Learning about Learning A Course on Neurobiology of Learning and Memory

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Lecture – 08
Application of Rescorla Wagner Model – III

Hello and welcome to the lecture-8 of the learning about learning lecture series. And so far what we have seen is the development of the Rescorla Wagner model as a good predictor of associative strength or to say the good predictor of behavioral response that one can expect from an animal trained in a behavior right as a function of number of exposures that you give the subject the animal for a CS, US presentation.

So, in a sense the model talks about existence of a maximal response, we call it as v max which is a function of US alone. And there exist associativity coefficient or we call it as alpha in our description. It describes the rate at which the learning can happen right that the fraction of the maximal response that can be associated that can be expected from the animal to exhibit in its change as a change in behavioral response in its repeated exposures.

Now, using those principles, we are investigating or we were actually looking at how one can explain the observations that are seemingly non-intuitive at the first place starting from Garcia and Koelling's experiment of associating to different extent a given CS to different US. When you have a simultaneous presentation of multiple CS with multiple US, there are certain CS preferred to associate with a particular US better than the other. In the specific case, we saw that flavor tend to be associated with the malaise, stomach malaise that can be induced as in US, then a tone or a light. On the other hand, a tone or a light is much more easier for the animal to associate with a shock, electric shock compared to a flavor right.

So, then we also talked about a Kamin's blocking experiment where in CS that is pre learned. If you have pre learned a CS and then the animal has associated with the occurrence of a US, then when you present such a CS along with some other new CS like compound similarity CS 1 plus CS 2 like tone you trained the animal in before, and then you present the tone along with the light in the compound stimuli to signal occurrence of a shock, then we see that learning the tone before completely inhibits or completely

prevents the light to form any association with the shock. We call it as Kamin's blocking experiment. We went through the Rescorla-Wagner model description, and showed how both these effects can be explained using this model right.

Then a little prelude to what we are going to see today is in this lecture is that I talked about how do we go about explaining the contingent presentation being important in acquiring this association for this animal. So, as are I we went back to the example of two groups in a group in which you have the CS and the US being present in a contingent manner on the compared to other group where the TS and the US are presented in a completely random manner.

There is no apparent relationship between the between them at all. And we saw that the animal not only learns better in the control group where there is a equal presentation of CS and US, but in the random group the fail to learn. Now it failed to make any association at all. So, how does Rescorla and Wagner's model captures this.

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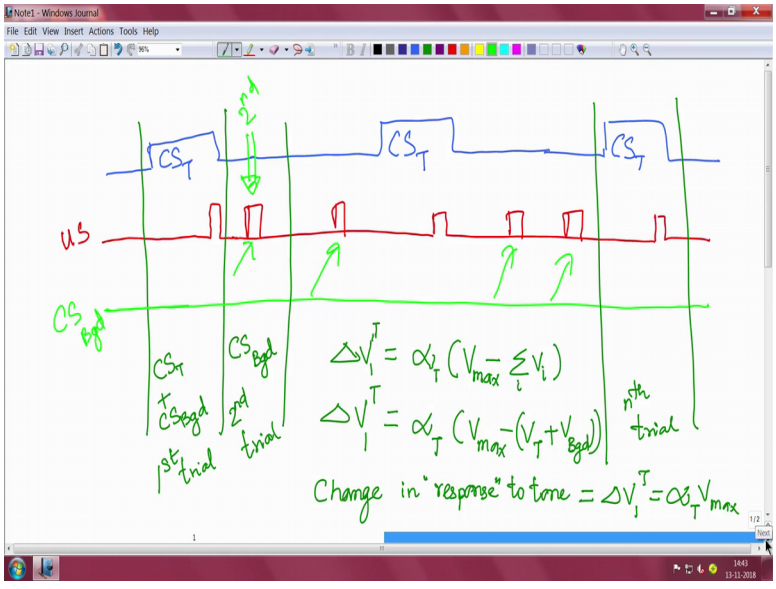

So, in order to understand that I invoke the idea of compound stimuli all right, let us look at the experimental group again. And then the experimental group consists of tone CS let us call it as CS T being presented let us say three times however the US electric shock the electric shock we can think of being presented not just at these CSs, but you also have these US occurring at some random places. In such a case I had said that if you want to talk about learning here, then you need to think of this as a compound stimuli

there were the compound is of tone CS, CS 1 and I said some a back ground CS right CB, we wrote we wrote it as CS Bgd with the background right.

So, even though so where is it coming from, it is coming from the fact that even though we as an experimental did not present any CS any obvious stimuli for the animal to associate with in these occurrences of the US. There is by default a background present all throughout in this case a background in that sense of the animal being taken by the experimenter to into the experimental room the apparatus in which the experiment the tone and the shock has been presented like that there were there could be several stimuli which are unavoidable, but they are present for the animal to associate the CS width.

So, we call that as the background stimuli and back that, background stimuli by itself is not capable of eliciting any response clearly that is why if you do not have the first CS-US presentation, the animal does not have a response is just the way that the any other CS would be. However, when you are repeatedly presenting these CS and the US where you the experimenter does not have did not provide the animal with any CS, the animal tends to take the background as the CS in these cases. So, the view of the animal here would be there is a constant presentation of CS background all right irrespective of whether we have given it voluntarily or presented it intentionally or not. As a result the learning that is happening at these places would be learning due to CS tone plus CS background; while in these places, it is just CS background.

Now, I was arguing in the last class that if you consider that then we can go back and write the learning or the change in the response on a trial by trial basis all right, let us go ahead and write it. So, let us call this as the first trial. I am going to count the trial as according to the occurrence of the US. So, this would be my first trial that would be my the following this would be my second trial and so on and so forth, this will be my nth trial. So, whenever there is an experimental provided CS that the learning will be distributed between the tone the experimental provided CS plus the background. And whenever the US is quote-unquote coming alone without any CS, any obvious CS, the animal tends to associate with the existing CS the notional CS which is a background.

So, if you distribute the learning, then for the first kind of trials where they are co presented CS tone is presented, then in that case you would write the change in response on the learning itself would be alpha. Now, let us talk in terms of the change in response

to just tone alone. So, the alpha tone that is the associate ability of the tone with the shock, and we have the V max this is fixed, this does not change, because given you US strength which is certain milliamperes of current you are fixing that V max minus summation of all the stimuli is responses elicited by all the stimuli right. In this case, we can explicitly write it as delta V 1 alpha tone would be alpha tone plus V max minus V tone plus V background.

Now, as you can see in the first trial there is no response that the animal kennel the V back background by itself or the tone by itself can elicit. So, both of them are 0. So, as a result what you are having is that, your response to the tone increases by alpha amount alpha times the V max right. So, if we talk in terms of the fraction of the V max that has been increased, then the change in response behavioral response here to tone will be delta V 1 T which is alpha T times V max all right.

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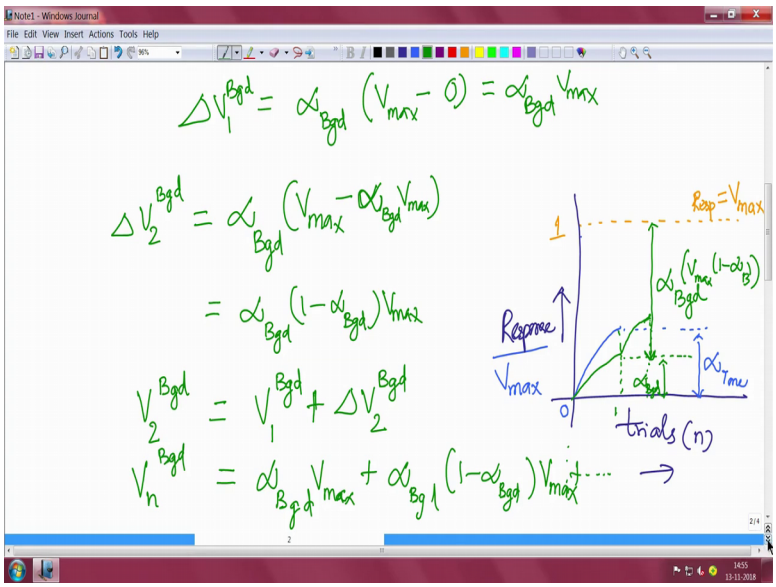

So, now in this trial itself similar amount of change happens for the background too V 1 for the background will be equal to alpha background times V max minus the same summation term that happened as before. So, I can I am going to just in short right does 0, which essentially means Bgd times V max.

So, at the end of the first exposure, if you look at the change in response for the background and change in response for the tone, they both are differing only in their differing by the amount of associate ability that is the alpha value that the coefficient of

association how much ever they are different that much they are different. Now, we can make a reasonable gas here of how an order of magnitude gas so to speak of how the alpha background and alpha tone would be.

Now, let us look at alpha background itself. Now, the alpha background is the associate ability of the background right. So, this is something to do with the visual stimuli that is present there, order cues that are present there, and so many different things. So, in effect you would think that the alpha background is at the best same magnitude as that of the tone or maybe just about if you do a proper habituation and make sure that everything is the animal gets used to we will come to the aspect of how that contributes for the specific learning.

But the point is if you do that, then you can hope to bring the alpha background within an order of magnitude of the alpha tone, but both of them are more or less equal. In such a case, you would see that one can plot what happens to the response all right. If you look at the behavioral response as a function of trials ok, if you plot the behavioral response of the animal, and I am going to stick to two different colors here. So, the blue represents the CS responses elicited by the CS alone; and the dark green would represent the response that is elicited by the background. So, you would see that this would have gone up by that that much where this is our alpha tone ok.

So, what I am going to do is, I am going to make my plotting easy I am going to look at the response divided by my V max ok. So, you can see in this axis then the maximum that the maximum that the maximum response, the maximum value each of them can take is V max, but that V max is equal to 1, because is V max. We are responsible to V max in this place the response equal to V max. And hence in this axis that would correspond to one because I am taking the response by V max as my measure in this axis.

So, let me write it down here this is the line where the response behavioral response becomes equal to that of V max, V m a x ok. So, in such a case, we can actually think of the rise in or the change in the behavioral response as a function of trial as a fractional change in their V max values I mean in their quest towards the V max values which is 1 right. So, in here I can think of this as one alpha has gone up it has gone up by one alpha, so then alpha tone.

And then if we pick up for background assuming it is slightly less than alpha may be to speak let us say halfway down alpha tone. So, we can think of this being the response levels. This is alpha background of the animal to pure background. However, what is going to happen is that next time when actually look at your look at the experimental paradigm next time when the shock comes when there is a US right that is right about here is not it, right about here, second trial. This is the second trial as we have already written.

During the second trial what is happening is that, only the background is present and tone is not present. So, then if you follow the same principle, and then write down the change, then here what we have is just since the tone has not present, so we are only thinking in terms of change in response. This is the second trial for the background will be alpha background times V max minus the summation of both the things present right, so which will be alpha tone plus alpha Bgd.

Now, the way we are actually plotting this graph, and this measure we are actually normalizing with respect to V max. It does not matter. So, let us pull it out like this V max into V max. So, what you can see is that the background the V 2 would increase by the differential amount right, the summation of these two so somewhere here and then whatever the remaining there right. So, let us see here. So, at the second instance, so this is number one at the second instance so what the animal is going to look at is that for the background I am already responding by this much.

So, since there is no tone this is it is not a compound stimuli. So, it is just a pure. So, I need to rewrite this. So, V max minus since it is a simple stimuli for the second trial. So, we can write this as V max minus whatever is previously present which is alpha background times V max right. So, you would see this as alpha background times 1 minus alpha background times V max. So, now clearly alpha being a value from 0 to 1, this quantity is positive.

And what you are going to do is that, you are going to gain the change will be greater than 0. Since the change is greater than 0, there will be a new response for the background which would be whatever the response for the background that was acquired during the first trial when the co presented with the tone plus this new change. Thus you

can see at this point the animal is evaluating ok. I am responding to the background by this much. However, my act maximal response could be that big.

So, it is going to look at it is going to accumulate alpha background fraction of this remaining V max minus V max into 1 minus alpha background or V max minus alpha background the present what we have written here. So, alpha background times just for the brevity and write it as V max times 1 minus alpha B, so that it is going to rest increase its response by that much. So, given the fractions here, so you would expect it to go little bit above are may be equal to the blue line.

And then let us go back and at the third instance what is going to happen is that if again there is no tone, but only the shock is being presented. The background this green curve is going to go up, but the blue is going to stay wherever it is, until a point where the tone and the background is both are presented. At that instance the animal, so let us go few steps more in the third step draw the curve once more.

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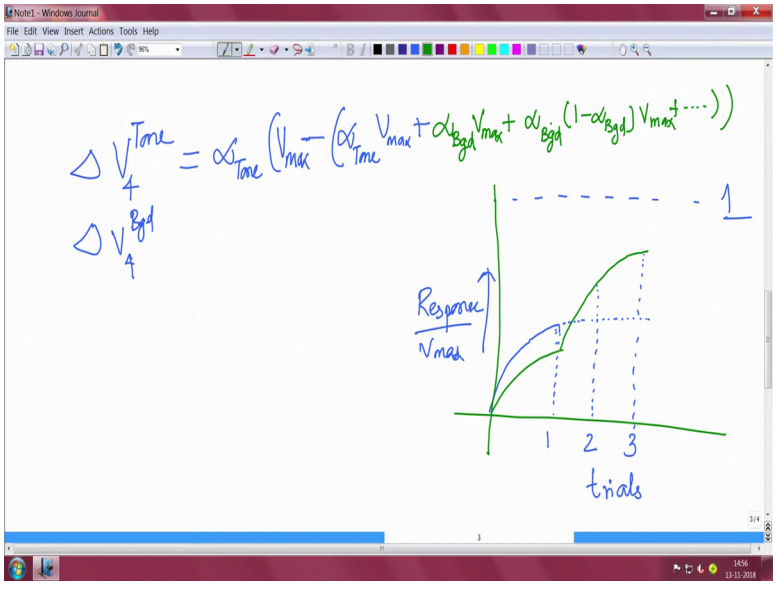

In the third instance, you can see that it is a continuous because there is nothing has nothing has happened; it is a continuous growth of the association. So, here there will be a slight of a little bit of a kink because there is a change in the distribution of the learning, while the tone curve would be will be continuing to remain some somewhere like at this point. So, let us talk about so that is the first trial, that is the end of the second trial, and maybe right about here the third means trial here defined by the occurrence of

the USs, third occurrence of the US. During the fourth occurrence, according to our experimental design, that tone is presented along with the shock so the background is also present; at that point the animal is re evaluating its response we are plotting response by V max in this axis. So, the maximum is one right.

So, when it is actually looking at what it should be responding to then at this point that is at V 4, the beginning of the fourth trial, at the end of the third trial, so then you can see the change then here we have to write it for tone also for the background. So, for the tone, it is going to be it will be alpha tone times V max minus summation of both right until now we whatever has been acquired which is V tone component is just only one time which is alpha tone times V max plus all the background components right.

So, it will be alpha Bgd times 1 minus alpha Bgd and so on and so forth, sorry. At this point at this point in time the response actually we should go back and see what the response is. So, the response here would be the V 1 Bgd we found it to be alpha Bgd to V max plus here we have alpha Bgd times 1 minus alpha Bgd times V max. And if there is a third instance, one can actually go ahead and write down and so forth all right.

So, and go ahead and write down and there is a general expression I think it is a good exercise to look at it. There is a general expression one can obtain for repeated presentations of these things, but however, that is let us not lose track and for every shock alone presentation right so calls the shock alone presentation there is an increase or there is an increase in response for the background and that is given by this.

So, at the end of the second trial just this alone just this alone would be the response. And if there is a repeated presentations in general for nth one, we can write like that. And keeping that in mind now let us come back we have to add in all of this. So, the response would be response at that position right, so that would be for Bgd V max plus alpha Bgd times 1 minus alpha Bgd times V max and so on and so forth meaning terms together and then.

So, what you can actually see is that if every time every single time a tone on the shock were to be presented together are the shock were not to be presented. Whenever there is no tone, then no way the value of the background would have gone up. But because it is been presented all throughout what is happening is that whenever the shock is presented

without the tone, the background conditioning happens at the cost of V max, at the cost of V tone. We will see in the next lecture.

Thank you.