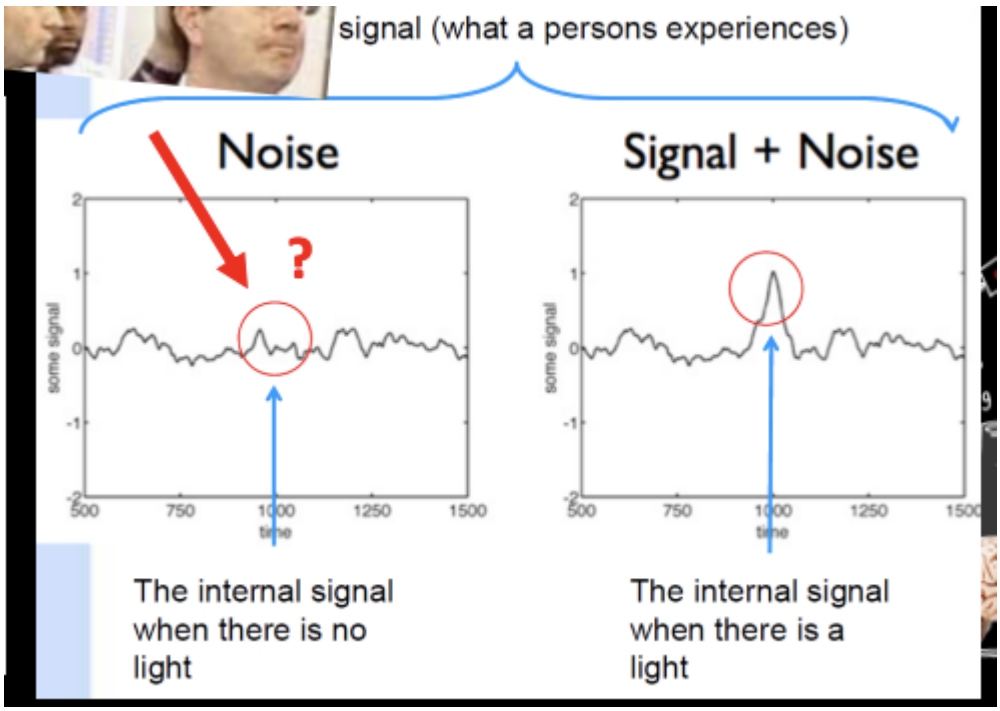


- Task: push button when detecting an unnatural source of light

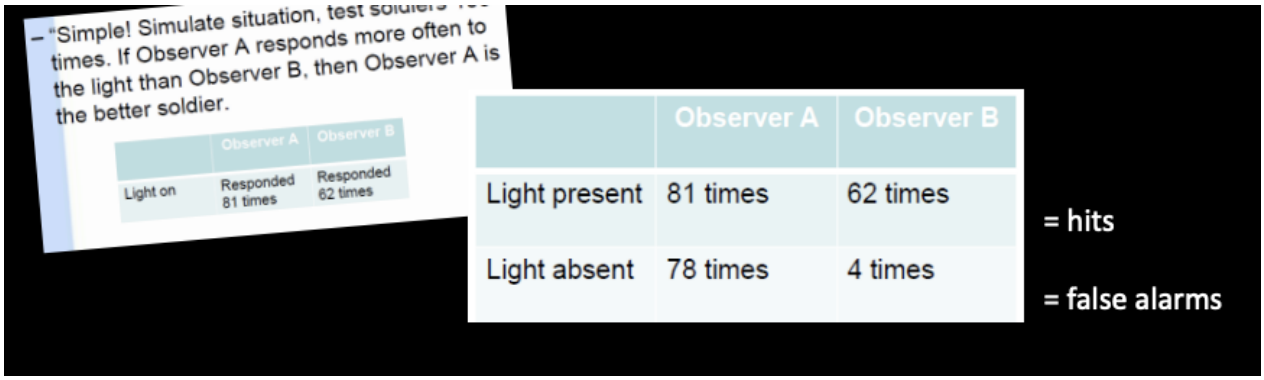


- But the universie is noisy and so are our senses

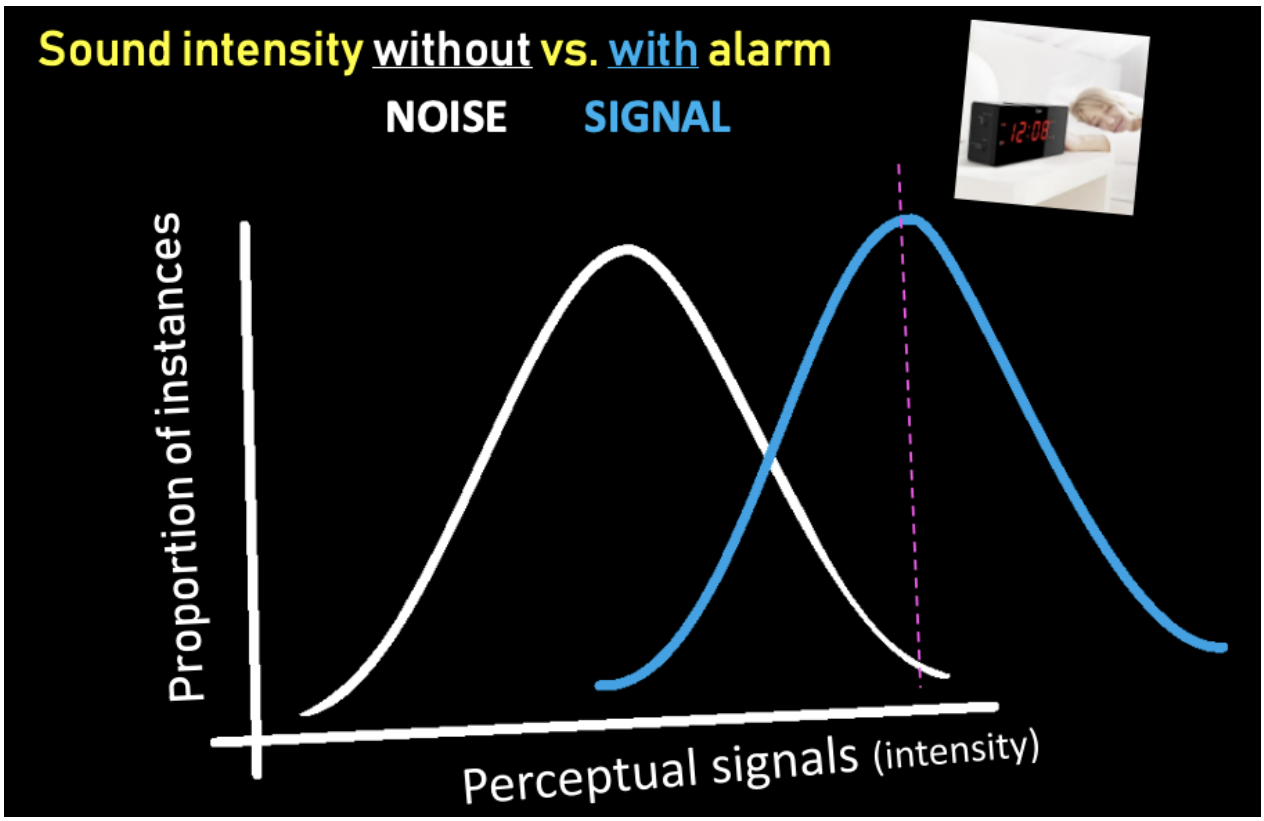


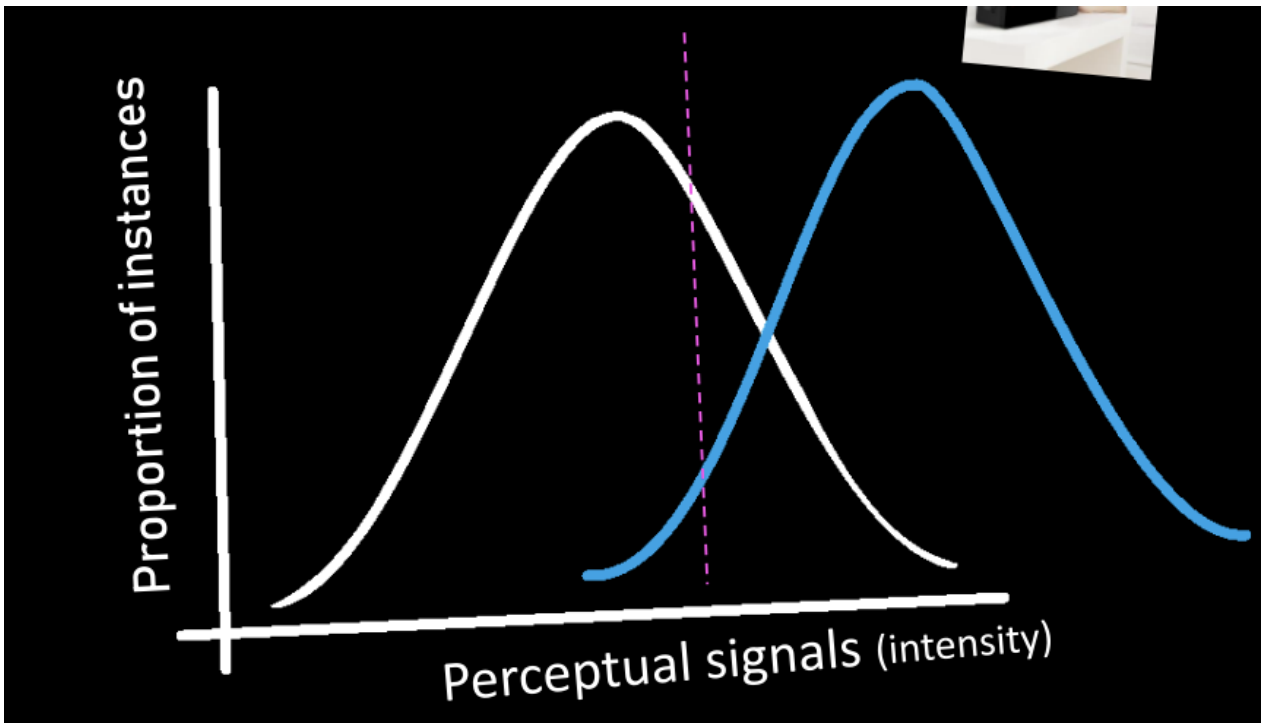


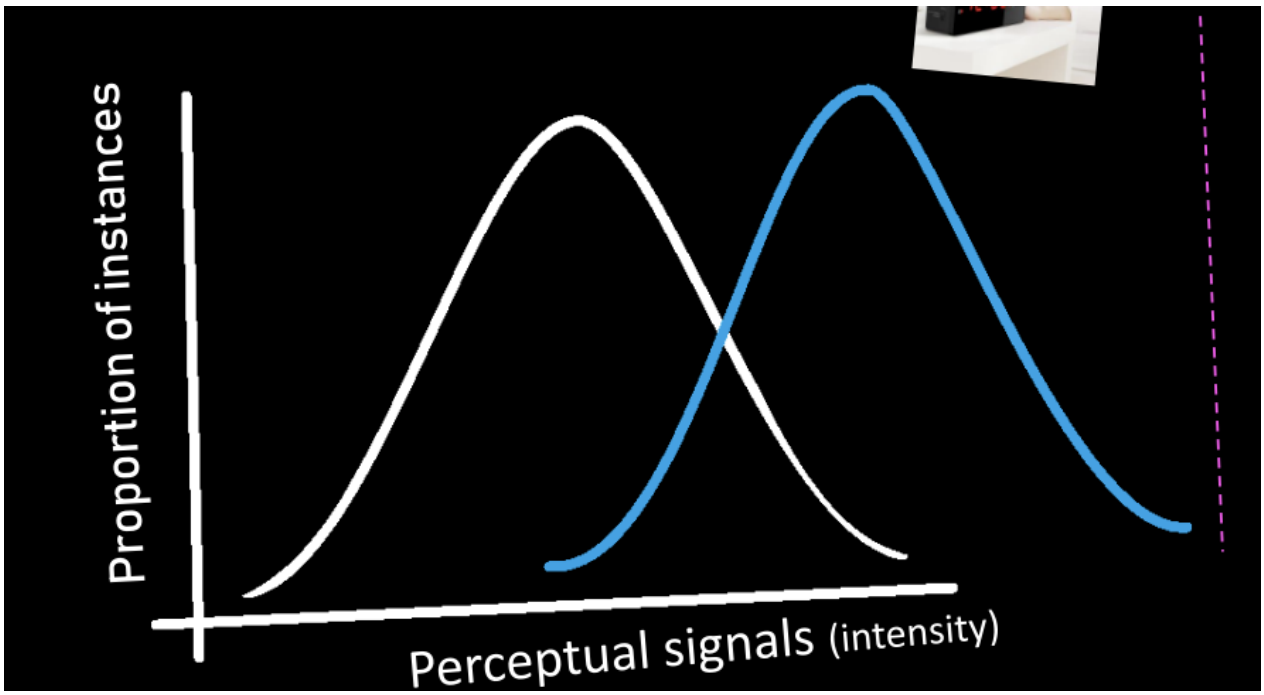
- Better observer?



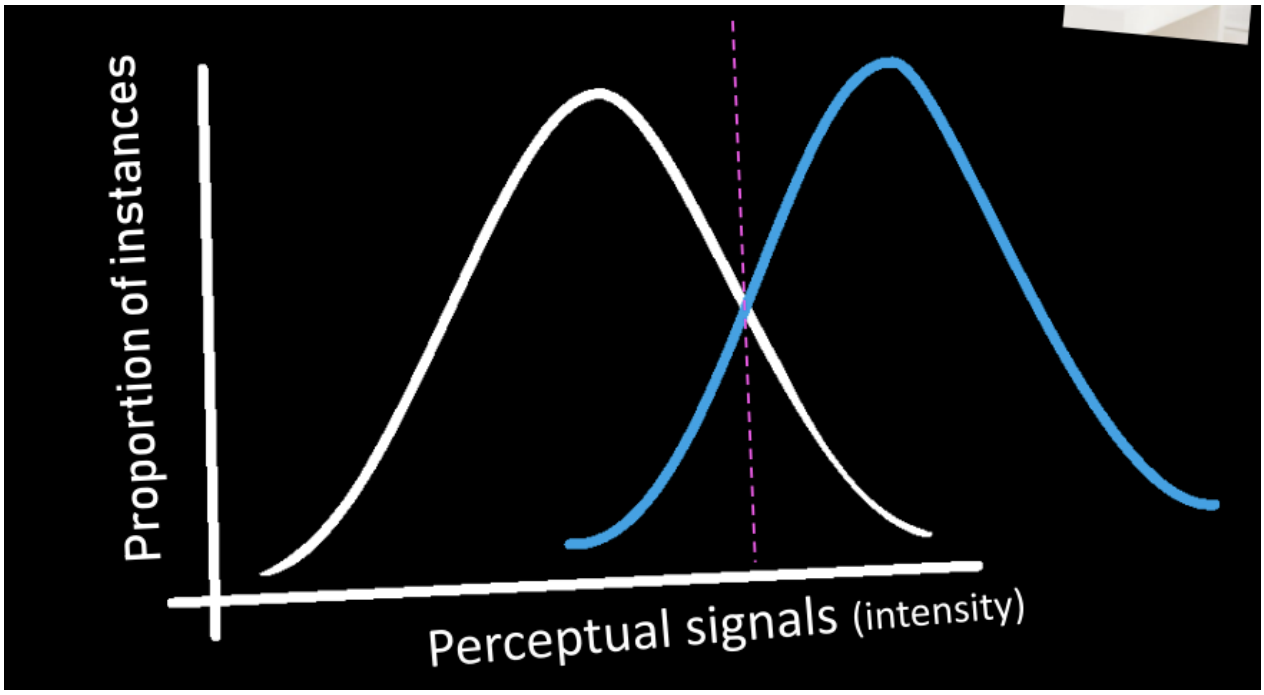
- Sound intensity without noise vs with alarm


Sound intensity without vs. with alarm
NOISE
SIGNAL
Proportion of instances
Perceptual signals (intensity)

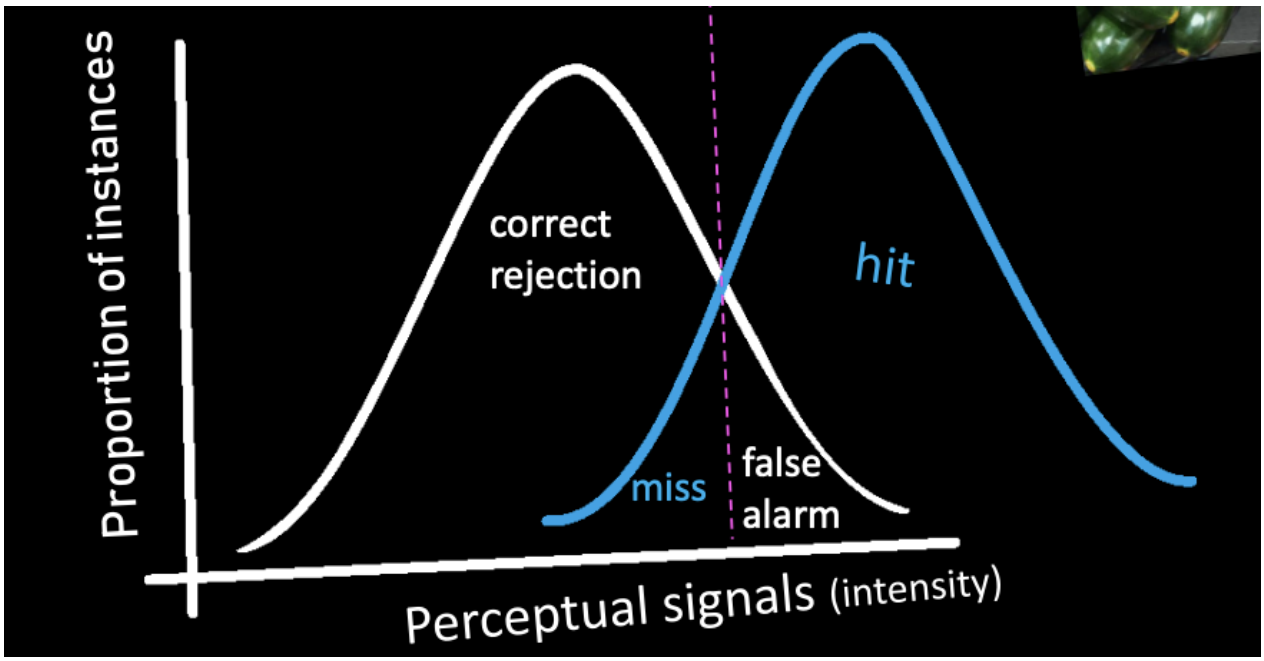

Proportion of instances
Perceptual signals (intensity)



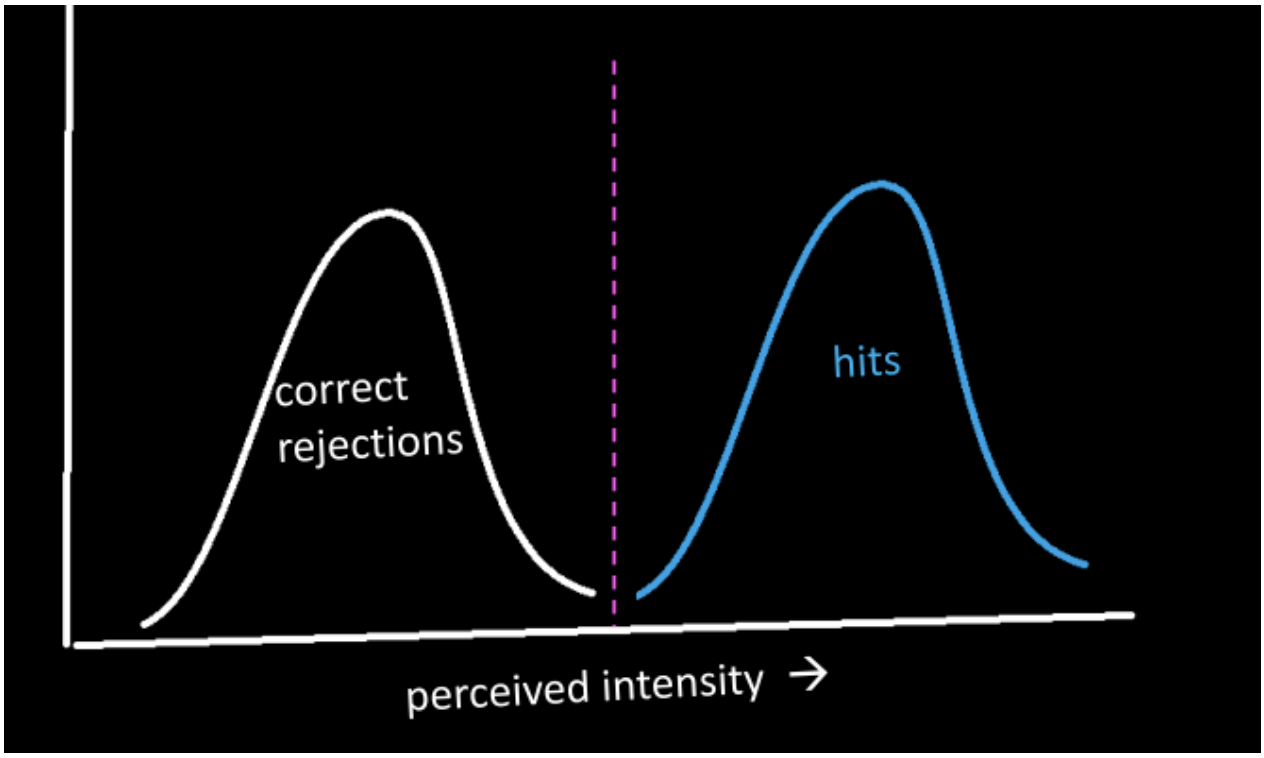
- No matter where your threshold is, your ability to distinguish signal from noise is the same



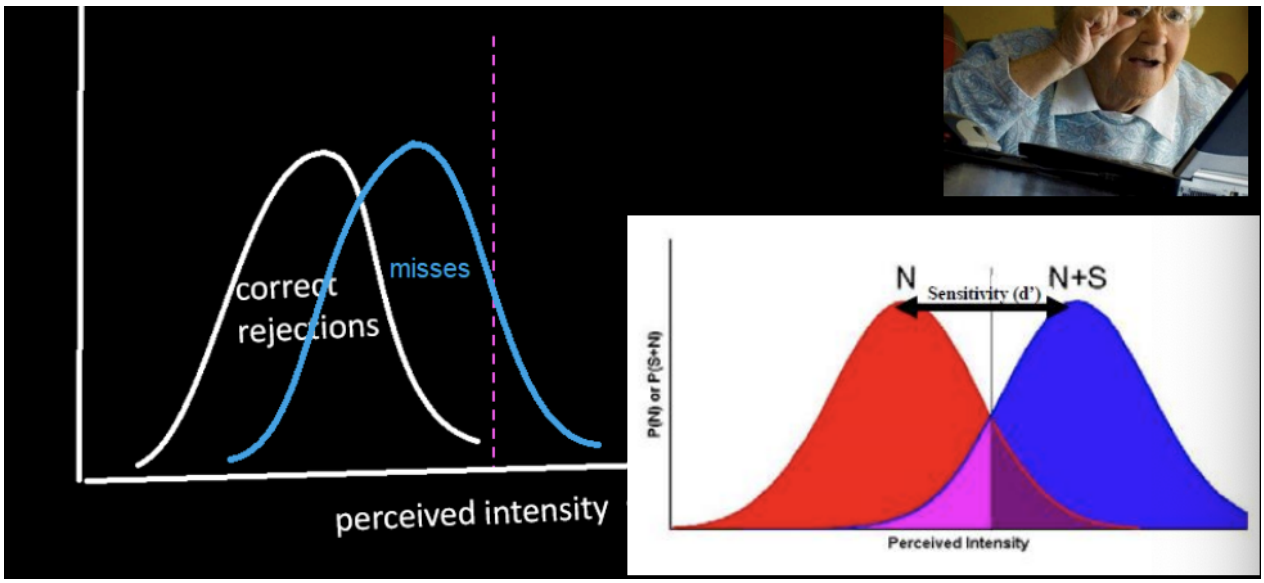
- Cucumber neuron's firing rate when seeing a **zuccini** vs. a **cucumber**: 4 outcomes



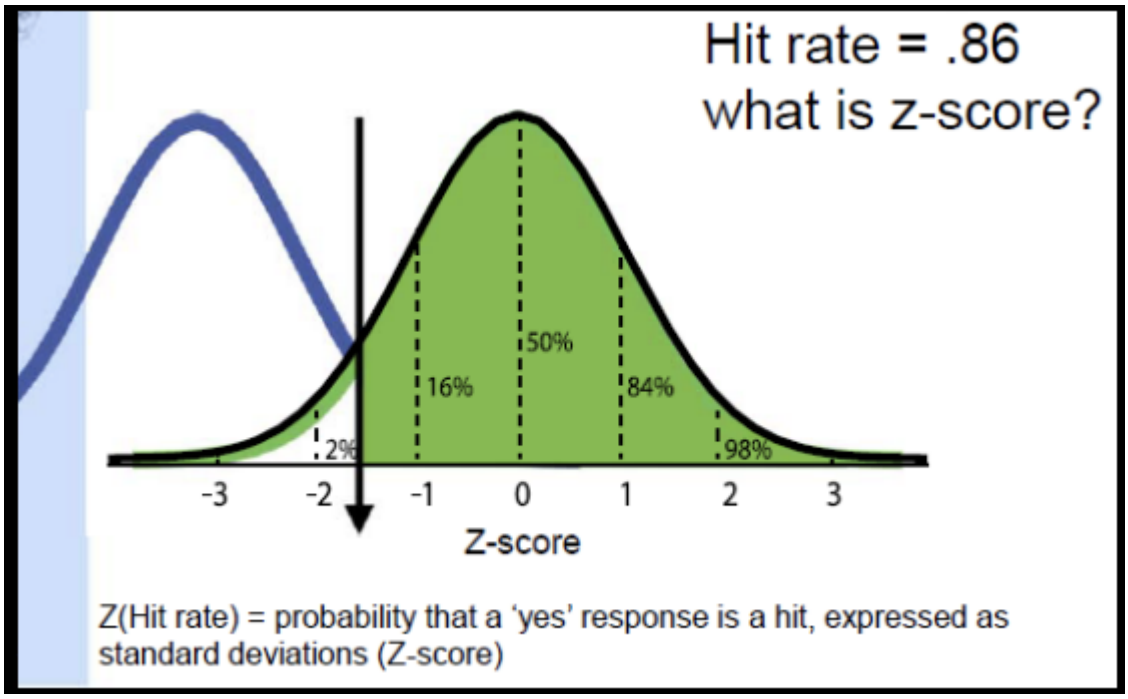
- The response matrix: the proportions of hits, misses, false alarms and correct rejections depend on:
  - your threshold
  - the distance between the signal and the noise distributions



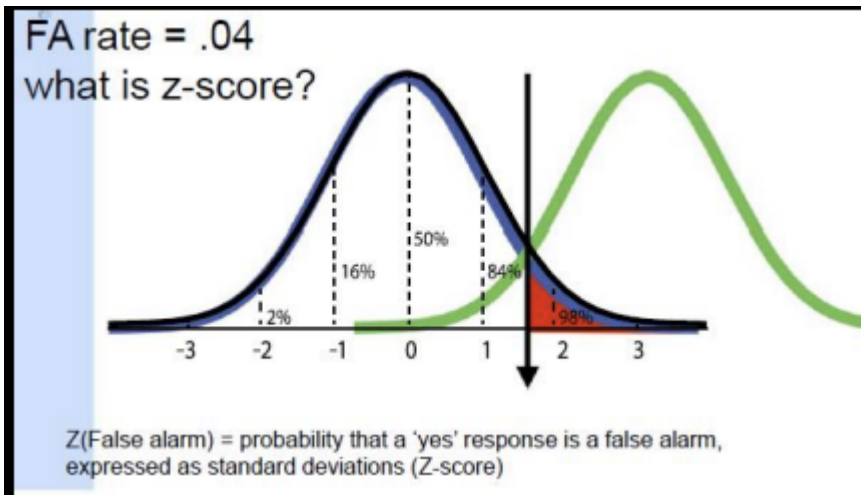
- The distance between signal & noise distributions varies among individuals and is called sensitivity (= perceptual skills)



- How do we measure this distance?
- We cannot measure 'perceived intensity!…or can we?'



1.08



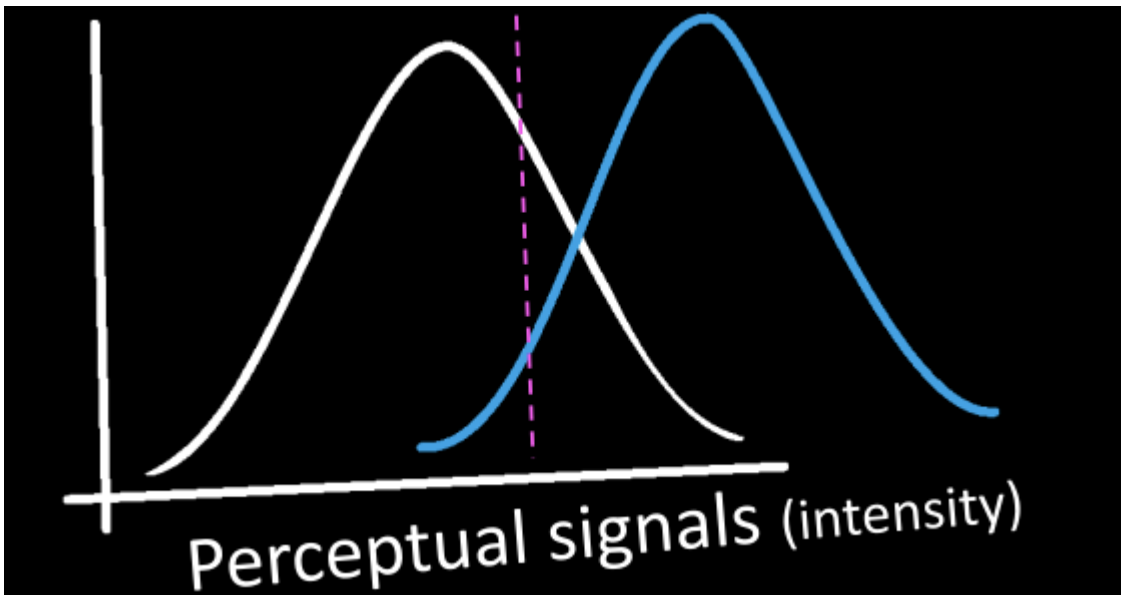
-1.75

Sensitivty = z-score for hits minus z-score for false alarms: 1.08 - - 1.75 = 2.83

- All that we need to measure sensitivity are the proportions

		State of the world	
		Signal	Noise
Response	Yes	P(Hit) 0.66	P(False alarm) 0.14
	No	P(Miss) 0.34	P(Correct rejection) 0.86

- Not affected by response threshold (criterion)!
  - z(hits)-z(false alarms) remains same



Staircase procedures

- If we want to measure performance irrespective of these subjective perceptual processes?

e.g. a person is slightly color-blind in our stroop task

REDBLUE

BLUERED

- This means controlling the subjective distance between the relevant and the irrelevant

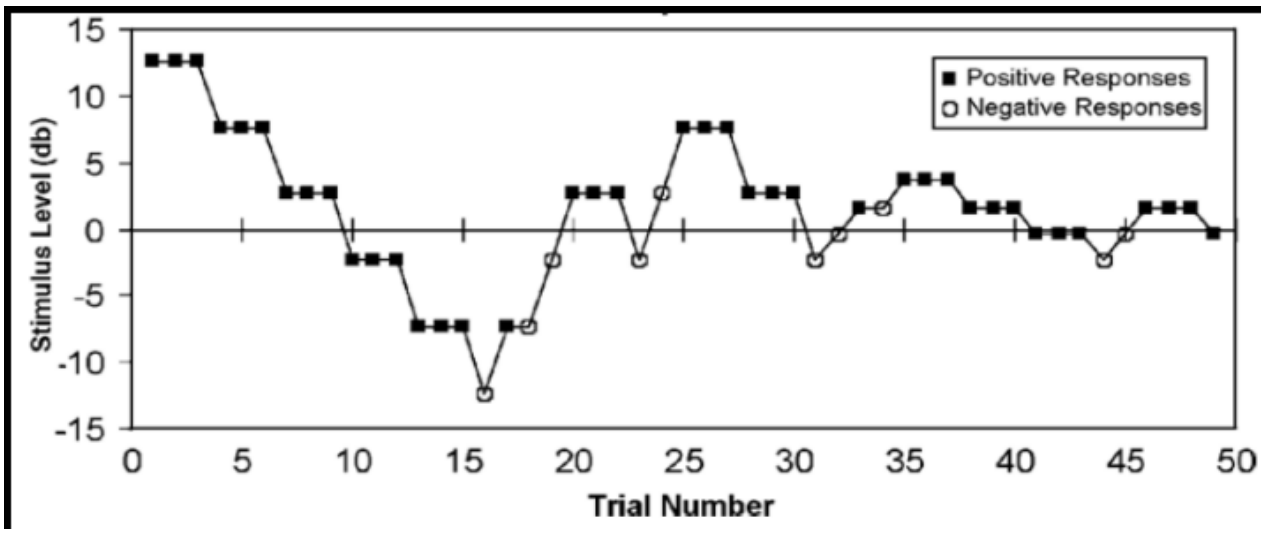
-> adjust stimulus intensity, duration, etc., on the basis of incoming responses
-> so that all subjects perform equally

- "Words are impacted by surrounding words"
- "What is the developmental trajectory of this?"
- **Standard paradigm: Show words for 150 ms**

> Attention extends beyond single words in beginning readers: Snell & al.

Example

- After X correct trials, decrease stimulus duratin by β
- After Y correct trials, increase stimulus duratin by β
- After each oscillation, decrease β a bit (until it hits 0)


Positive Responses
Negative Responses
Stimulus Level (db)
15
10
5
0
-5
-10
-15
0
5
10
15
20
25
30
35
40
45
50
Trial Number

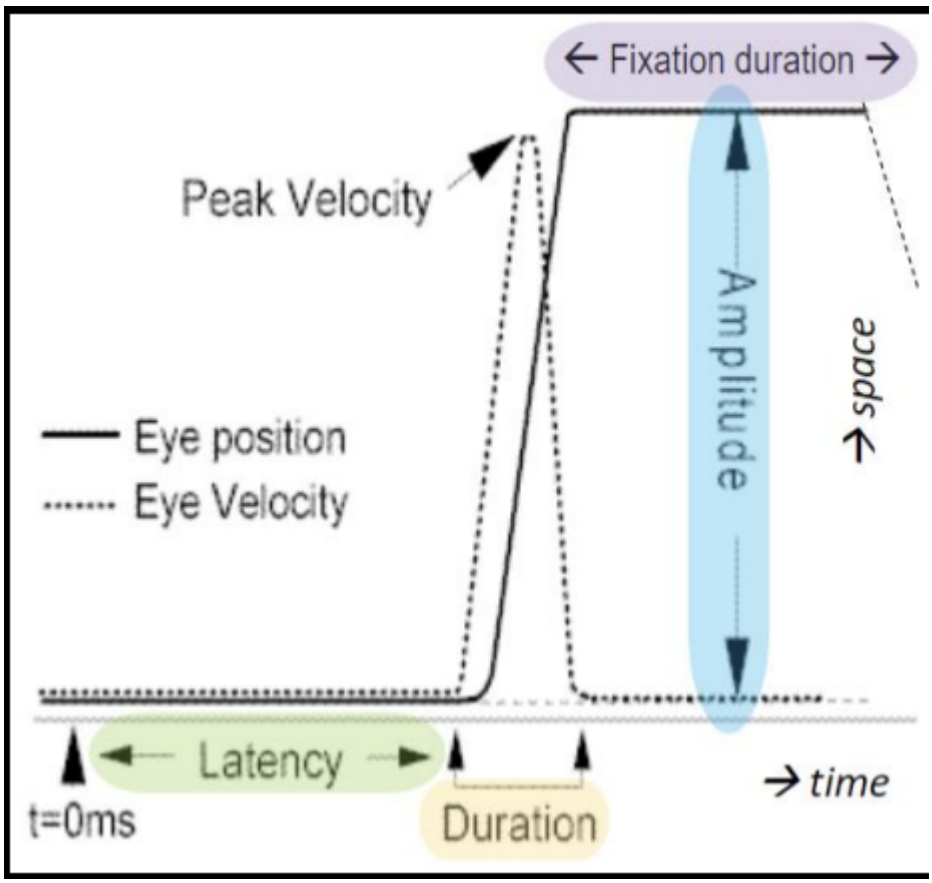
Mon Sep 25th - Eye-tracking and pupillometry

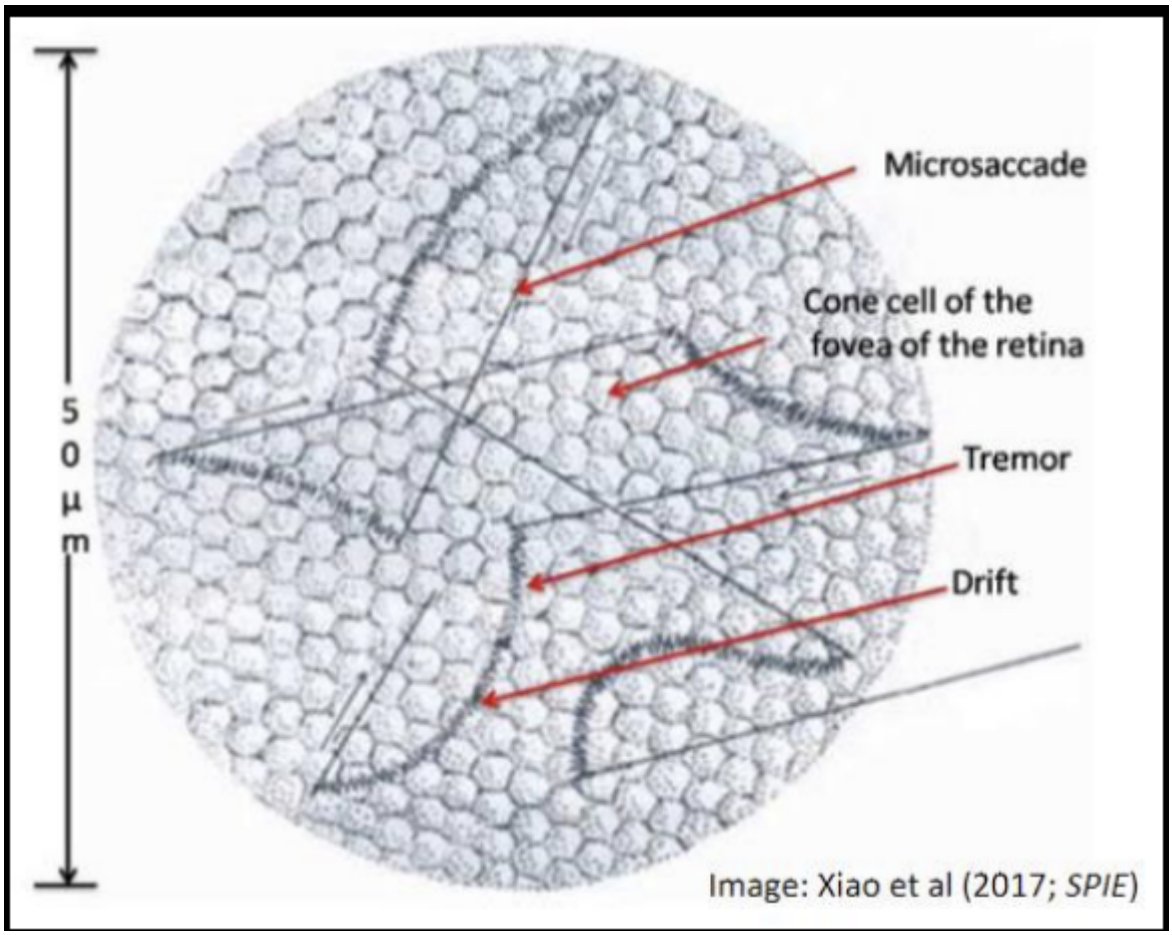
When and why to eyetrack

- Descriptive research: we're interested in what, why, where
- Explanatory research: oculomotor data may provide a window onto various cognitive processed

Terminology

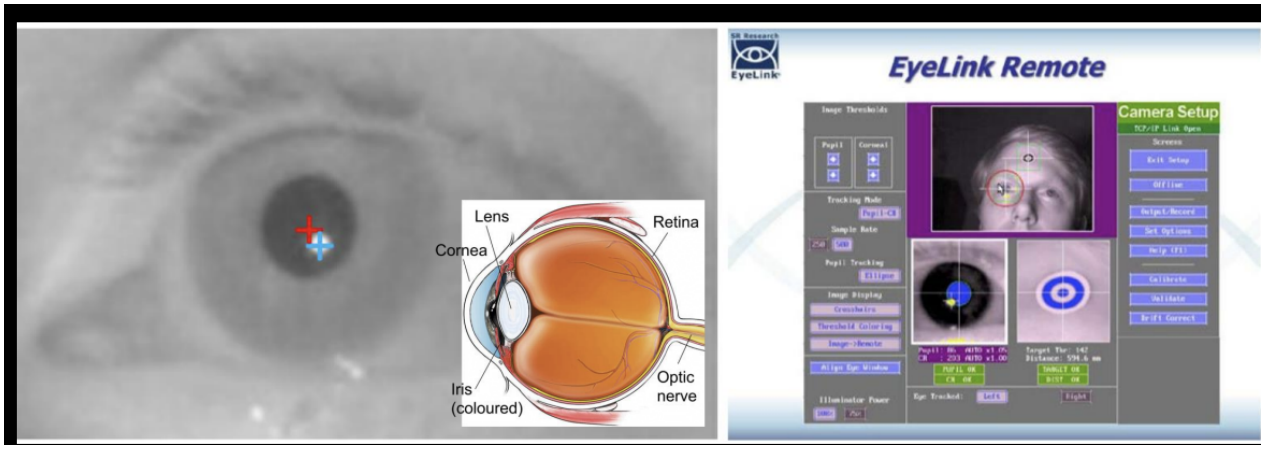
- Saccade
- Saccadic amplitude
- Saccadic latency
- Fixation
- Fixation duration
- Microsaccade



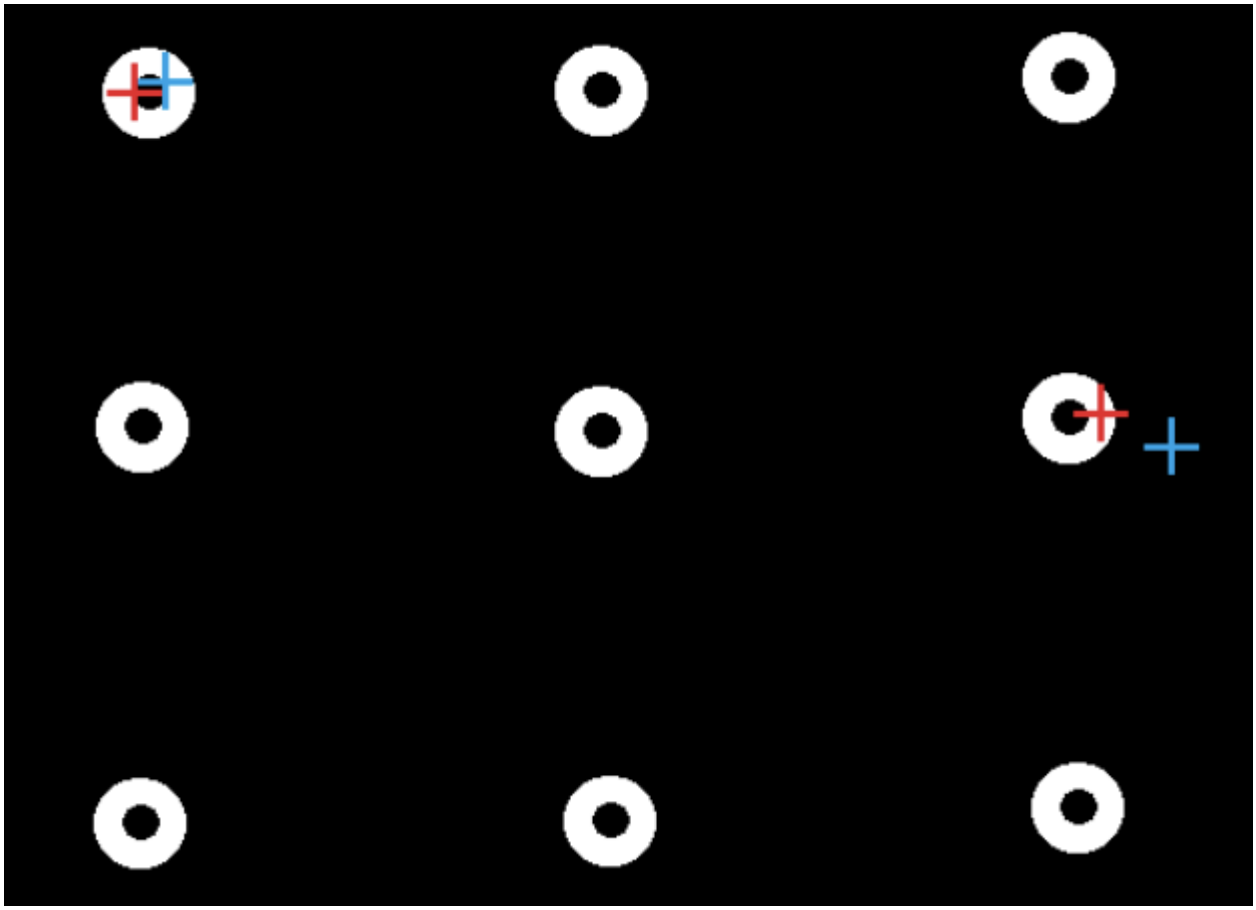


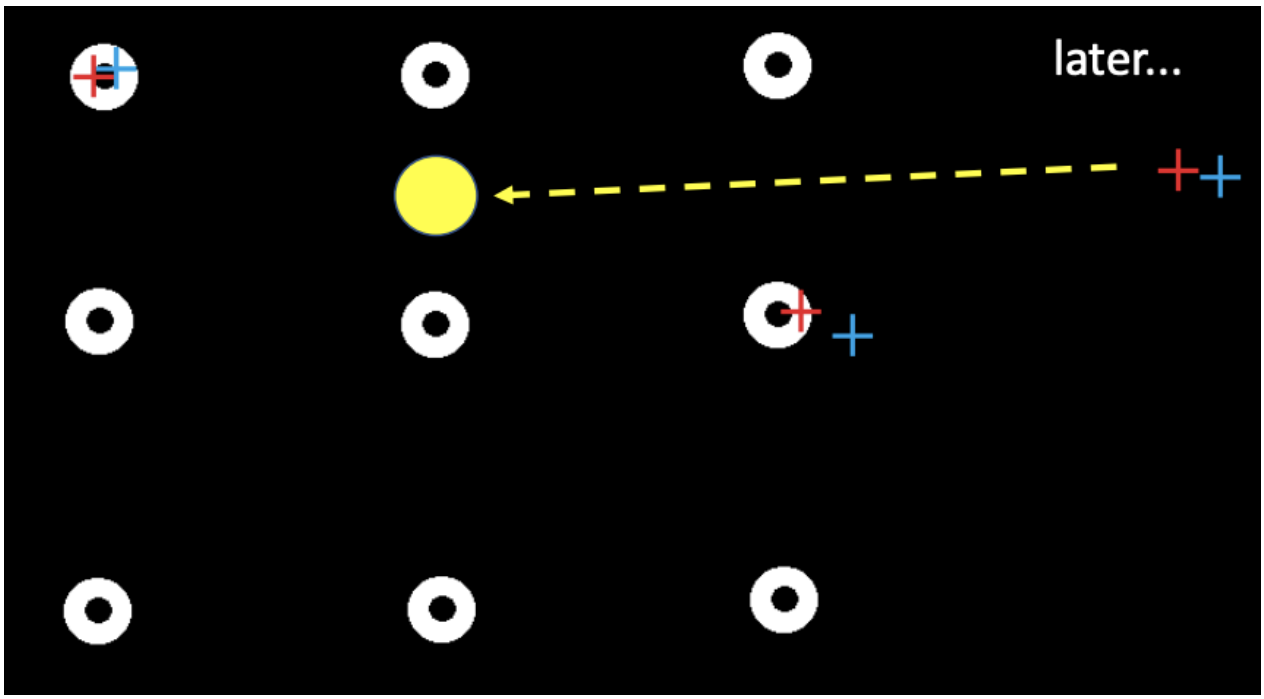
eye position: 2 signals

- **pupil location**: corneal reflection of infrared light sent from camera



eye position: calibrate

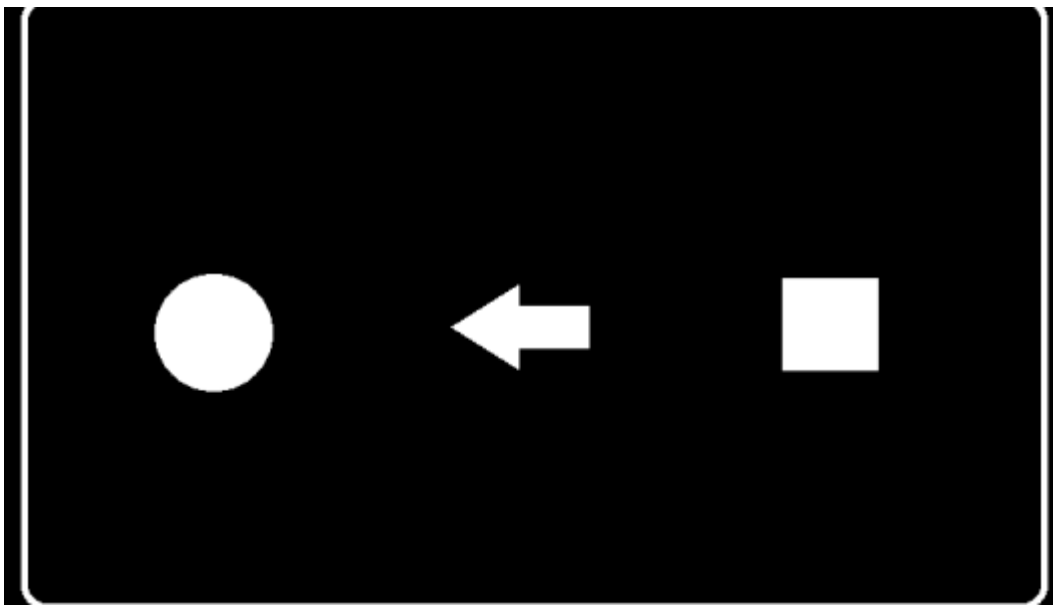




- what is gaze-contigent?
  - gaze-contingent refers to a design or experimental setup in which the presentation of visual stimuli or the behavior of the experiment is contingent upon the participant's gaze or eye movements

Posner cueing taks

- Attention is biased by top-down cues
  - it takes longer for you to note the square on the right when the arrow points to the left
  - task: indicate location of square (left/right)
- **Potential confound: Simon effect (Maybe arrow biased response rather than attention)**



- 2
  - Task: Move eyes to the square
  - Potential confound averted

Exam question

Why does the pupil shrink in bright light and when thinking about brihgt light?

This is because of the pupillary light reflex. This is a protective mechanism that helps regulate the amount of light entering the eye and ensures that the retina exposed to an appropriate level of illumination.

- In response to bright light
  - the photoreceptor cells in the retina send signals to the brain via the optic nerve, indicating that there is too much light entering the eye.
  - In response to this signal, the brain activates the pupillary light reflex. The parasympathetic nervous system, specifically the oculomotor nerve, sends signals to the muscles in the iris to constrict the pupil.
  - The contraction of the circular muscles (sphincter pupillae) in the iris reduces the size of the pupil, limiting the amount of light that enters the eye. This helps protect the retina from damage caused by excessive brightness
- When thinking about bright light
  - This is because the brain can anticipate the need to adjust the pupil size based on the environment or an upcoming change in light conditions
  - When you think about a bright light source, the brain can initiate the same neural pathways responsible for the pupillary light reflex, even if you are not directly exposed to the light.
  - This anticipatory response helps prepare the eye for the expected increase in light, so the pupil constricts in advance, reducing the amount of light that would enter the eye when you are actually exposed to the bright light.
- In both cases:
  - the primary purpose of the pupillary light reflex is to protect the delicate photoreceptor cells in the retina from potential damage caused by excessive light
  - The iris's ability to rapidly adjust the size of the pupil is a crucial part of the eye's overall adaptation to varying lighting conditions, ensuring that visual perception remains clear and comfortable in different environments.

Thu Sep 28th - LMMs

Logic of LMMs

- Fixed effects
    - **Experimental variable **(conditions)
    - those things about which we have hypotheses: (a specific direction of effect)
    - **Covariates** for which we expect a particular pattern
- Random effects
    - **Subjects items** (stimuli)
    - Those things that we expect may be variable, but for which we do n
    - ot expect a particular pattern
    - Both in terms of *intercept* and *slope*, i.e. overall performance and effect strength
- 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**

Mon Oct 2nd - Multi-dimensional cognition: Reading

- Balls of clay
  - 8000 BC: accountancy system
  - 3000 BC: logography & alphabet

> It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity…

Orthographic processing

Why is reading interesting?

- Reading relies on many realms of cognition:
  - Vision
  - Attention
  - Memory
  - Language processing
  - Oculomotor control

How do these functions come together?
How do these functions operate in applied contexts?

- Reading is one of the earliest topics in cognitive psychology
  - "…to completely analyze what we do when we read, would almost be the acme of a psychologit's achievements, for it would be to describe very many of the most intricate workings of the human mind"
  - 1886, Cattel
  - 1908, Huey

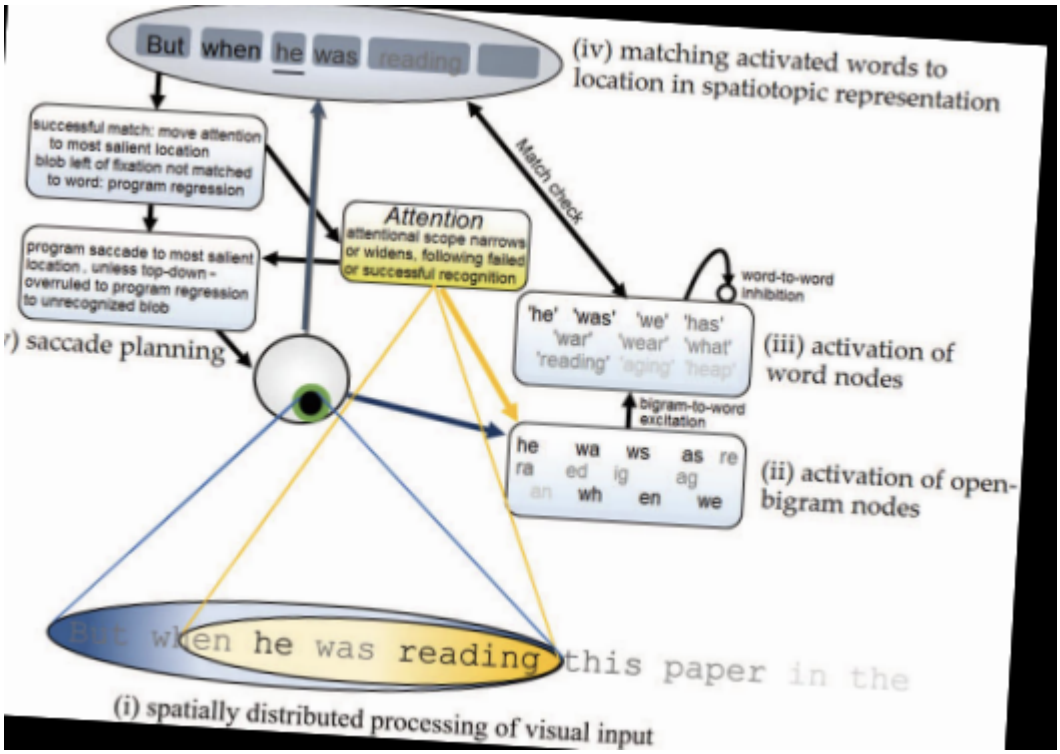
What is language?

- 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
- Language is a **hierarchical system**
- Comprises **builiding 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**

Building Blocks

visual features > letters > words > sentences > context

- Does the brain have distinct processing stages for these various building blocks? Cognitive models: yes

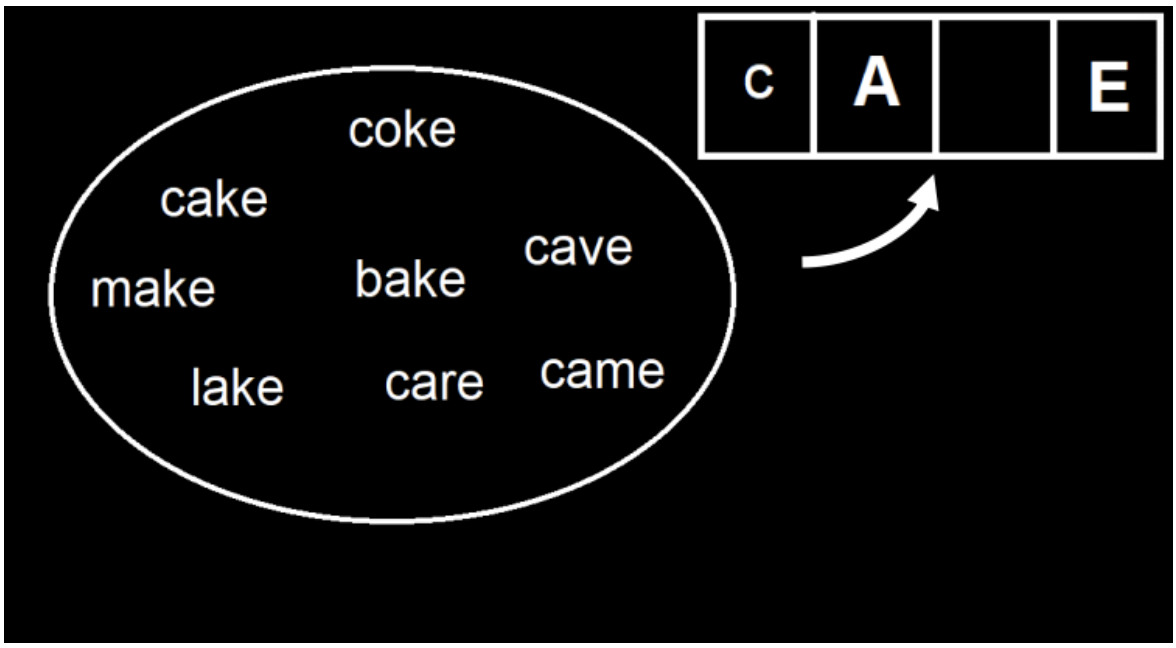


- From the perception lecture, we remember:
  - various levels of processing
  - interactions among levels
  - Top down vs. bottom up
  - Word superiority effect
  - Orthographic processing is **the interface between letters and words**

Back in 1886…

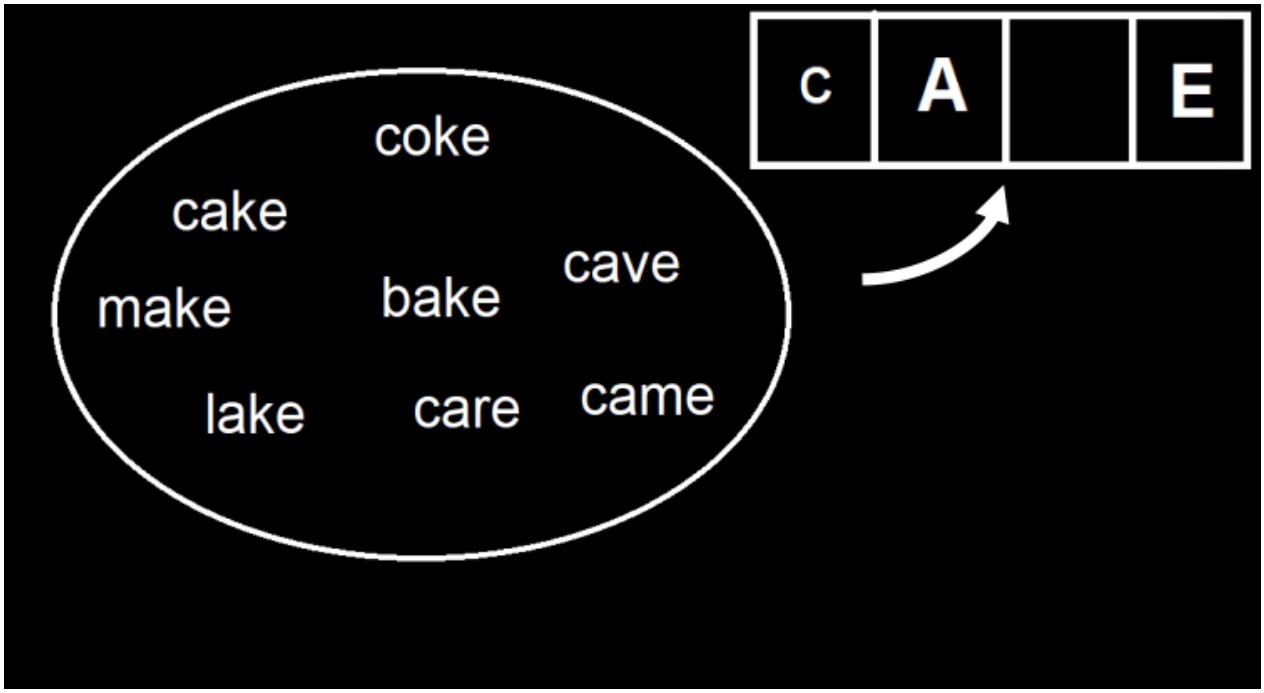
- Letters in words are recognized faster than letters in nonwords
  - Called word superiority effect
  - By James McKeen Cattell

- in PLUMP we recognized PLUM faster than whatever is in PMULP



A century forward

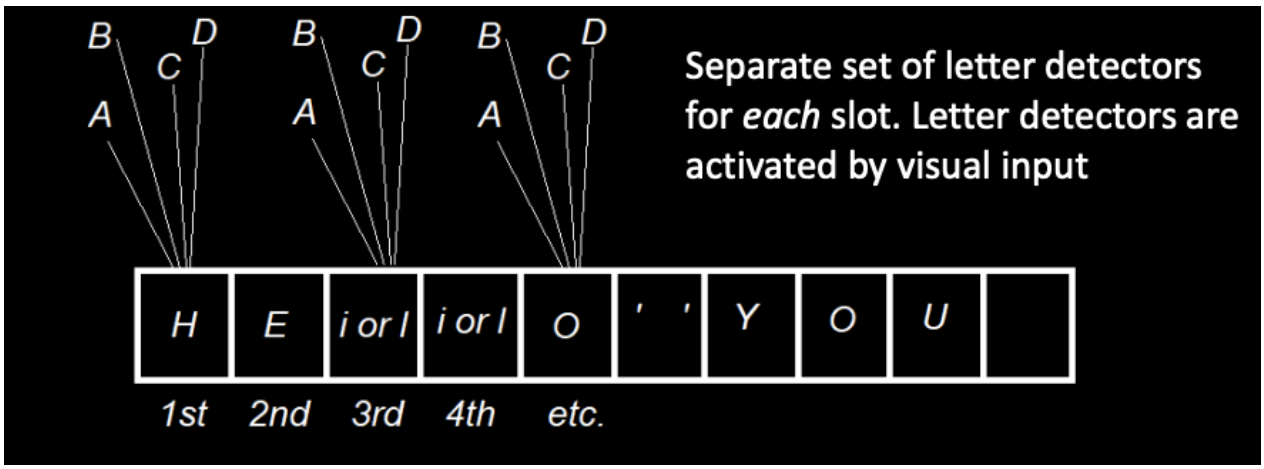
Words with large 'orthographic neighbourhoods' are recognized faster



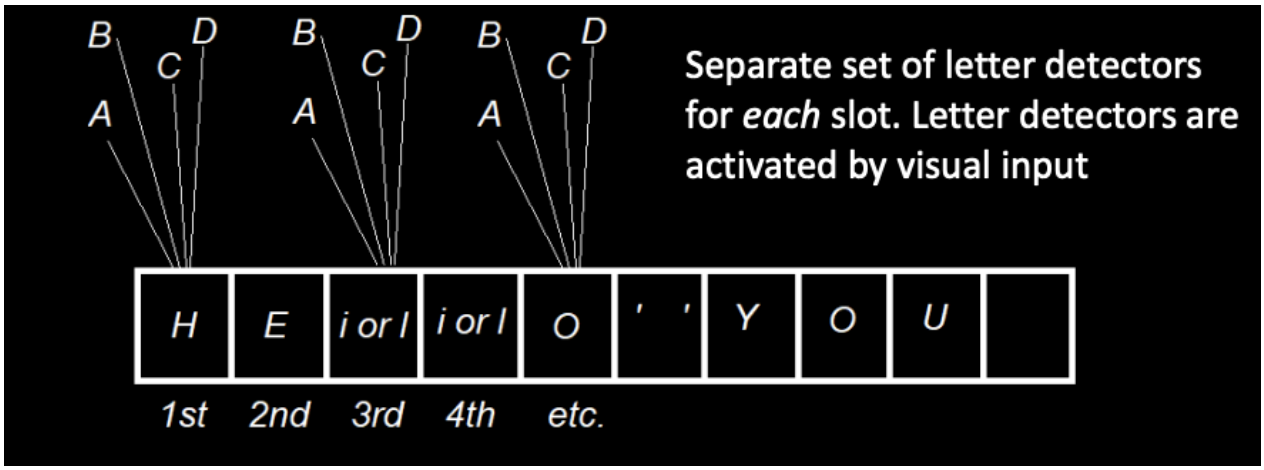
- a lot of feedback activation

How do we start processing a word?

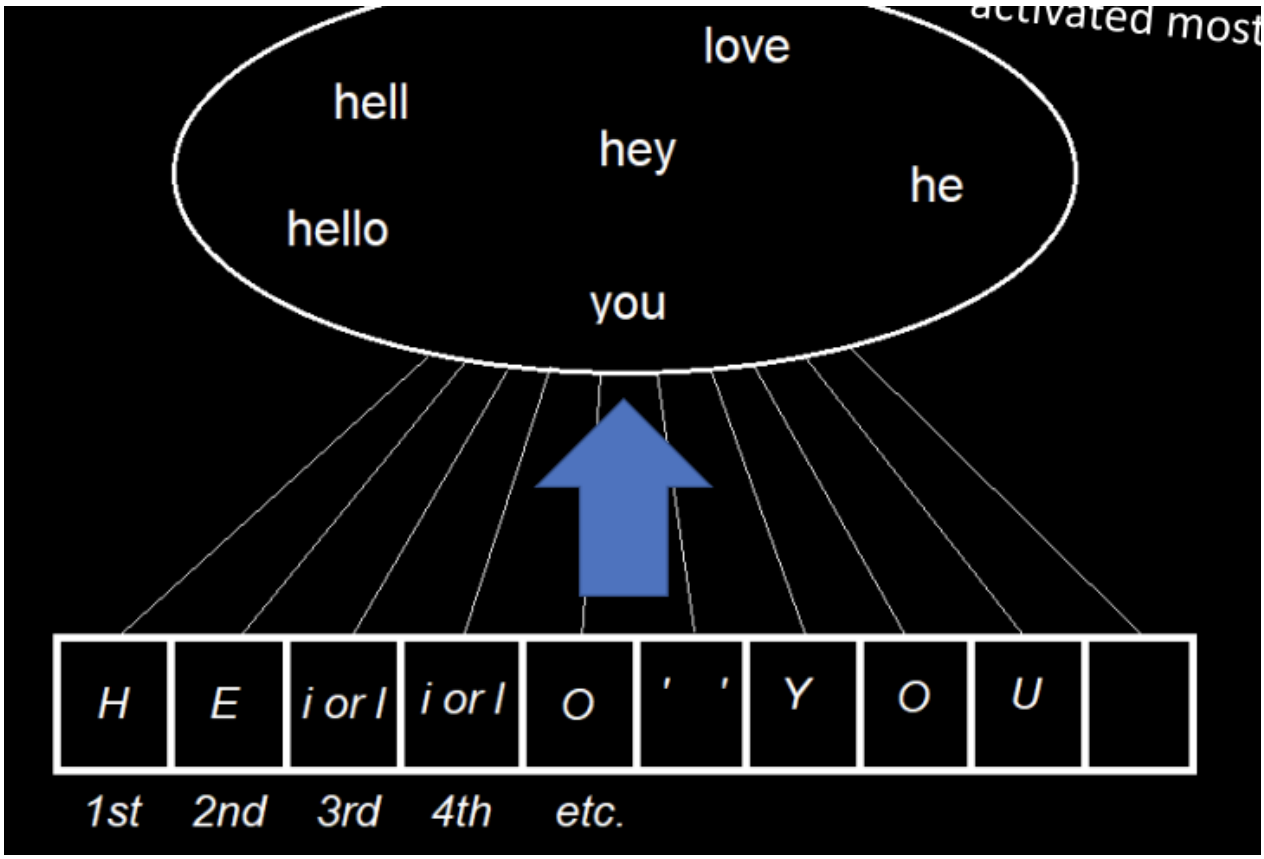
- Orthographic proceesing - *Recognizing letters and their positions*
- 1970s: somewhere in the brain, we have an array of 'slots'
  - Separate set of letter detectors for each slot. Letter detectors are activated by visual input



- There is a **populaiton receptive fields**



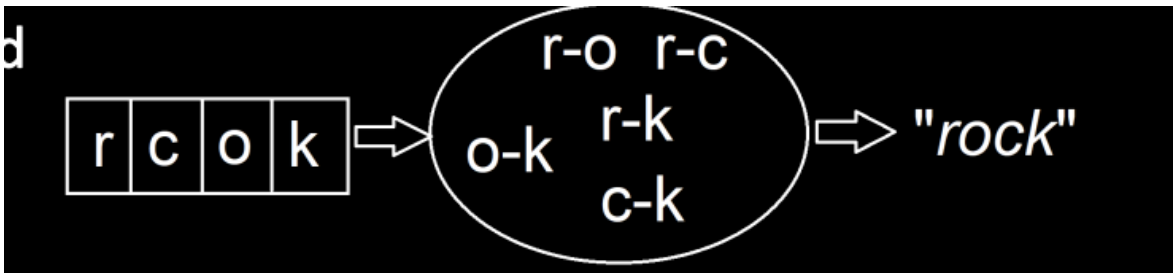
- Word detectors are activated depending on which letter is activated most at each position.

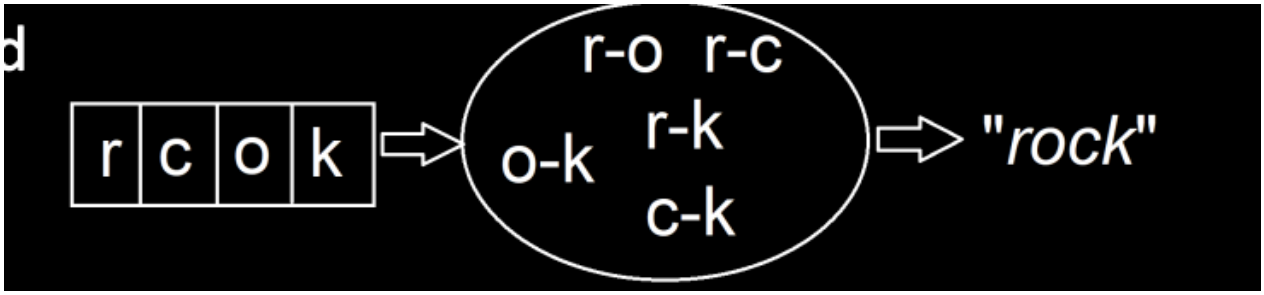


- Activated word nodes constrain letter detectors
  - This back & forth process repeats until word detector reaches a recognition threshold
  - However, letters are flexibly encoded in their positions

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.

- Potential solutions:
  - Positional noise: Letters activate not only their slot but also surrouding slots
  - 
  - Bigram representations: An intermediate layer between letters & words, where (locaiton-invariant) letter combinations are activated

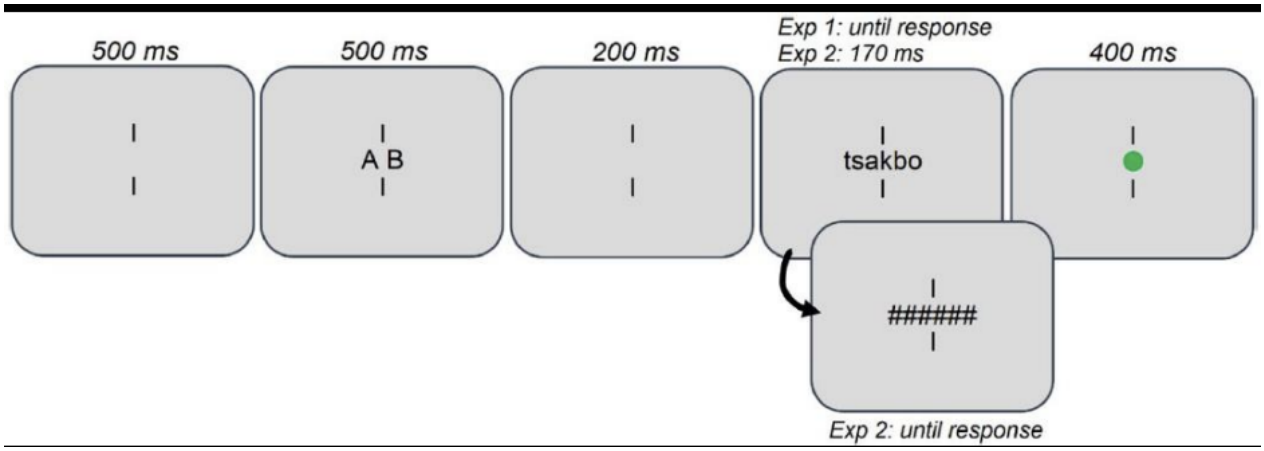




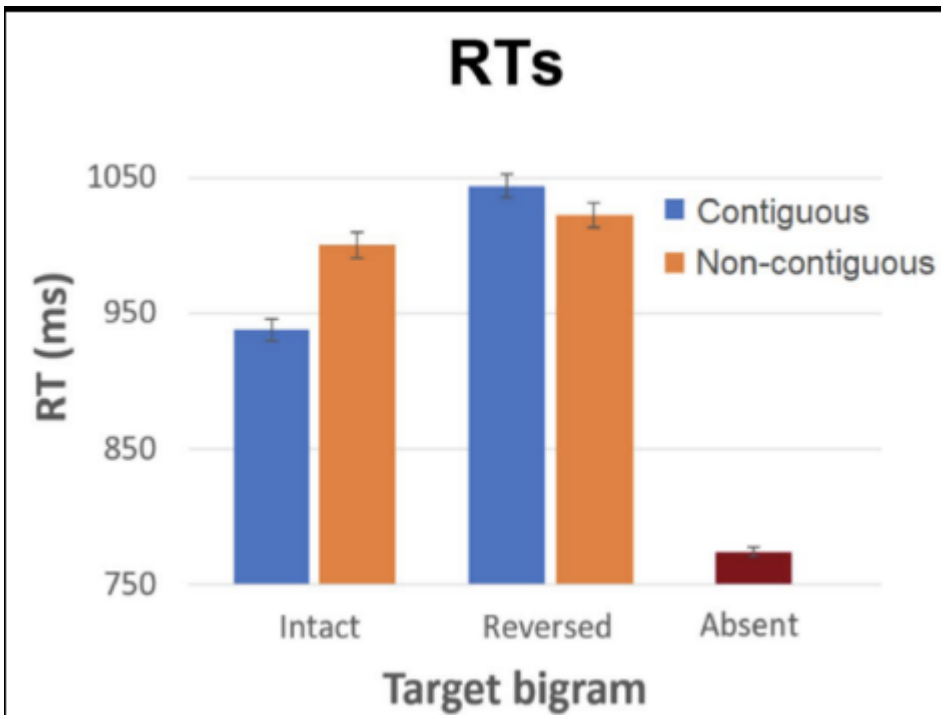
- Based on some recent research: How does the distance between 2 letters affect recognition of the bigram
  - Relative letter-position coding revisited: Snell et al.
  - if we look at bigrams CD and CF

abcdefgh abcdefgh

```
we see CD a lot easier
```



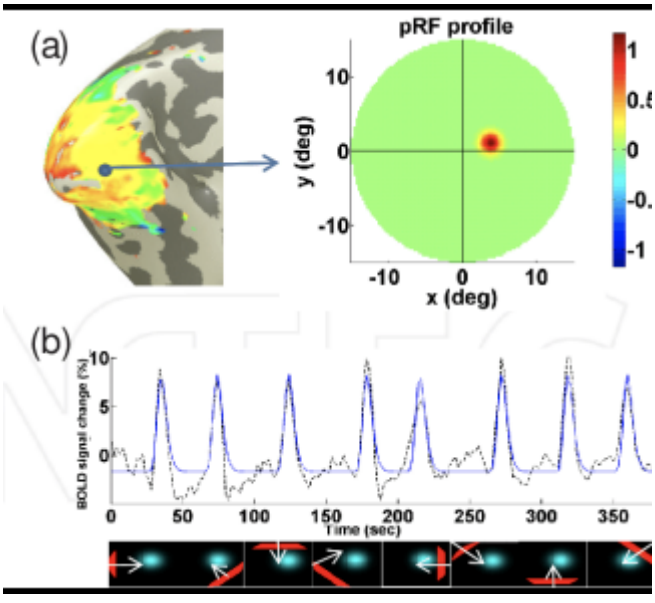
- Seeing CD & CF works fine
  - DC & FC not fine
  - erroneous recognition of DC



- Based on recent research, population receptive fields aren't small enough to know single letter locaitons

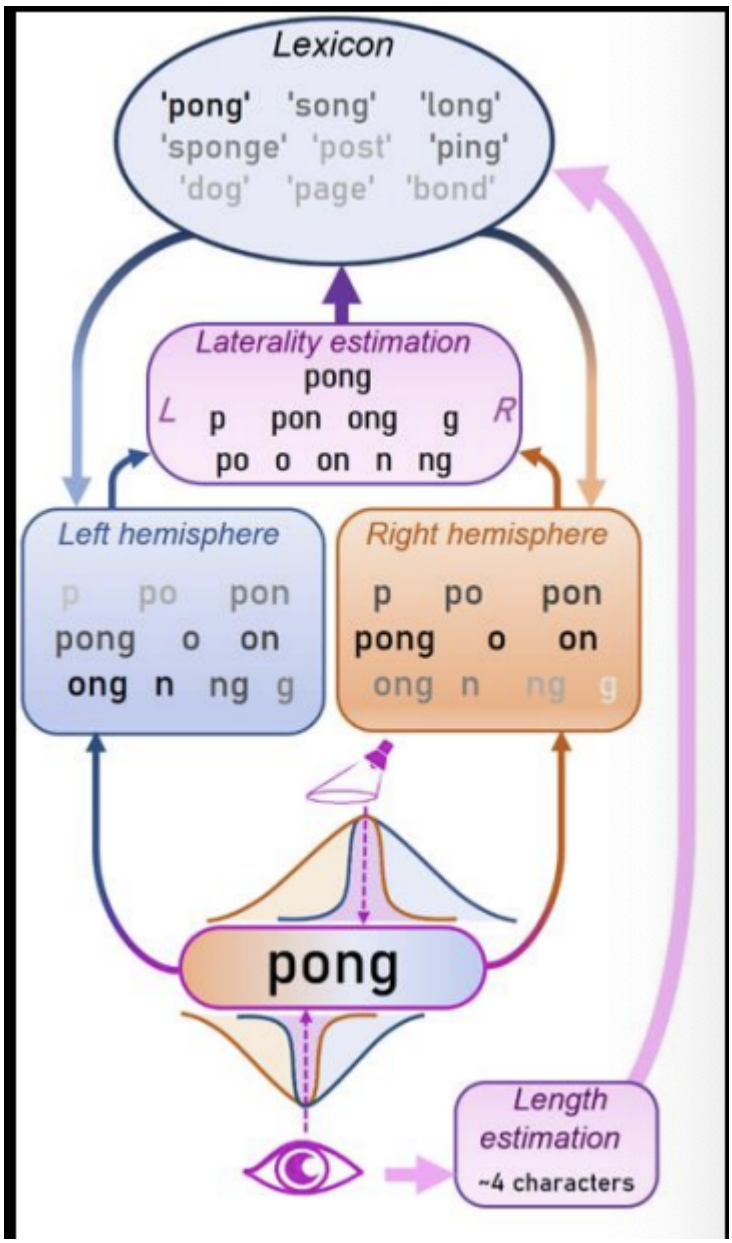
Letters are *flexibly* encoded for their positions

- Potential solutions:
  - Positional noise
  - Bigram representations
    - *Recent research How does the distance between two letters affect recognition of the bigram?*
      - Assumption is that the closer the letters are, the easier is to recognize the bigram



> Systematic variation of population receptive filed properties across cortical depth in human visual cortex: Frocosso et al.

- A new theory of orthographic processing… PONG (the Positional Ordering of N-grams)
  - 2 assumptions:
    - The brain is a sequence learner (t, th, the, ther, there)
    - It estimated the laterality of N-grams through bi-hemispheric activation differences



Instruction for report

4 secitons: Intro, methods, results, discussion + abstract (200 word summary)

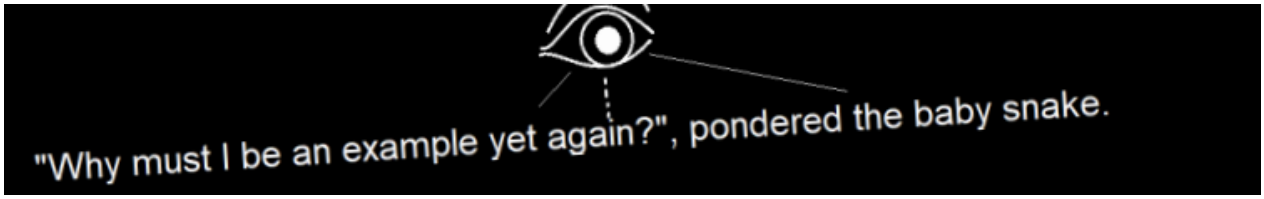
Intro :RQ, background literature, hypotheses (motivate these) 2 pag
Methods: Participants, expt design, apparatus, procedure 1 pag
Results: description of data cleaning procedures, analyses 1 pag
Discussion: Recap, answer to quesiton, critical evaluation 2 pag
take the reader by the hand?
betwenn 1500-3000 words

presentations - 5 mins per group blitz talks
not for a grade
but will be taken into account if there are incosistencies (prolly deduct points on report)

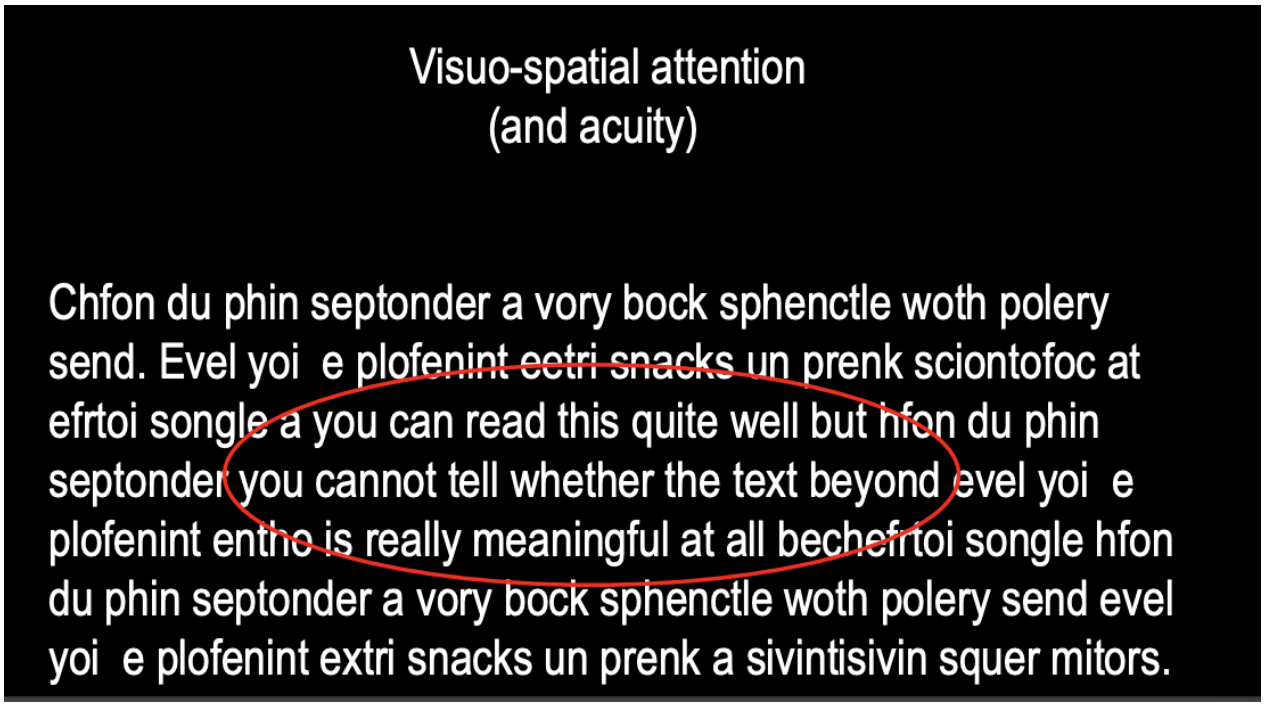
Attention in reading

When do we start processing a word?

- The key to a smooth read is to start processing a word already before looking at it



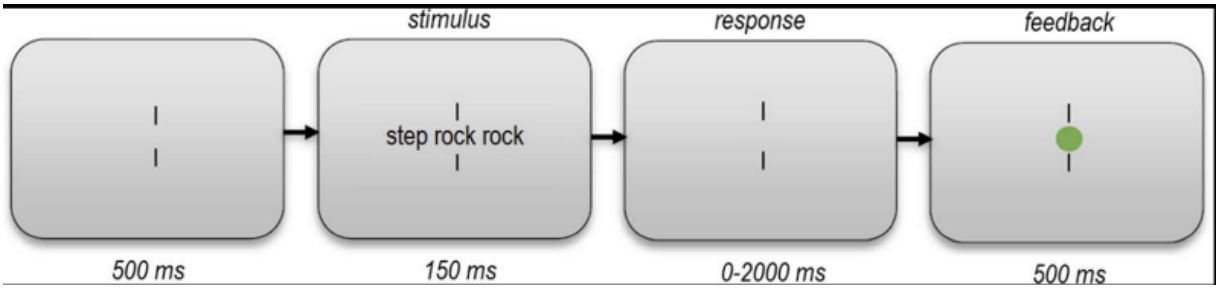
- Limits imposed by visual acuity: you'll get some letters and visual attention



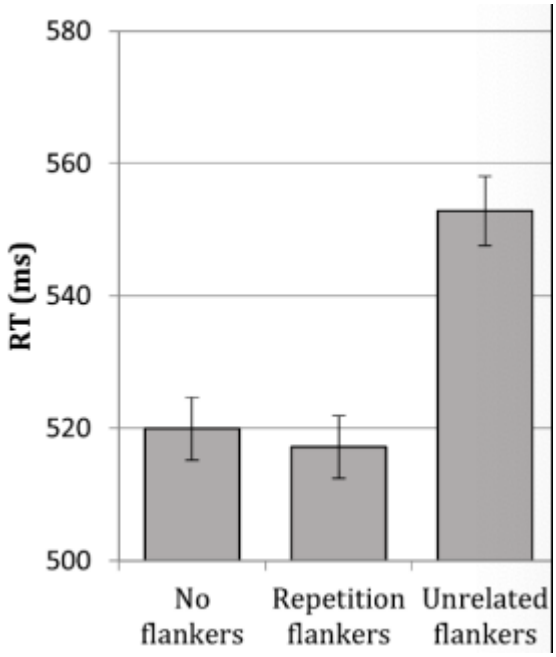
- Our visuo-spatial attention is not confined to the word at which we look directly.
- Convert attention moves ahead of the eyes to the next word.
    - or maybe attention was directed at multiple words from the get-go.
- A longstanding debate about attention in reading
    - *Rayner & Co.*: "Only one word is attended at a time"
    - *Joshua & others* maybe not

Serial processing of words:

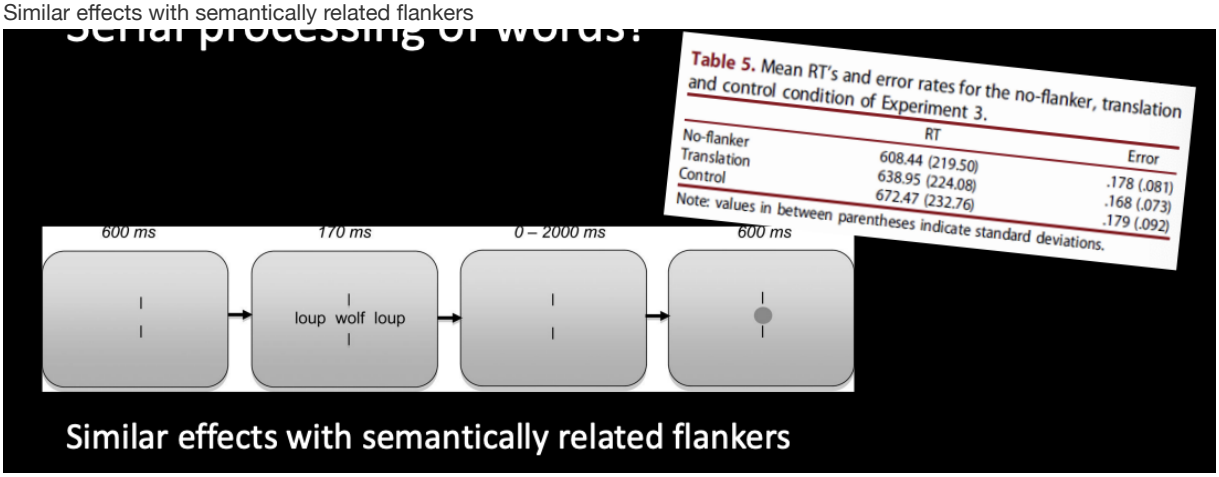
- Flankers lexical decision task:



- Rayner: Word recognition takes +- 200ms
    - It means that there should be no time to process flankers
    - We cannot prevent ourselves from processing the flankers! Only (sub-lexical) orthographic processing?

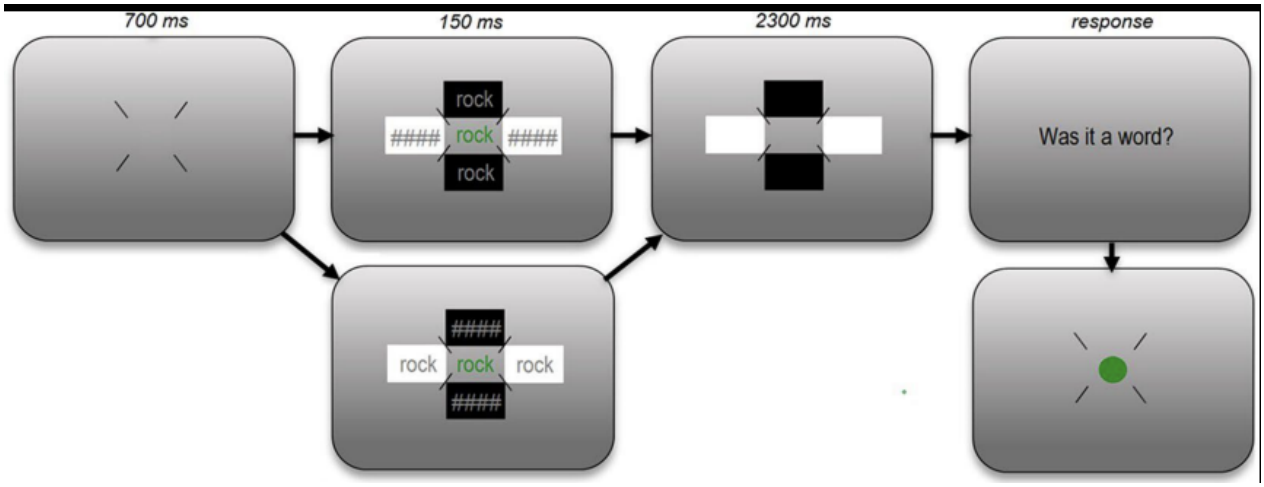


- Similar effects with semantically related flankers

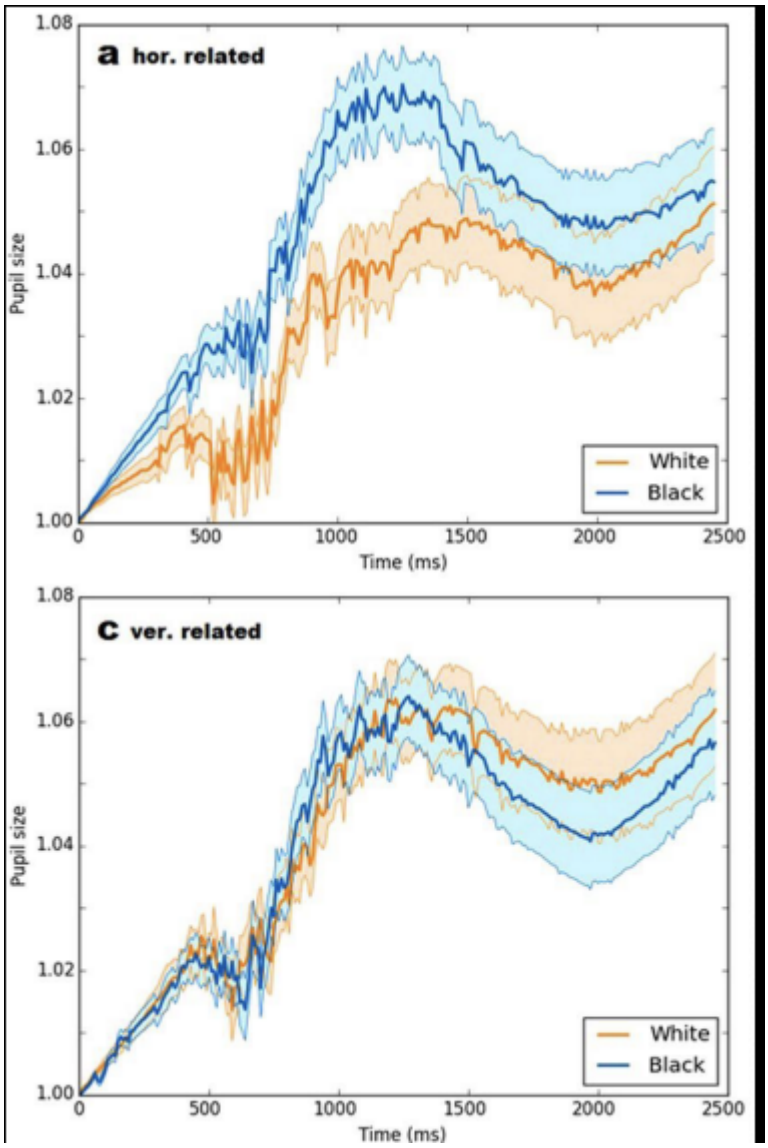


How to track covert attention (during reading)?

- Vary the brightness of flanker locations



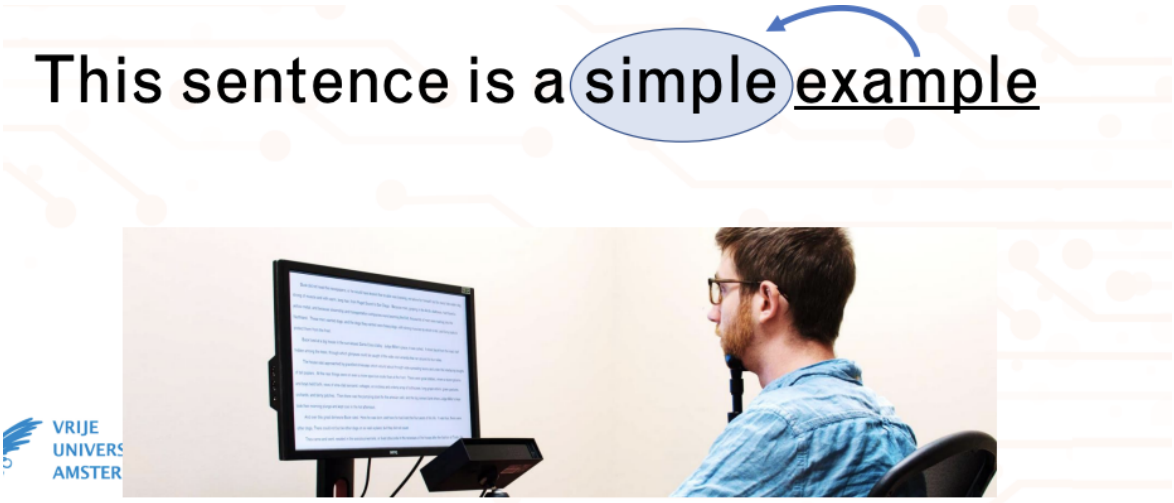
- Target recognition speed influenced by words on the left and right but not above and below…
- And pupil responds to brightness of words elft & right, but not above & below the target



- The flanker paradigm is an artificial task.
- Maybe attention is distributed differently during normal text reading?

- Various papers state that eye movements are unaffected by higher-order properties of upcoming words -> brain activity

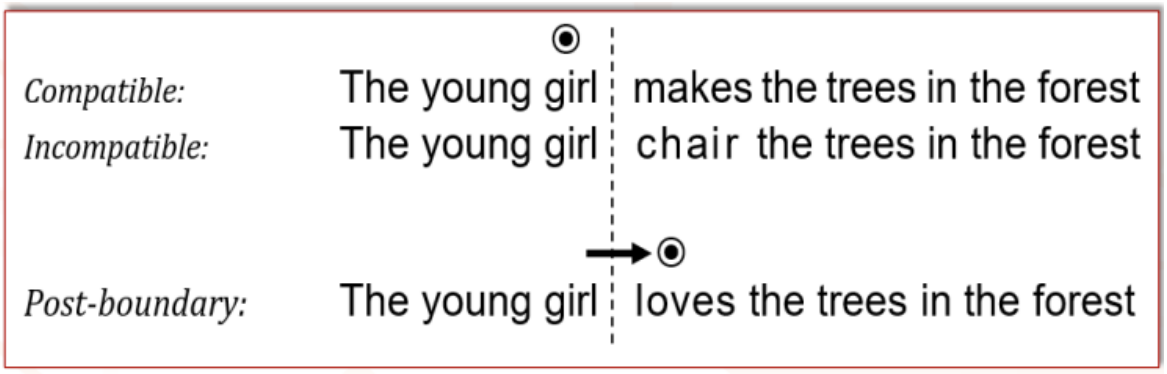
- Do readers process multiple words at once?
  - Empirial strategy: The sentence is a simple example



  - Typical outcomes
  - Word 1 influenced by letter overlap with Word 2
  - Word 1 **not** influenced by frequency or semantics of Word 2

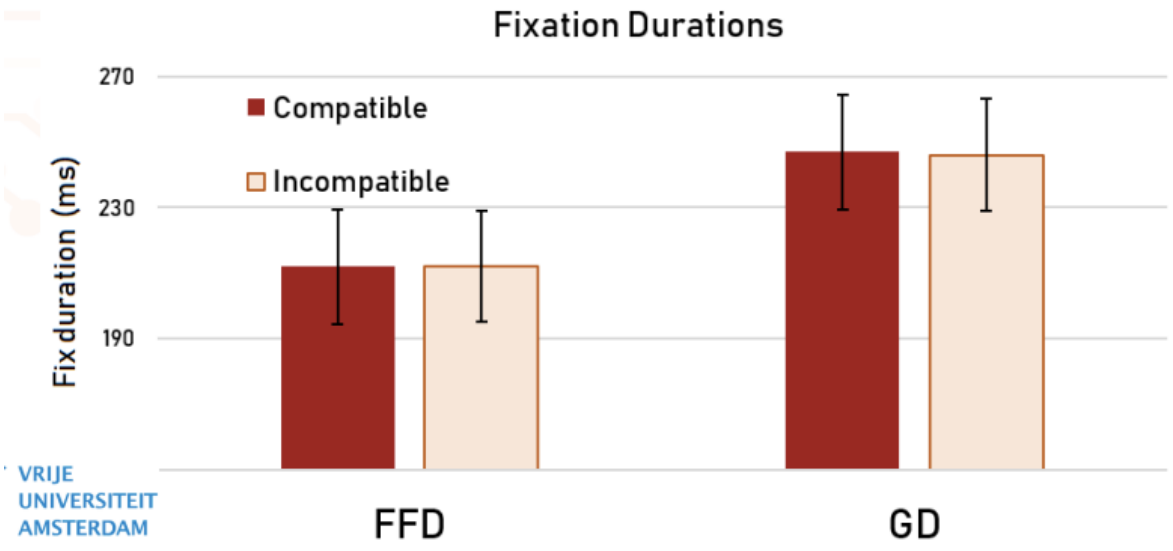
- EEG: Fixation-related potentials
  - Time-lock the electrophysiological window of interest to the start of a fixation on a target word
  - Prediction:
  - Syntactic processing of the target word should be hampered by a syntactically incompatible adjacent word
  - The dog jumped away
  - The dog yellow away

- Methods:

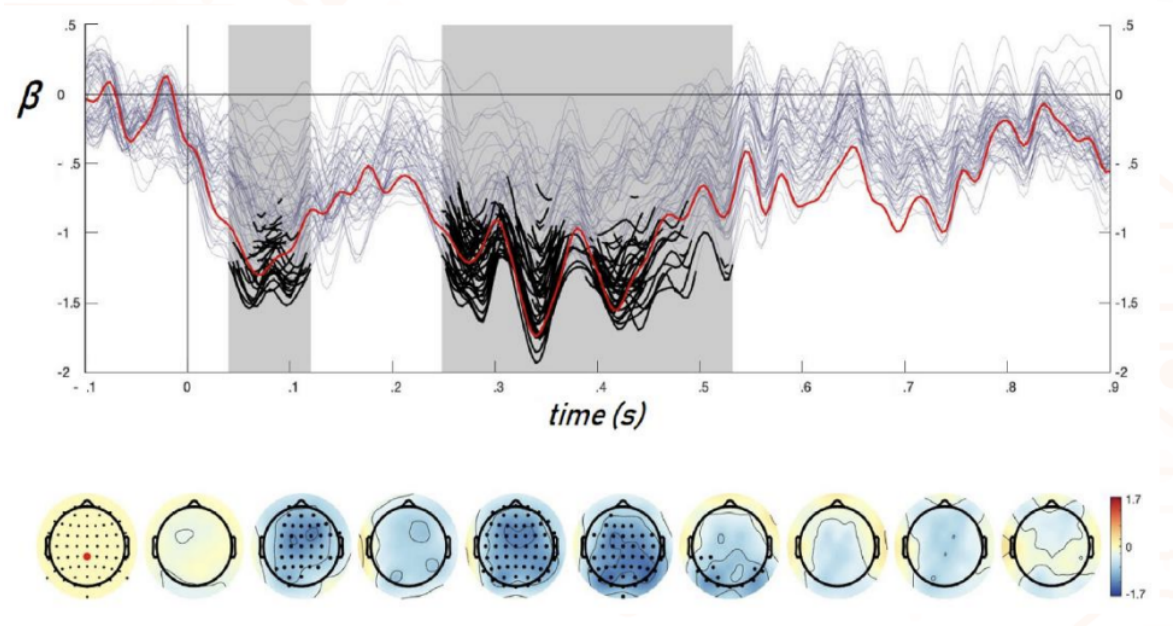


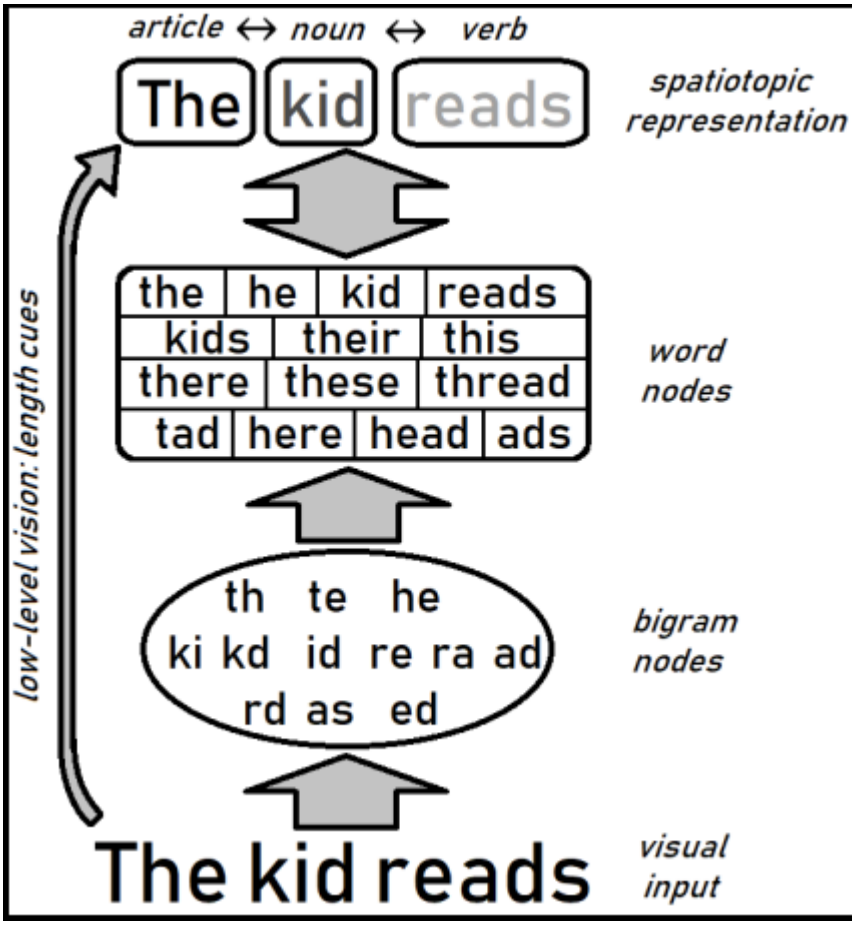
  - Any effect of the syntactic manipulation of word n+1 must have been triggered during the fixation on word n.

- Results: oculomotor data:
  - No effects



- Results: EEG data:

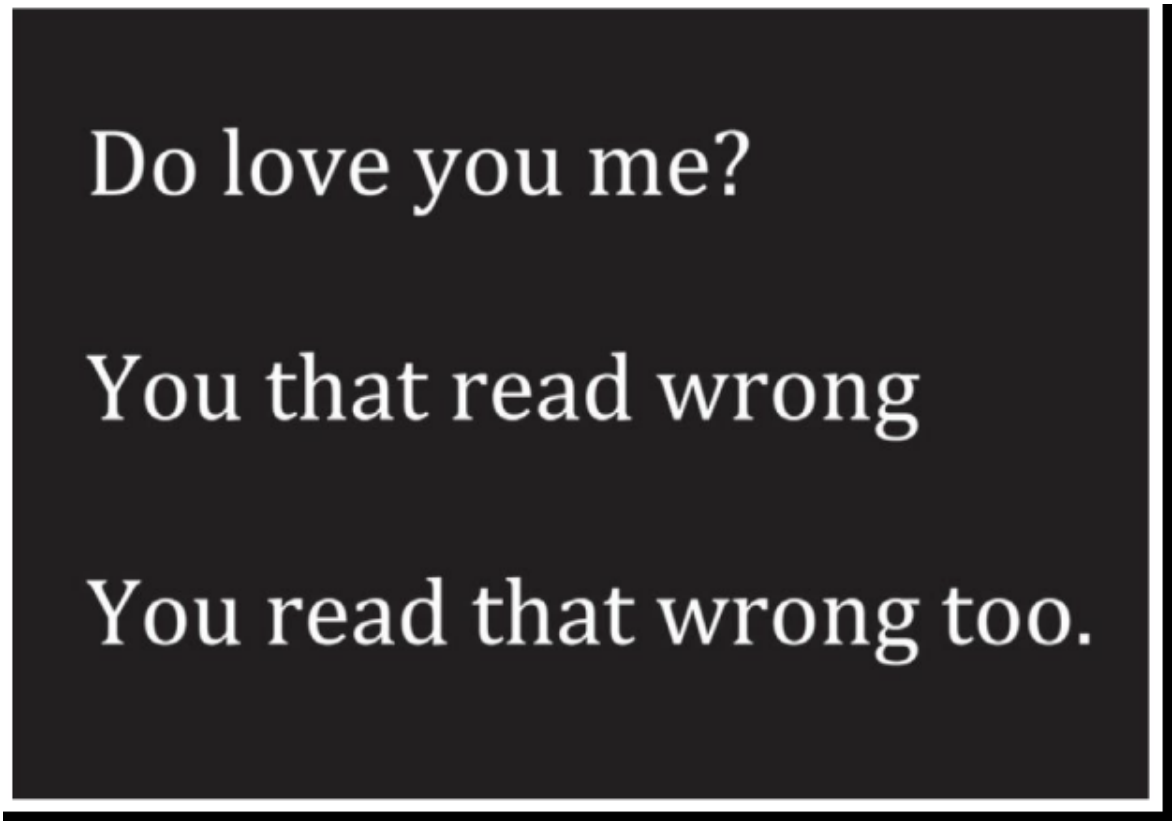


- Readers process multiple words in parallel:
  - OB1-reader
    

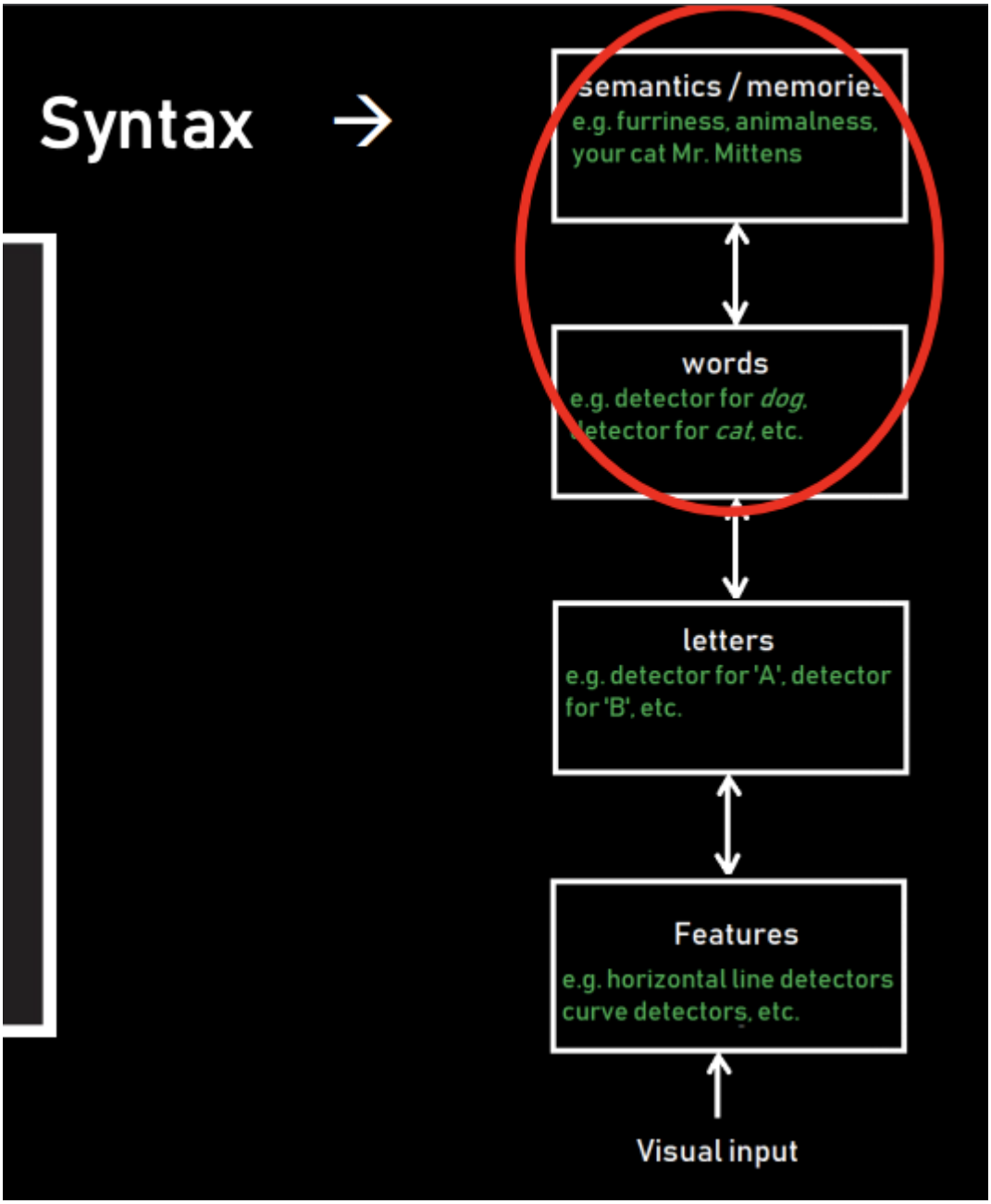
    -

Sentence processing

- Syntax



- Additional evidence that we're rpocessing multiple words in parallel
- Bidirectional influences between words & sematncis/memories



- Word superiority & sentence superiority
  - 'man' is recognized faster in the man can run than in run man the can
  - We tentatively recognize sentence structures and these constrain the ongoing recognition of words
- But are we completely lfexible?
  - baby dog eats meat vs baby eats dog meat
  - Our expectations constrain the mapping of words onto locations
- Unsolved questions…
  - How does word position coding work?
  - When does it happen?
  - What factors influence it? (refering to the previous 2 word shuffles)

Recap

- our attention is directed to mulitple words; not just to the word that we look at
- Letters and words are flexibly associated with locations
- Letters, words and sentences are separate things in the brian
- There is cross-talk between regions coding for letters, words and sentence structures.

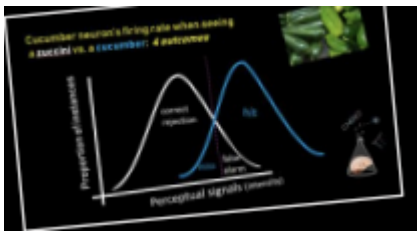
Thu Oct 5th - Interfaces

- All man made environments are interfaces
- Design determiens how well its users can achieve their goals and tasks
- Environments are interfaces because they provide *information* that guide user decisions
- Examples:
  - OS, Supermarkets, airports, universities
- Book chapters 7 & 14 outdated
  - e.g. Norman (1986) 'gulf of execution & gulf of evaluation'

Several useful design principles

- Good design considers:
  - Perception
  - Expectation
  - Attention
  - Memory

Perception

1. Reduce signal-to-noise ratio (SDT!) constrast, size, illumination, etc.
   i. 
2. Don't refer to more than 5 things with a singel sensory dimenion
   i. 
3. Take top-down processing into account
4. Redundancy gain: convey information in multiple wats
5. Make things discriminable

Expectation

1. Realism: display elements should correspond to the real world
    i. 

2. Realism - moving edition

i. 

Attention

1. Minimize access cost (i.e. navigating from one important location to another shouldn't take effort)
2. Proximity compatibility
3. Divide processing load among the senses

Examples: Touch screen car, shop pay screen

Memory

1. Balance memory and perception: we do not have to memorize what we can see, and vice versa
2. Aid predictions (same as last principle)
3. Safeguard consistency
4. 

- Similar principles in CH. 14 Table
- Not all environments are designed ofr our beneift

i. What would the ideal, perfectly navigable supermarket look like?
ii. Can touch screen dashboard be succesful and safe?
iii. Can the vu entrance be improved?
iv. Is Spotify a good interface? Can it be improved?
v. How good or bad is OpenSesame interface?
vi. Which travel broker is better Booking.com or Trivago?