Learning about Learning: A Course on Neurobiology of Learning and Money
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Lecture – 03

Hello and welcome to the lecture 3 of the Learning and Memory course that we have been going through.

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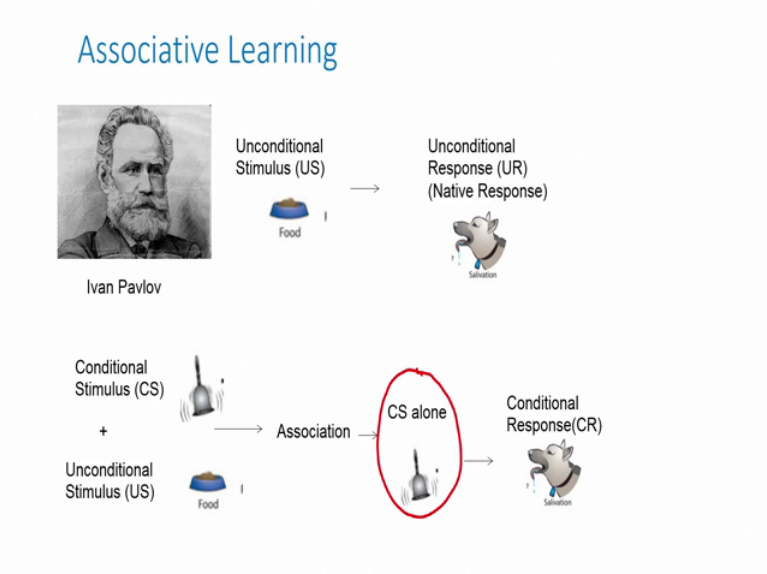

In the last lecture we kind of ended with the description of Pavlovs experiment with the dogs. I said they are just to recollect what we said there and I said there that he identified in a given setting you can think of 2 kinds of stimulus; a stimulus that can naturally elicit a response by itself in an animal. He called it as Unconditional Stimulus, US and the response it elicits as Unconditional Response, UR and there is another kind of stimulus Conditional Stimulus. These stimuli do not have a natural response in this context. It is important to note they do not have a response in this context right. They can have a response in a different context. In this context, they do not have a response.

But when you present them along with an unconditional stimulus over a period of time they develop an association such that they by themselves can elicit a response he called this response Conditional Response the response to the conditional stimuli alone after its been trained it is been paired with the Unconditioned Stimuli he called that as Conditional Response. In his dog and for dan metronome experiment both the UR and

the CR are happened to be same salivation. They need not be the same and in fact, in the present day experimental setting they are not the same and you we will see what this present day experimental setting is and there you will realize what why it could not it would not be the same and what do I mean by saying that UR and CR can be different.

Now here the important point I want to drive across is that when I describe and I put across the slide and then describe this experiment said its often means misconceived that the way the Pavlovian conditioning works is that over repeated presentations of the conditional stimulus along with the unconditional stimulus, that dog develops an expectation for unconditional stimulus that, when you play the bell it is going to bring the food it is going and as a result I need to prepare and that is why it is been salivating. Now that notion is not only in correct, but it is it seems very incutive but it is highly highly incorrect and it does not it does not gel well with the real experimental evidences that we have.

Now instead what I am going to try to tell you and then try to convince you is that, the CS in here the bell the dog thinks that the bell is the food that is the CS kind of replaces the unconditional stimulus here. Basically CS by itself develops a new response and that is it and that it nothing more than that all right. Now if the CS is developing a new response and what determines, when to develop this new response, how to develop this new response and when not to develop this new response. These are the questions that Pavlov and many other people following him try to address. One of the earliest and the simple minded reasoning of how this association can happen is that, hey look you are presenting the conditional stimulus and unconditional stimulus together.

So, maybe all the stimuli that are presented together tend to develop an association that is to say if you have contiguous stimuli then that are highly likely to develop an, they are highly likely to develop an association such that, later on when you are presenting the conditional stimuli they are capable of eliciting a conditional response. Well it turns out that is not the case let us do that let us examine that little bit through a set of experiments here.

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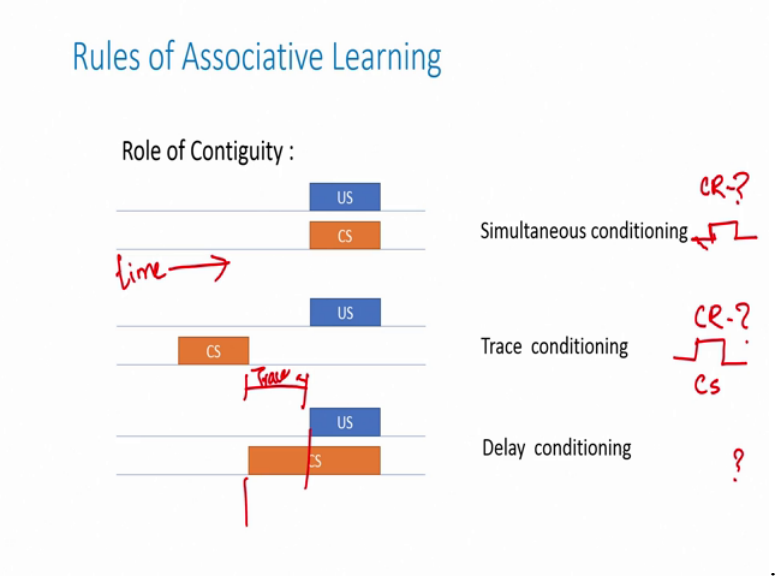

Number 1 is that we are going to present these CS and US right; I am going to call that conditional stimuli and US unconditional stimulus a CS and US respectively. Now, you can envision different kind of scenarios here. Why in an experiment where your CS and US is completely overlapping in time right time is along this axis. In such a case this kind of conditioning or training is called simultaneous conditioning, you can a later come back and then say, hey look I am going to just present I am sorry I am just going to present just the CS alone all right.

Now how much of the CR do I actually see observe in the subject right; that serves as a measure for our behavioral training. When you do this you can also say instead of co presenting the CS and US I am going to separate them in time, I am going to present the CS first and then after a little bit of a time I am going to present my US ok. And this is called as a trace and then again I can come and ask how well is my CR in presentation of just the CS alone.

Third I can actually present the CS and while the CS is happening almost at the end typically in the lab we do it at the variant of the CS you present the US. So, there is a delay in the onset of the US here that is the key here. The onset of the CS and the US are delayed though they are ending simultaneously this called as Code Terminated they are both terminated together though even though there is a difference in the onset time.

Again ask what is the CR, it turns out if they are contiguous the continuity is the thing that matters, then you would see that the simultaneous conditioning has the highest level of continuity because they are completely overlapping with each other. While the trace conditioning is on the other hand has a mac in this scenario among these three has a maximum amount of discontinuity so to speak and the delay having somewhere in between. But it turns out when you do this in an experiment and I ask how the CS are simultaneous conditioning is the least learned the exhibits the least learned CR responsible almost nothing next to nothing.

While the delay conditioning exhibits the maximum followed by the trace conditioning right. Its very counterintuitive where we have seen if contiguity where to be the case where there is a delay, where there is no contiguous manner, even that the trace conditioning right even there you see learning while where there is a maximum contiguity like maximum overlap you do not see learning. One explanation is to say that hey look continuity is not, I mean continuity is not the determining factor here and that is my goal here I mean going to drive across that point saying that it is in the contiguity, but is something else.

But there are possible explanation in line with continue contiguity to, meaning it is not completely ruling out the possibility it is not contiguous, but you can say that hey look when you present these two things together it has to do with the performance means when you are actually asking the animal to respond by playing the CS the association might have developed; however, the animal may not have exhibited the response simply because there is no use, animal understands that there is no use for exhibiting that response as a result it does not have any response.

The reason why I we I do not emphasize on that line of thought and then go along that relates back to the idea, what exactly is learned in Pavlovian conditioning. I remember I told you it is not the cognitive thinking of the dogs of the dog to say that hey look there is a bell and the bell is going to predict the food as a result I need to salivate. Instead it is very much a reflexive behavior that is that is getting driven where the dog tends to think the bell is the food.

So, here performance based explanation would assume that the dog is cognitively thinking about the usefulness of exhibiting a response. So, we will later on see go ahead

and see that it that is really not the case, in such a case then why we do not see conditioning then in simultaneous condition during the simultaneous conditioning is the lack of something else. What is that? And probably that is the governing factor that determines whether the association is being made or not. To understand what could be the other governing factor let us examine another little experiment that was done by Rescorla in 1968.

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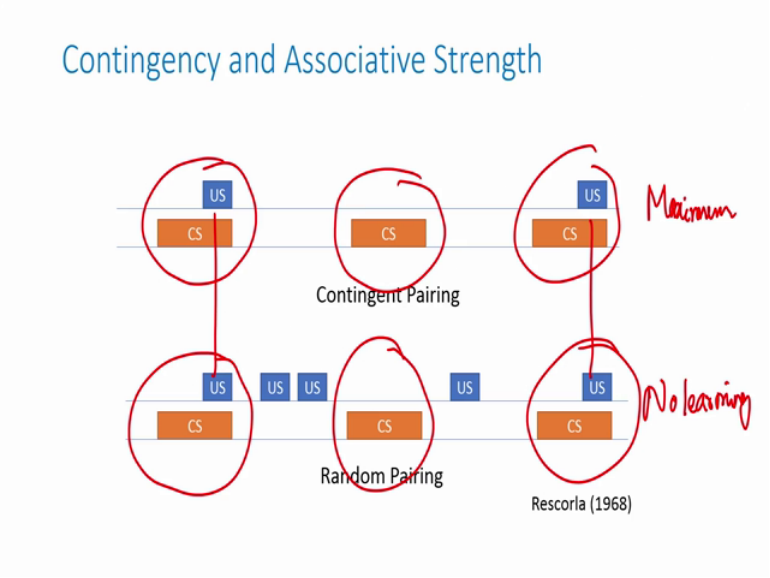

Where he introduced the notion of contingency that is the ability of CS in predicting the US. Remember, it is not the dogs ability to understand the CS is going to predict the US , but is just simple probabilistic estimate of a CS and CS being there when the US is being present ok. The dog does not need to understand it in the cognitive fashion, but I mean or any animal for that matter does not need to understand that in a cognitive fashion, but it just there is an overall estimate that you can actually mathematically write down for the predictability of the CS and US. We will get to that in a minute, but let us look at these 2 experiments and the experiment number 1 where I call it as contingent pairing there are 2 US's that are being present along with the CS and there is 1 CS where there is no US's being present at all.

In a random pairing we will exactly repeat this in addition to that we will present few more unconditional stimuli. If at all anything you would see there is more number of US's being present here ok, you would expect the conditioning to be as good as

contingent pairing are better. Because all that you are doing is that you are not taking away any of the things that are presented in the previous manner right you are presenting you are presenting both of them right these are present equally in both, all that you are doing is that in addition to them you are giving more US's.

In this situation if you ask how well the animal has learnt that is how well the animal has learnt to exhibit a conditional response when the CS is being played later on with our in the absence of US you will see you have a maximum amount of learning here while it is not even its not equal or its not higher, but in fact, no learning no conditioning at all in this random pairing. How can that happen?

If it were to be only contingent I mean contiguity right you are presenting equal amount of times I mean you can say that there is performance deficit blah blah blah bluh bluh, but the point here is you so, that the simultaneous conditioning was not working maybe that is not a correct argument; however, here it is a very very clear case where its beyond contiguity right because you have whatever this is presented here and here.

They are contiguous if they are as contiguous as the contingent pairing right the random pairing is as contiguous as a contingent pairing. The only difference in fact, the CS with no US is also present here the only difference is the presence of some of the US's when there is no US when there is no CS that is detrimental to the learning are developing an association between this CS and the US.

So, now what is what is going on here? One possibility one of the ideas that was put forth by Rescorla then was its not the contiguity, but it is something to do with contingency. The notion of contingency is determined by we will go to the board here. He said it is not just the fact that they are presented together, but it is actually the predictability and then he defined the predictability in terms of 2 probabilities.

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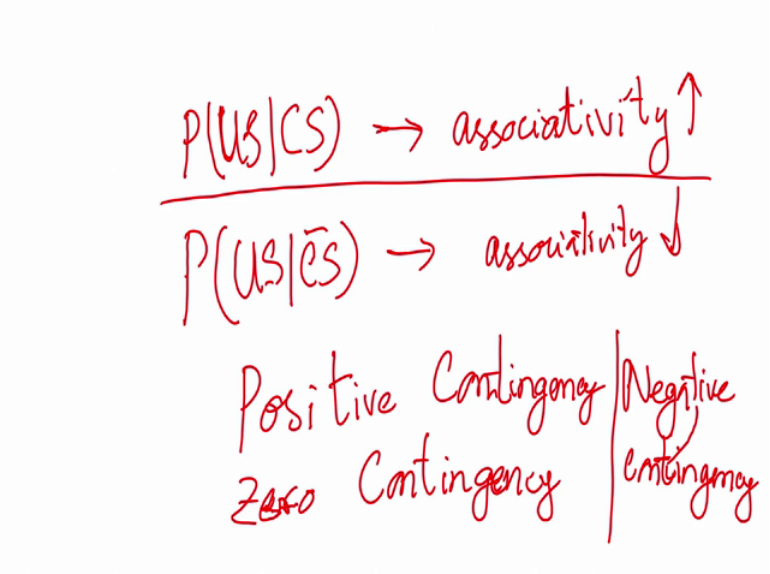

The probability that a given US given that CS has is occurred. If this is high then associativity is high. But that is not just sufficient because if you go back and look at our previous experiment both of them had equal amount of this probability of the US happening given that this CS has happened because wherever the CS is has happened equal number of times the US has happened there.

But it is also important to understand probability of US occurring in the absence of CS if this is high the associativity or the strength of association will be low right that makes sense right because you want to take mean evolutionarily speaking right now our learning is highly dictated by the evolution that is how we tend to think about how the brain works and the how learning works.

So, evolutionarily speaking you are developing a response and you want to develop a response for a condition, in which you know there is some predictability that is this if the CS were to predict the US then yes you need to develop the condition so, that I you need to develop the response so, that is very simple and straightforward. However, the usefulness of the CS is not defined by how often the US happens when the CS is present, but also determined by when the CS is not present can the US happen at all. Because if it were to happen all throughout irrespective of whether the CS is happening or not, you will see this being high anyway it is going to happen.

The point here is it does not happen when the CS does not happen does not occur, but it happens only and only if the CS is present then you have the highest associativity. A function of these two probabilities he notionally called it as Contingency. It is not well I mean it is not a function that is written in terms of probability that (Refer Time: 18:14) did not do that, but the notion was that that you can talk about the predictability in terms of these two probabilities from there what do we gain. So, right from here, we can start to think about contingencies of different kind. A contingency which is I kind of said higher what I meant is well the probability of US occurring is high when there is a CS and almost nil probability of the US occurring when there is no CS. Let us call that as positive contingencies; you can also think of zero contingencies or random contingencies where the probability of US occurring and CS occurring is not related at all.

So, I am going to talk about positive contingencies, zero contingency and Rescorla also recognized if these two are possible and these two probabilities are determining the contingency, then there is a third alternative that is possible which is negative contingency. As I said positive contingency meaning the fact the first probability is very high, the second is less. Zero contingency being both of them being equal and the negative contingency you can almost think intuitively the second probability is very high compared to the first one.

What we predict is that there needs to be a very high association; zero sets the base line while this negative contingency should predict the reverse meaning you should develop an opposite response. We will see how we can what do we mean by is it opposite and all that in a minute, but that is the idea. He can postulate just by based on this hypothesis that there are three different kinds of contingencies that the animal can actually evaluate and decide develop its response positive, zero and negative all right.

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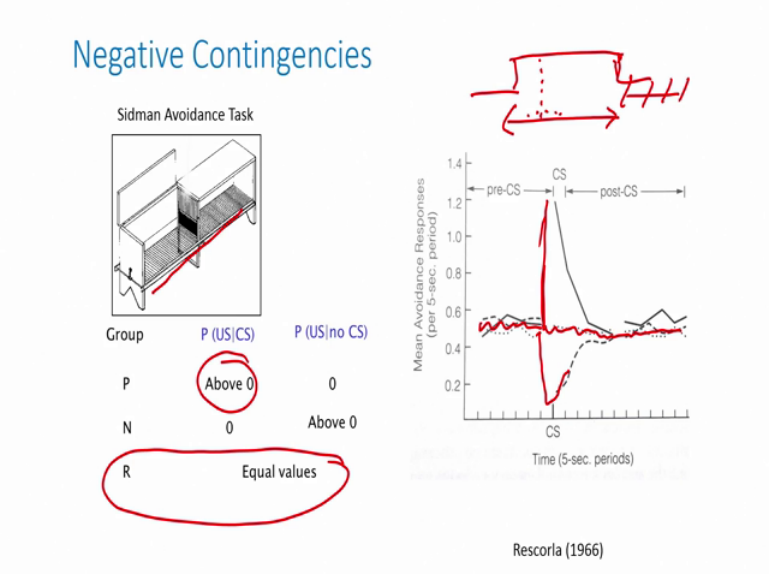

So, he went ahead and this tested these experiments. The experiment here is about using tasks called segments avoidance tasks. So, the task is carried out in a behavioral setup where the floor of the behavior that you see here is a stainless steel grid through which you can pass mild electric currents and then it has 2 boxes and the barrier separating these two boxes has a certain height and if you place an animal here for the animal to go into the other box, it has to jump over this barrier to go between these two boxes.

These are also called as shuttle boxes they can move from one to the other. But the idea is that for it to move from 1 box to the other, it has to perform this behavior of jumping across the jumping over the barrier. Now he took those took these boxes and then the task he designed was to say he look, I am going to present a mild electric shock nobody likes a electric shock right and we all get taste of this electric shock as we grew up we do not like it its not bad, but we do not like it and animals are not any different they do not liked it too. And so, they would like to avoid that experience so, the way out for the animal to avoid that experience is that, in response to the shock if the animal jumps to that next box for that matter if the animal start to jump to the next box for the next 30 seconds it is guaranteed that the animal is not going to get any electric shock.

So, he would do with the pre conditioning experience in a pre preconditioning experiment where, on an average about in 10 seconds there will be electric mild very very mild electric shock that is given to the food shock that is given to to the animals. So,

the animals understands this so, they keep jumping from one box to the other so, that for the next 30 seconds they do not get the shock and as a result they have the stereotypic jumping behavior from one box to the other.

Now having developed this behavior into this animal, you can use that to study the association how we do that? He would play a tone now play a tone and then within about within about 10 seconds of the tone if there is an electric shock would come. So, now, he would present this 24 times so, that the animal learns to associate whenever there is a tone, learn to associate the tone with the experience of the shock as a result they will start to jump to the other box. So, now, that is the behavior that we are actually training the animal for.

So, that would form the positive contingency group because you are with some certainty, providing the electric shock upon presenting the tone. So, your tone is being presented on an average about 10 seconds, but then its distributed about that 10 second mean you would give the electric shock he would give the electric shock, then you measure the idea is that later on I am going to just play the turn and then see how well the association is developed.

And of course, the random group is very simple what you will see is that, you will present electric shock whether irrespective of whether the tone is being present or not present I mean they are complete I mean both of them the onset of the tone and the electric shock is completely uncorrelated right both of them are derived randomly.

So, that is what the random group would be. And the animal anyway had developed this basal level jumping behavior. So, they will continue to have that behavior there too. But the negative contingency group that is where the engineers of this experiment lies where he realized hey look now what I can do for sure is that, whenever there is a tone that is being played, I will ensure in that period there is no shock at all.

So, the shock is given in a period where there is no tone at all. See in the positive contingency group in about that there is a tone and it about in 10 seconds delay around that 10 seconds delay, it various places you are presenting the shock and then the shock of course so, oh I had to make sure we understand this clearly this here I am talking about the onset times. So, that the tone begins and the and then the ends so, there is some time period for that tone within this time period all the shocks come; however, there is

about 10 second delay because you want to make sure to said delayed conditioning about the 10 second delay at different instants in time, the shock can come so, that is the positive contingency group.

While the random contingency group has no relationship as I was telling you, while the negative contingency group this happens in the time period where there is no shock at all I mean where there is no tone at all that is in this period. Now let us look at how what the animals have learned how do we do that? We put the animal bring the animal back into the shuttle box now this time no electric shock but just going to play the tone.

What you see here is that in the on the right hand side the plot of the mean avoidance response means the responses in terms of we are talking in terms of what fraction of the time they are I mean how many times they are actually jumping and stuff like that. Now there is a basal level response during the precondition pre CS period this is the period where they develop the stereotypic behavior of jumping across right that is same for all three groups.

It is not surprising because you are the person who are separating in three different groups until this point they are all the same so, they are exactly the same. However, the moment you start giving this CS and the training CS and the US training, you are separating them into three different groups now you test them by just presenting the CS. The response that they exhibit for the CS in these three different groups are very different right this is the beauty of this experiment.

You have a group of animals they are exactly identical until the point of training and the point if they are only different in this point of training afterwards you are testing again its exactly the same they are not experiencing anything different; however, the behavior that they exhibit is very different just because the training is different. The positive contingency group exhibits higher amount of mean avoidance response, because they are expecting the association of the CS to the US is very strong here I mean its positive CS probability is above zero here as indicated right. So, you want to avoid that. While the random group do not show any change at all I mean that is not surprising at all right it would be to dive in a surprise when you are sticking to the contiguity principle, but here if you buy into the idea of contingency no issues here because the CS does not have any

predictive value so, it just does not change the behavior the response continues to be the same as it used to be the previous.

However, during the in the negative contingency group when you test on during the test, you see they reduce this jumping behavior they still that is the key here. The alteration because of the association is both the in both direction you can actually increase if the CS has a higher predictive value for the shock US. Now the absence of the US in turn acts as a and different kind of US here. The absence of a US allows the animal to modify its stereotypic behavior to reduce, because it is it is no point simply jumping there you want to better conserve that energy and do something useful right. So, that is a direct followed of the idea that the associations are in indeed the one by the contingencies and you can modify these contingencies positive negative and random.

So, now with that I think we are just about exceeding the time limit of the lecture, we will continue in the next lecture how these contingencies with two other experiments determine one of the fundamental and the basic laws of laws in psychology of learning and memory and I will see in the next lecture.

Thank you.