**Learning about Learning A Course on Neurobiology of Learning and Memory**
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Lecture – 07
Application of Rescorla Wagner Model – II

Hello and welcome to the lecture seven of the learning about learning lecture series. And I hope you have been enjoying this course as much as I do. And until now what we have seen so far is that how we can describe the development or the evolution of the associative strength when there are multiple exposures to the CSUS events that have been happening right. So, we talked about three main experiments; experiment concerning contingencies by Rescorla, the experiment concerning selective CSUS association by Garcia and Koelling.

And the ability of pre learning in blocking new for new association formation in a compound stream that may come in. And we also formulated Rescorla Wagner model or a framework for describing how associative strength are learning in this case develops over a period of repeated trials that are being presented to an animal. The trials here referred to exposures any exposure of CS and US combinations. In summary the model goes pretty much like this.

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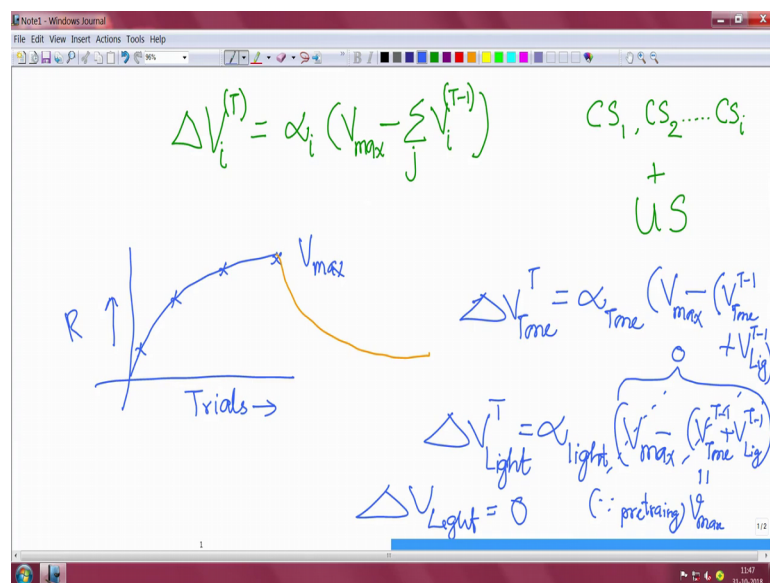
We can write down the response the change in response for an ith stimuli right. There are, imagine a situation where there are multiple stimuli. So, the CS there are multiple CS's so let us call them as each one of them let us enumerate them and CS 1, CS 2 etcetera. So, like that there are many such stimuli. All of them are co presented with a single US. If you do that right, then we are asking here, how what will the response be what will be the change in response in indeed be at the end of trial number T where in until now T minus 1 trials have happened. So, at the trial T, how much will the response for CS i alone CS 1 or CS 2 or CS 3, one of the CS alone if I were to present on probe how much of the response change would have would this bring about.

Now that is given by the associativity coefficient alpha i. And times V max we saw that the this V max is totally determined by the US given US and if you do not change the intensity or the interval or the nature of the US then that V max is fixed that V max minus summation of the responses that individual CS's can elicit until now until the beginning of this trial. So, that is what I represent it as V i superscript T minus 1. So, it is not a power, but you have to read it as superscript. So, let us make it more explicit we will call that as within the parentheses so that we know it is actually a superscript. So, using this we try to analyze the learning as well as the extinction data, that is when you present the animal with a repeated CS and US even we know that the animal learns.

And let us say that learning if you plot it out the response behavioral response elicited by the presentation of CS alone. If I had to plot out at the end of or at the that is a function of different trials, we said it is it is going to asymptote like that where each of these, a cross marks denote the data points at this different intervals. And this being the V max which is totally which is totally function of US. So, now that is the learning and we can say we said that we can actually not only model the learning, but the extinction which is also a different kind of a learning. And that is basically a presentation of the CS alone without the US right.

Once the animal has learned the CSUS aspiring it needs the ability to modify itself right. And for you know future case where it turns out that the for some reason the CS is not quite well predictive of US then it need to modify it is response right. That is that is what the beauty of learning is right. It can modify your responses based on the recent experiences our ever past experience. So, one of them is that, if it turns out that the CS is no longer predictive of US, US is no longer pad with the CS then we need to reduce your

response accordingly and that is what happens and we said that is extinction this also could be explained by V max. I mean by setting the V max equal to 0 and could be explained by this Rescorla Wagner equation.

And then we said it is good, that the model there is a model that can predict the learning. Can it explain the three fundamental observations that we that I talked to you about and then from there can we take this model to make some predictions that are not obvious until that point. So, in order to do that we first investigated Kamins blocking experiment wherein we said that if you have to think of a compound stimuli then we have to write down the response individually for the tone and the light. If you when you do that since in a pre learning experiment the response to the due to the tone right.

So, what we did was we wrote down the total change in response right as a response due to tone or rather we did not we the better way to write it is the change in response due to tone at the end of the trial number T, can be thought of as alpha of the tone. The associativity V max which is independent of the tone or the light and summation of tone and the light here. So, the only two terms so we can actually write it as V tone plus V light good.

Both of them measured at the beginning of the trial are beginning of the trial T 1 are the response until the end of the trial T minus 1. When you do that you can what you will see is that when you write for V light in a compound stimuli right it will be exactly the same except we will replace the tone with the light. As a result, if you have pre train the animal really well then what you are left with is this being equal to V max due to your pre training right.

Because so pre training right. So, what happens is that V max minus V max this is 0 clearly. So, as a result this whole term right, this is equal to this as a result this whole term becomes 0 is this whole term is 0 giving rise to a 0 change in response for light right. So, no matter no matter wherever we start, right from the first depending on how well we have trained them right from the first trial onwards in a compound trial where there is a tone pre training we have this being equal to 0 as a result what we see what come in saw which is in a compound stimuli tone inhibits the learning of association by the light, very good.

Now, how do we explain Garcia and Koellings experiment using Rescorla and Wagner model.

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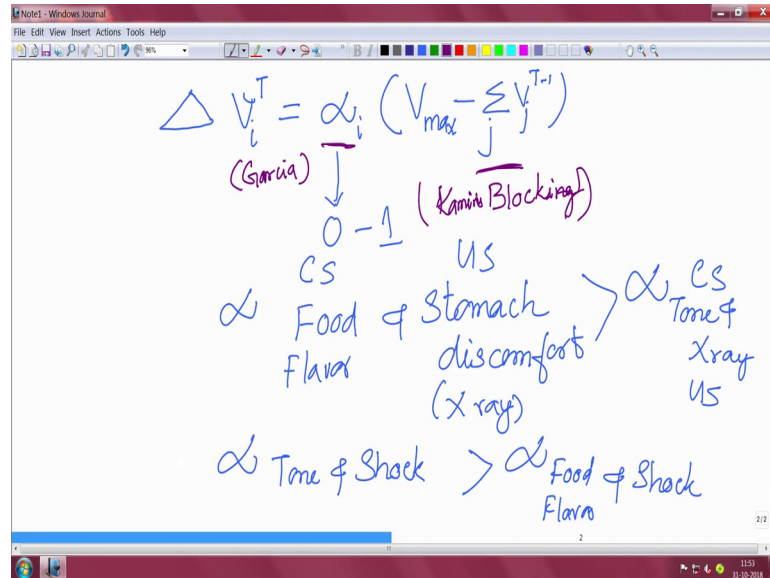
So, one of the key features of this model is the presence of the tone alpha. So, let us write down delta V i in a trial T is given by alpha times V max times V max minus summation right that is the key here. Now this term alpha can have values between 0 and 1. Now Garcia and Koellings experiment what they argued is that; this alpha for food and stomach discomfort right food is higher than alpha for tone. And they induce the stomach discomfort through X ray or lithium chloride in presentation. So, I am going to write it as alpha tone and X ray I am going to refer to that in future as just that.

So, what their inherent argument is the alphas for the US of sorry the CS of the flavor right CS food flavor, with that of the stomach discomfort this association is may high than, this the tone as CS and the X ray as US. However, if you actually ask in the same experiment if you actually ask what is the associativity of tone and shock or for that matter tone light and shock versus if you compare that with respect to the food flavor and shock. They saw that this alpha between the tone and the shock where CS's the tone and shock is the US. See that alpha is higher than the food and the shock food flavor in the shock. So, just by the varying nature of the alpha, alpha being a function of both the CS and the US captures the idea of Garcia and Koellings experiment.

And since the alpha for one of the associative pair is stronger so the learning in the first trial for that association is higher. So, the response change in response is higher thereby that starts to dominate that starts to dominate and then inhibits the in the further presentation of the trials it inhibits the learning of tone and the X ray association. Thus not only Koellings experiment; we can also capture Garcia and Koellings experiments observation nicely within this alpha the degree of associativity. And what we have shown you is that by both the alpha and the summation through the alpha and the summation term we have seen that the Rescorla and Wagner model captures Kamins blocking and Garcia and Koellings differential associativity observations right.

So, I am going to write this as responsible for blocking and this as an explanation for Garcias experiment ok Kamins working and Garcias differential associativity. Now, where is the contingency coming from, so the whole model the we started out this whole story by saying that one of the key features are that people have observed in this associative learning is the animals ability to capture the contingencies of the CS and US that has been present that is been presented. Let us go back and recollect the experiments there we were discussing where of the sort when you are actually presenting the CS illustrated in the blue line here.

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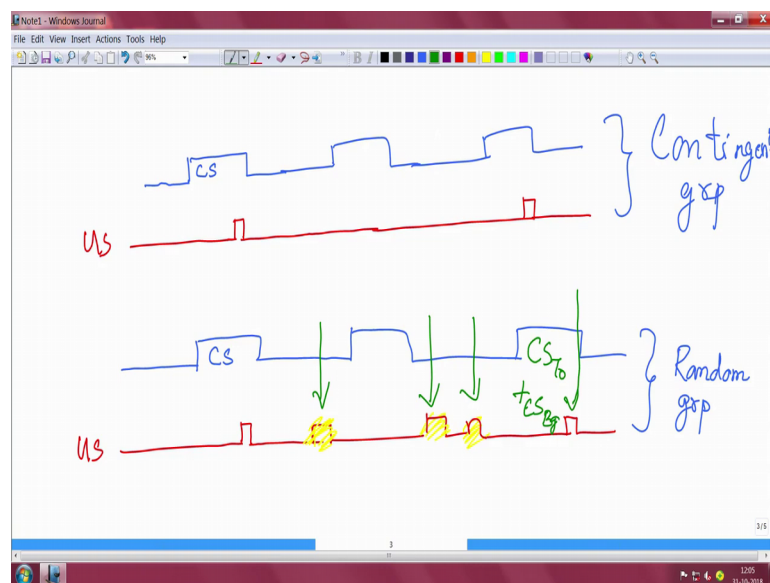
And multiple CS's in a single trial in a single exposure US is presented once in a while. Sometimes in a sometimes present along with the end of the CS, but sometimes not. So,

this versus a totally random manner so the random manner meaning the CS's is pretty much the same. However, the US the electric shock is presented not just along with the CS, but also somewhere in between. Now, when you compare so that is the CS and this is the US right. When we compared these two experiments what we saw was that the animal refused animal did not learn the association of the CS and the US in this group we call it as a random group.

So, during this description of during the description of the experiment I told you that after this presentation even though there are more electric shocks that is been presented more US's that is been presented, the animal fails to develop a response for CS alone compared to this group we called it as a contingent group. Now, how would you explain this because every single event of the CSUS combination is presented equally in here, except in the bottom in the bottom cases you have few extra US's as highlighted here few extra US's. So, we can highlight that nicely this is 1 number 2 number 3. So, these three US are in addition to the US that are present in the previous case. Yet the animal fails to develop a response for the CS. How do you how do you capture that what aspect of the Rescorla Wagner model captures this.

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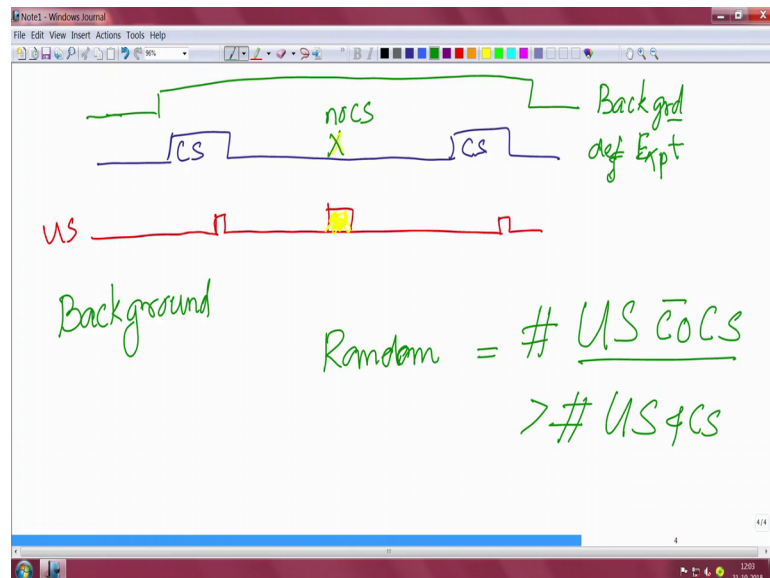
In order to understand this, Rescorla argued when you are actually presenting let us redraw that CS and the US presentations again. When you are actually presenting the US in the absence of CS; the CS here that you are saying that is absent is the CS ok I am

talking about the US that I have highlighted and then that were represent in the absence of so, no CS here right there is no CS. Now how does this affect the learning that is what the question we are asking.

So, their argument was, it is a CS defined by the experimenter the experimenter says; hey look I am presenting the tone and I am coupling that with the US electric shock. And that is the that CS the definition by the experimenter what the CS is that CS is not present. But that does not mean the animal by per say is not receiving any CS at all there are quite a few environmental cues that can act as a CS they call it as background stimulation background stimuli or in general they call it as background. Now the background in the absence of any specific experimental defined or some in some way there is no meaningful definition of a CS that you can see even though you do not see it the animal perceives rest of the stimuli that is different from it is everyday life.

It looks for things that were not present in its everyday life until this point, but it is present there. For example, this could be the fact that, the experimental tip the animal and placed term in the apparatus where it is receiving the electric shock. In that case that whole setting would serve as a background. Now that background the animal associates that background with this US. So, granted the CS defined by the experimenter in this case tone is absent; however, this background is present at this point in time. You may rightly argue; hey, wait a minute that background is present all throughout, granted it, is present all throughout.

So, the way you want to look at this whole experiment is not as a CS US single CS single US pairing, but rather a compound stimuli a compound stimuli involving a experimental defined CS in this case tone and background which you can not avoid, but the animal can pick out other things. So, it is really the CS defined by the experimenter that is present only at this point. But there is also another CS that is present all throughout, until from the start of the experiment until the end of the experiment they called it as background. So, any experiment that you want to do you want to think of that as a compound stimuli presentation paired with the US.

Now, as you can see, if this were to be truly random then what does it mean, a random presentation would really mean by definition number of US presentations without CS would be more than the number of US and CS right. I am here assuming that that time

interval between the CS's are higher than the duration of the CS together right given that since that duration is high. The chance that you would see US in that time window is going to be even if it is a purely random you would expect this to be the highest that is the occurrence of the US without the CS being there, that is the hallmark of randomness. If you have done that or even being equal then what we are doing is that there are more number of pairings of the US and the background then the US and the CS ok.

Now, my argument is going to be that such a biased presentation of one stimuli being higher in number than the other is sufficient enough to draw or to make or suppress the learning of the experimental defined CS, and that is really what is happening here. So, if you go back in this experiment because of this suppression of the US's association with the background. So, you can see the US background associations can happen in this many places. These individuals gain in associative strength such that when real event happens granted this is a summation of CS tone plus CS background coupled with the US here. However when it comes to this point the amount of learning that is left because it is V max is fixed here right so, the amount of learning that is left, the amount of response that it can the animal can increase to the tone alone is very moderate.

If you repeat it enough number of times what I am going to or what I will try to show in the next lecture is that in fact, you would overshoot at this point the animals response to a tone. So, by it corrects itself such that eventually over repeated presentations the CS at the tone acting as a CS alone is not capable of eliciting any response all right. We will see that in the next lecture.