

Cognition and its Computation
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Lecture - 54
Decision Making

Welcome. So, we will begin our lectures on Decision Making and the frontal cortex. So, as we know or we have learned over the course the executive functions are controlled by the executive region of the brain which is the in the frontal area or in the frontal lobes which is in the anterior portion of the brain and there are many parts to it.

And probably the most complicated of functions that are performed by these regions is decision making. And we must note that it is not unlike what we talked about speech and language decision making is not just made by humans, but decision making is made by all many other animal species.

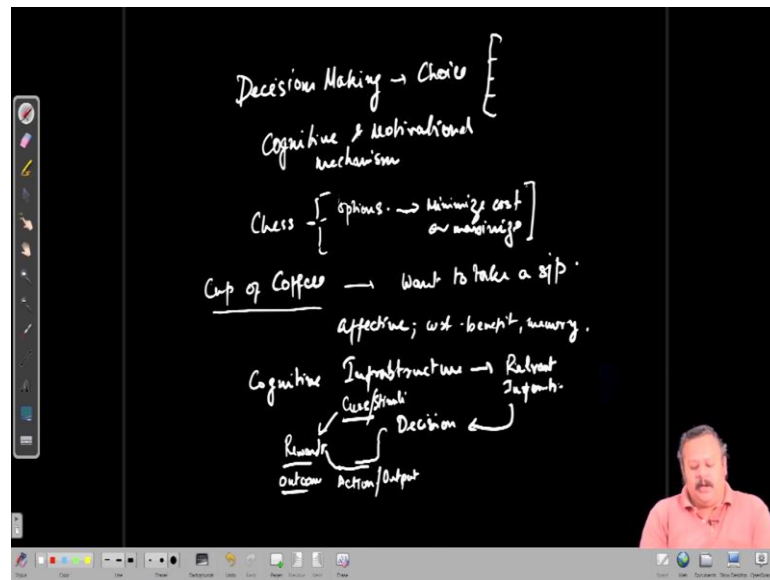
And so, it is possible to design tasks of decision making and studying at the very single neuron level what is involved in the mechanisms behind decision making. And similarly, a lot of studies have been performed in humans with fMRI in decision making tasks and we have a plethora of information about the different regions in the frontal cortex that are involved in decision making.

So, what is decision making? I think all of us are probably familiar with it in the literal sense and it is not very different from what we understand in literally. Decision making is essentially making a choice and follow possible path or follow a possible course of action among many possible choices at that point of time. So, we make a choice and if we are rational then we make a choice based on the basically to improve the current situation or to stop something bad from happening or reducing the costs.

So, it is ultimately a trade off of cost and benefit. And this cost and benefit can be of different forms in different cases in different kinds of context in decision making. However, we can refer to them as singularly as something that is a positive outcome which is reward and a negative outcome which is the absence of a reward or a punishment.

So, it does not mean literally that the outcome is getting some sort of a reward in a physical sense, but it can be in the effective sense also. And similarly, the punishment can also be in the effective sense and not necessarily in a physical sense or it can be some sort of a feeling. So, what we understand?

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So, if we start. So, decision making is ultimately making a choice from many options that are available. So, the process involves a number of cognitive and motivational mechanisms that are involved, which could be a related to thought, which could be logical calculations, which can be getting a better feeling and so on.

And so, all these mechanisms can be involved in the decision making process and there are a lot of them. And it is a very complicated process and if you just think about chess player let us say who is making a move at a point of time in the game. So, as you may be aware if you play chess that at a point of time chess player has many many options that are available to the player. I mean to like options in the move that the person can make.

And all of all these options the person with their ability of logical calculations and without error if they can, then they make the best possible move. And that is move that is going to favour that chess player and that is basically towards winning the game. So, that is basically trying to minimize the cost or maximize the gain which is lose if you are going to lose in a less bad way and if you win as well as you can as quickly as you can.

So, and you can imagine how many calculations can be done and; obviously, different people have different levels of abilities in that. And so, decision making varies greatly from person-to-person and. So, this is a very complex task a very complex decision making task where we have to do a lot of calculations I mean thinking assuming that a person is a chess player, but decision making is involved in every step of the way in all aspects of life almost all the time we are making decisions.

And even right now I am trying to make a decision whether I should look towards here and start writing or continue talking about another point and. So, if you think about it then there are many many things in the background that are going on based on which a decision is made and an action is taken.

So, even if I think of let us say I have a cup of coffee in front of me and I need to decide whether I want to take a sip or not. If that decision also has a lot of information that has to be integrated in order to make the final decision. We may not realize that all the time that all this is actually going on, but indeed all the calculations are going on.

If we could slow down our thought process, we would probably be able to see unless we are impulsive that we do not think about what we are doing or a person is not thinking about what they are doing and simply do it by in an impulse. So, we are talking of rational decision making. And so, the first thing that comes to mind whether the effective part of it, whether I actually like the coffee or not maybe I was drinking it and I kept the cup with the coffee. And so, I may not be liking that coffee today it may be something different.

So, that will play a part. There can be a cost benefit to it that is I am if I drink that coffee, I think I will be able to stay a little longer wake up wake a little longer be awake a little longer and be able to finish this task at time end. And the cost is that I may not be able to sleep tonight or something whatever can be or a heart burn if I drink more coffee.

So, we are continuously evaluating these processes based on the relevant information that is available in the current context and then making a decision. Then also memory and learning is involved intricately with this that is the memory of what had happened with that cup some time ago that may be stopping me from sipping the coffee anymore today or I mean.

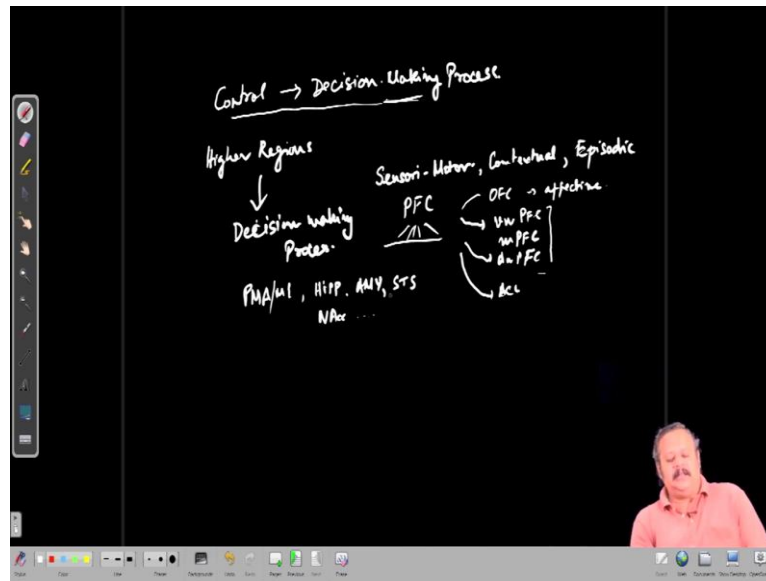
So, if I can think of ways in which the past can influence this decision then all sort of memory and learning comes into play in this even this mundane decision of taking a sip from a cup of coffee. So, as we said the effective part is there the cost benefit analysis is there and also memory and learning is involved behind the decision making process. And the cognitive infrastructure that is available that actually brings out the relevant information.

So, we would say the cognitive infrastructure which is the parts of the frontal cortex. The they interact and bring out the relevant information based on which decision is to be made. And a decision is based on either some cues that are sensory in nature and ultimately based on the decision I actually perform an action and that produces a reward or which can be positive or negative.

So, these cues are the stimuli from the sensory world and the action is the output of from the from my side or the person side or the animal side as to what choice it makes out of many possible courses of action and then there is an outcome. And so, the cue predicts this reward the stimulus predicts the reward and the action produces the this is the reward or it is the outcome.

So, stimuli and outcome are predict in I mean the connection is predictive in nature that is given this stimulus like if you think of the Pavlovian conditioning given the bell ring the prediction is that there will be a reward or food. And so, the dog actually goes for the reward and the salvation is reflex that is happening. So, the action that is the action that is being taken by the person. So, some of these actions are taken in a very split second very fast.

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And so, as we so, if we think of the whole process there is hierarchy of control over the decision making process. So, and in different cases the level of control is different. So, some things that we are we are very used to doing and we have a habitual response or an action that is taken.

Those kind of decisions are taken in a split second. For example, if you are driving and while you are driving all of a sudden, the signal in front of you turns red and you immediately press on the brake to stop yourself. So, here the higher regions of that are controlling. The decision making process that are controlling the decision making process are less involved.

In those are the cases where it is in the sensory motor phase that the decision is being taken that is I have the stimulus and based on the relevant information I take an action. And there is some modulation on the action that is taken and this is the most preliminary form of decision making. Next the decision making can be contextual.

So, going along with the idea of the red light. Let us say now you have come and stopped at a red light and let us say that the red light is not turning green for a while. So, you start wondering whether you should cross the red light or not in this current scenario. Because based on memory you are calculating this is much longer than what the usual wait time is for the red light or maybe you see other people ignoring the red light and crossing along because they probably know that something is wrong with the light.

And so, based on the contextual information you come to a decision as to whether you will drive across that red light or not. So, this is going one step forward and then there is the episodic kind of decision making where you rely on a previous experience or rather a previous cue and that cue is present to decide for only the current scenario and not in general it is not there. So, for example, if you came across a sign beforehand and on the same road that aware of delays because red light not functioning or something like that can be connected with why this incident is happening.

And so, with that information that you have behind from the past a little ahead of the time you know that ok, that sign meant this and so I can cross over and do not need to stop any longer in this red light. So, this is episodic. And so, you would not be doing this on other times. It is only because for this episode you have this information for this period of time that you can actually take this action or rather decide to move along the over the red light or through the red light.

So, there are number of models that have been proposed in terms of the decision making process. And there are many regions in the brain that are involved in the decision making process and the list will be in a very broad way it is the prefrontal cortex. And there are many many subdivisions that we know of now based on lesion studies or from FMRI studies or from animal studies that specializes in different aspects of decision making.

So, for example, at a still at a broad level the orbitofrontal cortex may have to do with effective portion of decision making, but then again orbitofrontal cortex is divided into many regions and each of them has different roles as we are deciphering now over the last few over last few decades.

So, similarly the entire frontal cortex PFC can be divided into many divisions like the ventromedial prefrontal cortex, the medial prefrontal cortex and the dorsomedial prefrontal cortex and the list goes on and different parts of them are specialized for different aspects of decision making.

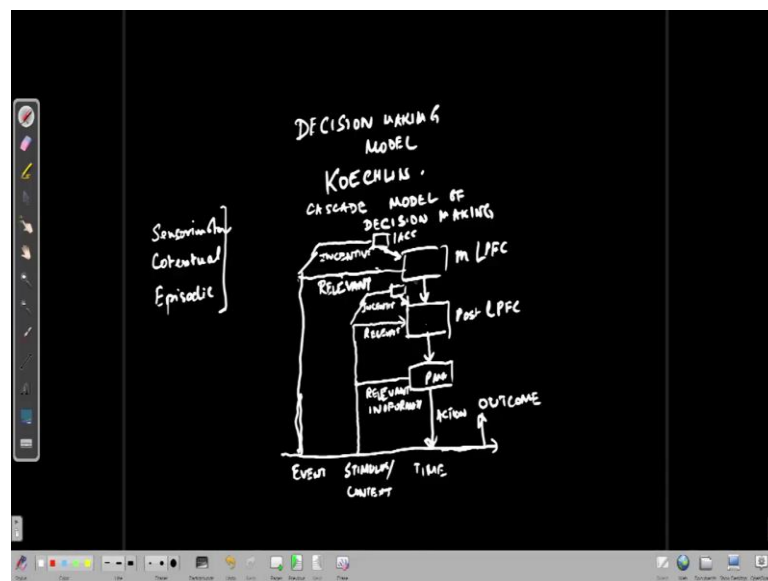
Similarly, the anterior cingulate cortex is involved in decision making. The other regions that play a role in decision making would be the pre motor areas as we know that it is in terms it is in on the output side of the decision making process that you make a plan of your motor action that you want to take.

And so, the motor then pre motor to M 1 all these are involved in the decision making process. Similarly, in terms of long-term memory hippocampus comes into play amygdala; obviously, comes into play for either reward or value cues of a particular outcome or stimulus or for the effective content of a particular stimulus.

Similarly, the superior temporal sulcus is involved in the decision making process the nucleus accumbens because of the relation with reward also involved in the decision making process. And actually, this list goes on I mean if you think about it the entire stimulus processing system is involved in the decision making process.

Because without the stimulus cue we would not be able to making make the decision. But if we think of the executive parts then it is really the PFC these few regions that we have talked about that are intricately linked with the decision making process. And in that sense Koehlin has a model of decision making this which comes probably the closest to what can happen.

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And the evidence suggests that this sort of a decision making model is probably how we perform decision making by Koehlin. And this is basically combining the three kind of scenarios the sensory motor then we have the contextual part and then the episodic part. And this is called the cascade model of decision making.

So, this is a broad model and if you think about it there are I mean as we will go on our lectures on decision making you will see that it is an abstract model, but aspects of that same thing can be correlated to in all kinds of decision making like a social decision making or reward based decision making or memory based decision making and what have you.

So, if in the model goes like this if this is the time axis and there is an event occurring in time at a particular time point. This can later on modify my decision making process and which is part of the episodic part of decision making. So, next in time let us say we get a stimulus or a particular context and.

So, from this the stimulus information the relevant information feeds into the pre motor area and that produces an action. So, this is basically the sensory motor part of the decision making. So, this is from the stimulus and content you derive the relevant information and based on that you make a decision and produce an action which has an outcome.

At the higher level the same stimulus we can have the relevant information extracted at a higher level in the cortex which is the posterior lateral PFC which projects to the pre motor area to control its behavior. So, the same relevant information is extracted at hierarchically at a higher; at a higher-level.

And that posterior lateral PFC then can modulate the premotor area and change the course of action or modify the course of action the motor area is ready to take from the relevant information. Similarly, there are many past events that are going on. And so, from that for a particular situation the relevant information would be extracted and essentially recalled from memory and that has that can feed into the regions of the PFC.

In particular the medial lateral PFC which also projects and modifies the inputs outputs of the lateral PFC to ultimately modify the action. Similarly, across both the cases in both the situations there is some incentive value associated with the same stimulus. So, this is the incentive value of the same stimulus. And so, that feeds into the anterior cingulate cortex which can then provide input the reward-based input on to the medial lateral PFC.

Similarly, here also there is an incentive value that is calculated from the current context and that feeds into the supplementary motor area which then can also modify the posterior lateral PFC actions. So, this kind of cascade model as you can see, we start with the rudimentary sensory motor situation of decision making which has a layer over it which is based on the current context and which has a layer further over it which is based on the episode of this current event and the previous memories that is also required to get the to for making a decision at the current moment.

And there are parallelly reward or essentially outcome values which can be positive or negative or aversive reward or aversive values. And they can modify the pathways that are controlling the ultimate output from the pre motor area or making the plan to produce an action.

And so, with this model we will be closing our discussions on decision making per se and we will continue on with the in the next lecture where we look into take a more closer look at the different processes involved in the prefrontal cortex frontal cortex areas in order to make decisions.

Thank you.