Midterm 2 Review

PSYC 365

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The exam

- 35 MCQs
  - Readings
  - Lectures
  - See practice questions
  - MCQs on the Egner paper
- 1 SAQ
  - Rosenberg paper

Answering short answer questions

Things to keep in mind:

- Be concise! Point form, not paragraphs
- Focus on the **key details** so that you can have enough time to answer each question
- When studying: It can help to write long form at first, then trim down and focus on key points
- The papers are dense, and condensing them down into shorter form is a key skill not only for this class, but for reading and engaging with any scientific papers in the future

Answering short answer questions

Ask yourself:

- What was covered in the lecture about the paper?
- What was focused on in the Tips document?
- For more open-ended questions:
  - What extra context was focused on in the lecture when discussing the paper?
  - How was the paper linked to other themes in the class?
  - What were some critiques of the paper discussed in class?

What to review

- Egner (Class 12) & Rosenberg (Class 14-15) papers: Use tips, lectures, papers
  - *Rosenberg:* You are not responsible for material in Methods of paper that are NOT in the lectures, but there are methods covered in the lectures that will appear on the exam
- Attention:
  - Passingham: Chapter 3
    - See practice questions
  - Lecture materials: Class 13
- Motivation, emotion, and attention
  - Lecture materials: Class 15
- Older material
  - See practice questions for examples
  - Review lecture slides

Predicting and attending

Photo by Jen Theodore on Unsplash

Models of object perception have focused on bottom-up, feed-forward processes, which assume we are passive receivers of information. But there is lots of evidence that we are not passive – that we actively predict and attend and that this determines what we actually see.

Learning Objectives: Predictive Coding

- Describe predictive coding models of perception
- Evaluate fMRI evidence from Egner et al. for predictive coding vs. bottom-up feature detection models
- Discuss what predictive coding views mean for our understanding of how our brains work and the grasp we can have on reality

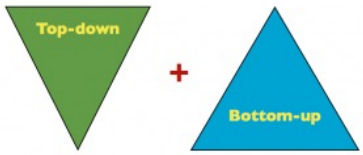
Predictive Coding (PC) Models: The Brain's Job is to Minimize Prediction Error!

Forward Model

- Your representation or model of the world
- Generates predictions
- Tries to "explain away" sensory signal

Error Signal

- Error signal sent upward based on match between model and sensory information
- ONLY prediction error gets passed forward – not actual signal



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- Representational units encode the expectation of a given stimulus.
- Error units encode the mismatch between predictions and the bottom-up evidence.
- The goal is to minimize prediction errors.

Egner et al. – a brief review

Big Picture Question

- Does predictive coding explain visual object recognition better than classic hierarchical feature-based models?
  - Examine by taking advantage of what we know about category selective populations of neurons in fusiform face area (FFA) and parahippocampal place area (PPA)

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FFA activates more to faces than houses, and PPA activates more to houses than faces.

Research Questions & Predictions

Research Question: Does BOLD activity in the FFA reflect responses to expectation + surprise? Or just face features?

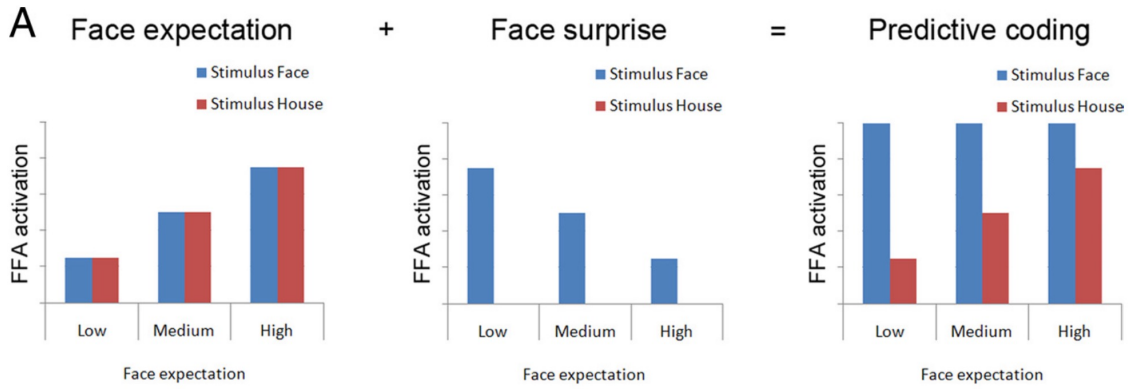
- General Hypothesis: FFA activity will be an "additive function" of expectation and surprise.
- Alternative hypothesis: There will always be more FFA activation to faces
  - Expectation and surprise will not matter!

You should know

- Who were the participants?
- What were the independent and dependent variables?

See paper and your lecture notes for Class 13

Predictive Coding Model



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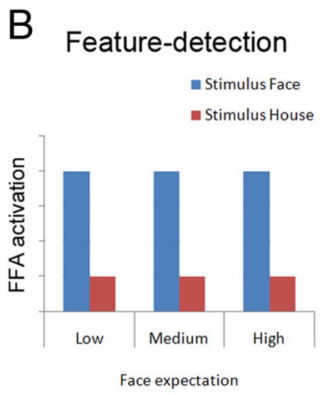
According to the predictive coding model:

1. The higher the face expectation, the higher the FFA activation despite whether the participants are seeing faces or houses. This reflects the activity of representational units.
2. The more you are expecting to see a face, the less surprise or error signal you get when you see a face. This reflects the activity of bottom-up error units. There is no activation for houses because the FFA activity is thought to only reflect expectation for faces.

The researchers predicted that there would be *equal* amounts of *total* FFA activation at each level of expectation (face expectation + face surprise) in the presence of face stimulus.

Feature Detection



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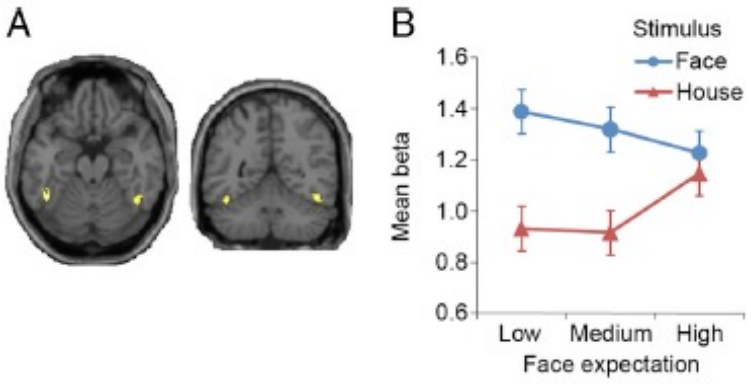
According to the feature detection model:

1. The FFA activation in response to features of the faces is larger than the FFA activation in response to houses, despite the participants' expectation or surprise.

Egner et al. Results



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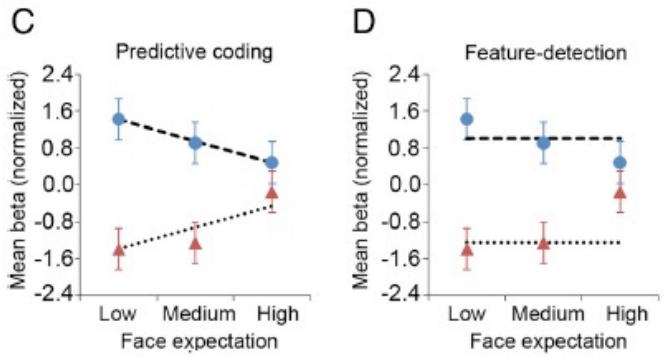
- In the low and medium expectation conditions, the FFA activation for face stimuli relative to house stimuli.
- However, in the high expectation condition, FFA activation was statistically indistinguishable for faces and houses.

Egner et al. Results



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The computational models were designed **to quantify and compare the ability of predictive coding and feature detection models**.

- In the predictive coding model, the lines and circles/triangles fit pretty well, but not in the feature detection model.
- Therefore, the data supports predictive coding models.
- Note: the researchers predicted that the predictive coding model would assume that expectation and surprise would contribute equally to FFA activation. However, **the**

predictive coding models that fit the data best assumed that there was a 1:2 ratio, where surprise contributed twice as much as expectation.

Egner et al. Conclusions

- Prediction coding models describe the process of visual inference better than feature detection models
- Encoding prediction and error is a general characteristic of how the brain works

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The authors say their results are INCOMPATIBLE with feature detection model.

Selecting Attention


Sustaining Attention
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Learning Objective

- Confidently describe recent research defining a neural marker of sustained attention and its relationship to ADHD

A bear @A_single_bear · 1h

Dear crow,

Did you enjoy the tiny bag of fries you flew off with? I do not think it is right or fair that you can do this to me just because you have wings and I do not, but I accept my limitations as a bear.

Yours,

A bear

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The Problem: No *summary index* of attention

- Attention is key for perception and all kinds of cognition
- But different types of attentional process are measured in too many different ways
- So none of them will work as a measure of individual attentional ability!

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Rosenberg et al. – a brief review

Rosenberg: 3 Assumptions

1. Individual differences in sustained attention will be reflected in complex patterns of correlated BOLD activity across brain regions
2. These patterns will be observed both when you're doing a task and at rest
3. If we can distill a signature of these patterns we should be able to use them to predict attention ability in a completely different set of people

Question: What attentional processes are involved in sustained attention?

- Information selection
- Inhibition of unselected information
- Enhancement of selected information

Rosenberg: Questions to be Answered

- Big picture question
  - Can we find a neuromarker, or brain-based measure of general attentional ability?
- Specific question
  - Can we get take a data-driven approach to pulling out patterns of network activity to give us a marker of sustained attention that will generalize across populations?

Methods

- Yale participants: 25 students
  - gradCPT task
  - Resting state fMRI data
- Beijing participants: 113 kids & teenagers with ADHD and typical controls (mean age 11 years)
  - Resting state fMRI data
  - ADHD-RS scores (inattention & hyperactivity/impulsivity)

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- In the scanner, participants saw images of cities and mountains.
- Their task was to press a button if they saw a city scene, NOT a mountain scene.
- d' or sensitivity was used as the measure of their performance = # of hits - # of false alarms.
- Parents completed the ADHD-RS questionnaire - a measure of the participants' degree of ADHD symptoms.

You should know

- What happened in the gradCPT task?
- What were the key assumptions justifying the approach to data analysis? (see paper and class 13 slides)
- What neuromarkers of sustained attention were calculated for each individual?
- What were the behavioural variables measured in each population? What did they measure?
- What were the main relationships reported between SAN neuromarkers and specific measures of attention?

Goal: Identify a neuromarker of sustained attention based on whole brain *intrinsic connectivity*

- Step 1: Derived a network of regions whose connectivity strength predicted gradCPT task performance (d') in Yale group. Created brain scores of connectivity strength (high and low attention) that predict d'.
- Step 2: Examined if statistical model based on network strength while performing gradCPT can be applied to resting-state data to predict gradCPT task performance.
- Step 3: Examined if SAN model can be used with resting state data to predict ADHD scores in kids and adolescents in Beijing.

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1. Examined which patterns of connections between brain regions are associated with good and bad performance on the gradCPT task and created the Sustained Attention Network (SAN) Model.
   SAN model=a statistical model that predicts an individual's sustained attention ability from their scores on the positive and negative network strengths. Based on the network scores of all but one member of the group, the researchers could then predict the d' score of the 25th person on their network scores. In a cross-validation process, the researchers correlated their predicted d' score with the participants' actual d' score based on the participants' network scores.
   A higher score on the positive network strength predicted better performance on the gradCPT task. A higher score on the negative network strength predicted worse performance on the gradCPT task.
2. See if the SAN model can predict gradCPT task performance from participants' resting-state data.
3. See if the SAN model can predict ADHD scores of kids and teenagers in Beijing.

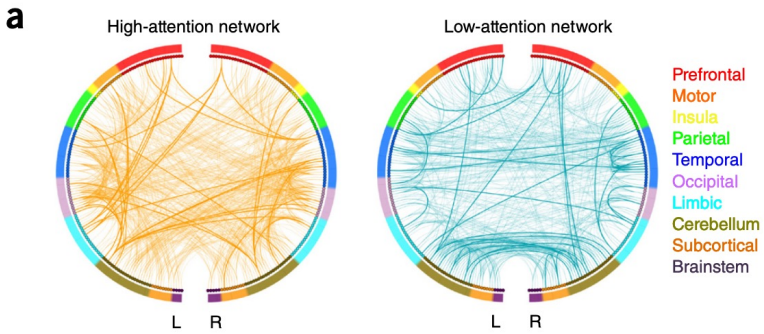
The SAN Networks

High Attention Network

- Connectivity pattern correlated with high performance on gradCPT (Yale Students) and low ADHD scores (Beijing kids)

Low Attention Network

- Connectivity pattern correlated with low performance on gradCPT (Yale Students) and high ADHD scores (Beijing kids)



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You should know

- What is the main advantage of using the SAN model as a neuromarker?
- What is the main advantage of using resting state data?
- What do the authors say are the main are the two main implications of their findings for understanding of neural underpinnings of sustained attention?

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Lecture 13
Attention

Learning Expectations

- Identify the difference between covert and overt attention
- Explain classic models of selective attention and the brain systems
- Define the attentional set
  - Explain the underlying neuronal mechanisms

What is Attention?

- Attention: What we notice in the world at a given time
- Broken down into types of attention
  - **Selective Attention:** A combination of what we perceive from the world and what we are aware of
    - Includes inattentional blindness
  - **Sustained Attention:** The process of choosing what to focus on and suppressing all unnecessary distractions and stimuli for an extended period
  - Includes change blindness

You can think of selective attention like a spotlight, whereas sustained attention is like blinders. Selective attention is pulling out details while sustained attention is blocking out distractions.

Overt and Covert Attention

Overt

- Gaze is focused and flexible
- Gaze and focus are aligned
- Attention is guided by the eyes

Covert

- Gaze is fixed on a specific point
- Gaze and focus are not aligned
- Attention is guided by the mind

Learning Expectations

- Identify the difference between covert and overt attention ✓
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Selective Attention

- Allows you to filter and focus on relevant stimuli
  - Ability to discern important background information
- Can be overt or covert
- Helps in identifying targets
  - Target importance is based on goal relevance, temporal relevance and salience factors
  - "Distinctness" is determined by two attentional systems

Selective attention cannot be passive. It's a combination of both sensing something and attending to it. Think of the difference between seeing something and looking for it.

Attentional Systems

Top Down

- A deliberate, conscious and goal directed system
- Directly controlled
- Requires the use of an attentional set

Bottom Up

- An involuntary, feature based system
- Automatic, serves as a response
- Captures attention without requiring attentional set
- Often can be contrary to current goals

Attentional Networks

Dorsal Attention Network (DAN)

- Involved in top-down processing
- Includes the Frontal Eye Fields (FEF) and Intraparietal Sulcus (IPS)
- Can engage when planning
- Maps to regions of space or distinct features

Ventral Attention Network (VAN)

- Involved in bottom-up processing
- Includes the Ventral Frontal Cortex (VFC) and Temporoparietal Junction (TPJ)
- Involved in responses

Both are able to communicate with each other, and work together to modulate V1

Learning Expectations

- Identify the difference between covert and overt attention ✓
- Explain classic models of selective attention and the brain systems ✓
- Define the attentional set
  - Explain the underlying neuronal mechanisms

Attentional Sets

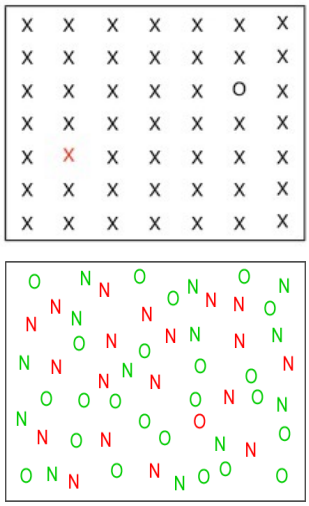
- **A mental template used to help identify an object**
  - Help separate and engage with stimuli categories that are relevant to our goals
  - Operates by identifying shared features between the template and stimuli
  - Can consist of locations, features or associated features
  - Cued by FEF and IPS activation

Which attentional network and system do attentional sets belong to?

Biased Competition

- **The activation of neurons tuned to task relevant stimuli**
- Used to create the attentional set
  - Target neurons will preemptively fire
  - Competing neurons will experience suppression
- Helps prime and regulate activity
- Occurs primarily in the DAN

Targeting



- Visual search tasks are used to assess attentional abilities
- Tasks can be created to trigger different attentional networks

Sustained Attention

- Used when we are required to attend to low attentional/mundane stimuli for long durations
- Typically measured using Sustained Attention to Response Task (SART)
- Performance can serve as a marker for ADHD and impulsivity
  - Based on individual differences

Learning Expectations

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Connolly et al. – a brief review

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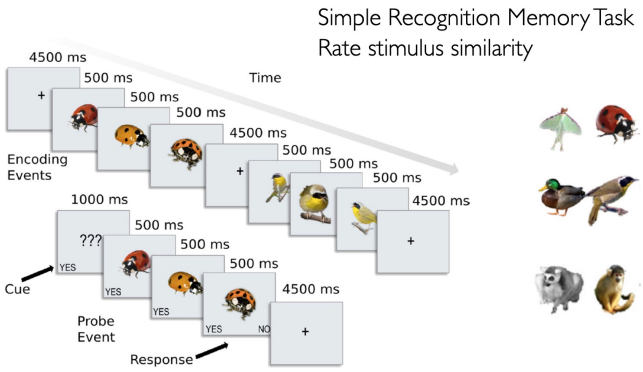
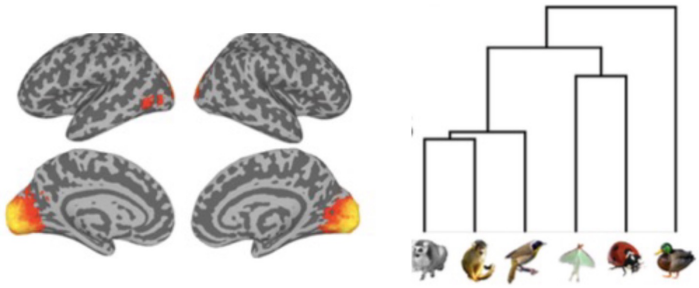


Connolly, Haxby et al., 2012

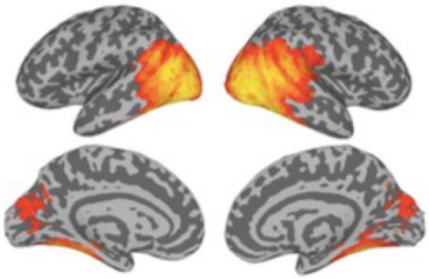
Connolly et al. – a brief review

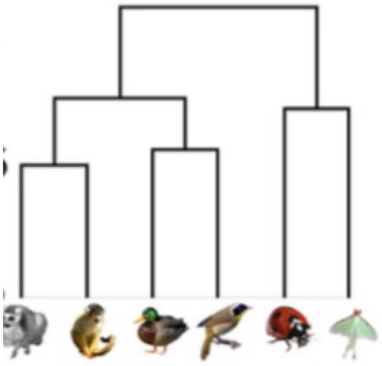
RSA Results: Early Visual Cortex (EV)



• Does NOT represent stimuli by animal class in a way that matches behavioural similarity ratings

RSA Results: Ventral Stream (LOC & IT)

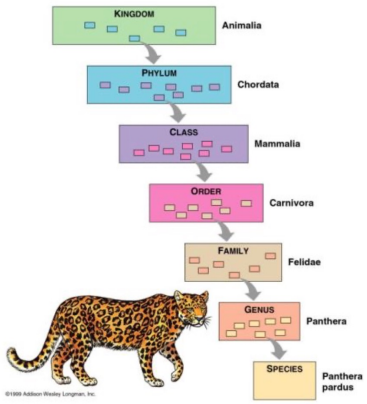




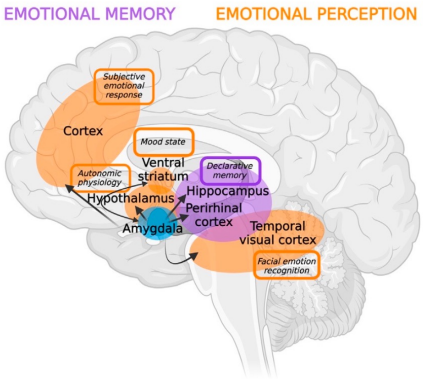
• Represents stimuli in a way that matches behavioural
similarity ratings!! Maps onto biological class structure!

Conclusion

Human neuroimaging reveals a ”hierarchical category structure that mirrors biological class structure” in the ventral visual stream.



Inman paper



- Multifaceted influence of amygdalae on behavior
- You should know the key regions from this figure that are key nodes in networks the amygdala participates in for its functions in emotional perception and memory

Inman paper

Exercise your paper reading muscles and answer the following questions about the Inman et al. paper:

1. What three amygdala functions have been demonstrated by case studies from the last 3 decades?
2. What is unique about the structure of the amygdala and what does that mean for its multiple functions?
3. How do the authors summarize the role of the amygdala in present perceptions?
    1. List two findings from lesion and stimulation studies they use to support this claim.
4. How do the authors describe the role of the amygdala in prioritizing certain memories? List two findings they use to support this claim
5. How do the authors claim that the amygdala's role in perception and memory reflects its unique structure?

Emotion, Motivation and Attention

How do our emotions guide our motivation and attention?

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What we've learned so far...

- Attention types: overt, covert, selective
- Attention systems: Top down and bottom up
- Attentional networks: DAN and VAN

There are other factors that guide our attention!

So far we've talked about different attention systems and attention types. We learned about the attentional networks that are attributed to these attention systems. There are other actors in our cognitive theatre that guide our attention that do not really fit into any of these categories. Attention that is not related to the "grabby" features of an object or to our conscious short-term goals. Two examples are motivation and emotion.

1. Describe four evolutionarily conserved emotional/motivational systems.
2. Explain ways in which amygdala and mid-brain systems play a role in guiding motivated attention.
3. Evaluate factors that influence individual differences in vulnerability to depression and anxiety.

Our learning objectives for this class are:

Emotion and Motivation

- Motivation: impulse to approach/avoid something that is rewarding/punishing.
- Emotion: physiological sensation of emotional arousal and the subjective feelings that accompany them.

They overlap, but they're different!

So before we start talking about these two concepts it's important to differentiate between them. Sometimes they are used interchangeably, but they refer to different aspects of behaviour. Motivation is the impulse to approach or avoid something that is rewarding or punishing, and emotion is more about the subjective pleasentness or unpleasantness of the thing. To simplify, the urge to have a cupcake is motivation, and the deliciousness of the cupcake is emotion. Even though they are related to each other, they are different things!

Theories of emotion

- The basic emotions theory say that we have universal emotion systems that are discrete from each other and universal across human cultures.
- Other views say that any emotion can be defined by how much it's related to good or bad, or approach or avoidance, and how worked up your autonomic system gets (= arousal). Any emotion we feel falls on a combination of these two dimensions.

What did Jaak Panksepp say that differs from these two views?

The brain systems for attention and motivation are responsible for…
Now that we talked a bit about the differences between motivation and emotion and how their presence can affect our conscious human experience, let’s dive deeper into both of them.

Blue Ribbon A Grade Systems

1. Seeking system: positive reward, approach! -> hope, anticipation, desire, curiosity
2. Fear system: possibility of destruction, avoid! -> high anxiety, alarm, forebonding
3. Rage system: goals thwarted, approach! -> hate, anger, indignation
4. Panic system: loss of social reward, withdraw & approach! -> separation, distress, sadness, loneliness

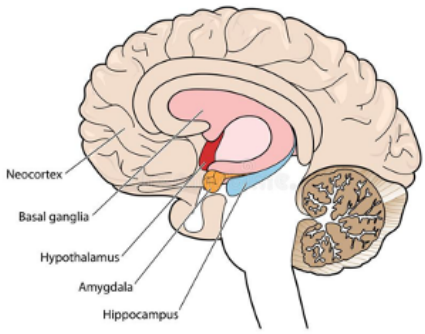
But how does a limited capacity information processing system selectively process a continuous stream of inputs?

Seeking system is the motivational system that are associated with emotions such as hope, anticipation, desire, exploration. It makes you interested in exploring and excited when
you're about to get what you desire. DA is highly involved in this system and not surprisingly psychostimulant drugs that activate the DA system also increase activity in this system.
A situation that makes us feel pain activates the fear system. The motivational aspect here is avoidance, and high levels of stimulation in this system provokes the flight response in animals, whereas weak stimulation leads to the freeze response.
When the body surface is restrained, irritated or frustrated, or when our goals are thwarted the RAGE system gets activated. This system is associated with feelings of hate, anger and indignation.
Finally social loss triggers the PANIC system, along with feelings of separation distress, loneliness or grief. It serves to make sure parents take care of their offspring, and the offspring need to express that need. The best example of this is baby monkey's

distress calls. This is an example of approach, whereas sadness for instance serves to provoke those around us to comfort us and take care of us during hard times!

Amygdala: hub for motivated/emotional attention

- Important node in many networks
- Tags what is biologically important which guides our attention
- This process is also affected by past experience
- The inputs are then selectively processed according to whichever are the most relevant to the goals of the agent
    - This sounds a lot like selective attention, and it is! Selective attention guided by emotional salience of the inputs coming into our brains.
- Amygdala also modulates the ventral visual system, just like DAN!



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Patient S.P. had an intact emotional experience compared to controls.

Amygdala is not necessary for the subjective feeling of emotions. It guides "emotionally biased attention".

Patient SP and other patients with amygdala lesions also did not differ from control groups when they were rating the positive or negative emotional meaning of the words. The only difference was the emotionally biased attention and classical conditioning. So we can conclude..

These findings suggest that acquired amygdala damage does not necessarily decrease
the experienced aspect of emotion or understanding of the overall significance of
arousing stimuli.