Learning about Learning A Course on Neurobiology of Learning and Memory
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Lecture – 04
Associative learning II: Garcia and Koelling's Experiment, Kamin's Blocking Experiment

Hello and welcome to the lecture 4 of the Learning about Learning Course. And, in the last lecture we talked about the various associative rules that govern the strength of association, when it is found in an animal right do in response to learning. Mainly, we talked about how the probability of US occurrence given a CS or happened and the probability that the US will occur given that the CS has not occurred ok. So, the associative strength depends on both these probabilities. Probability that the US has will occur in the presence of CS given that CS is occurred and the probability that the US can occur in the absence of US, in the absence of CS.

Both of them together determine a fundamental quantity called contingency; we said that determines the associative strength. And, we showed and we talked about an experiment done by Rescorla wherein he introduced the notion of positive contingency, zero contingency and most importantly negative contingencies. I said the existence of negative contingency is a direct proof that it is the contingency, there is the probabilities of the US occurrence given in the presence and absence of fears that governs the associative strength and not just a simple co-presentation of CS and US.

What are the thing can actually determine the associative strength, let us step back a little bit and look at what association are we talking about. The association here we are talking about are between two stimuli right. These are any environmental factors, any sensory information that comes in to an animal that has some unique properties. We classified them as unconditional stimuli and conditional stimuli based on their ability to elicit a response by itself or not being able to elicit a response. Now, if you think about what use thus an association will have for an animal, when you are talking about making this association between these two stimuli, clearly it boils down to survival. And, somehow this learning has to help the animal to survive in the environment in a better way.

So, in this context it is a little bit naive and simple to assume that every unconditional stimuli is equally probable to associate with the conditional stimuli. This not be the case and it is not the case, if it is not the case can we do an experiment to actually check it. Now, Garcia and Koelling set out to do this. They did that using the, a theological behavior exhibited by the rodents. One of the important vital tasks for the rodents is to be able to expand their food palate right. So, if you think of a rodent the rodents survival ability depends on their ability to find the food from various different sources.

And, they go ahead and look get the food from burrows, under grounds and so on and so forth. It can be a huge menace and people try to get rid of the rodents, we through various different means. One of the important characteristic that Garcia and Koelling made use of is called as bait shiners. What it means is during this process of trying to exterminate these rodents, what people discovered is that when you present a poisoned food alright. So, you take some amount of food that you know that the rodent is found of and you mix a little bit of poison in the poison that food.

And, then present it in a place where the where you suspect the animal is actually coming and eating the food. It does not seem to work that well, the reason being what I call in a in a very jovial fashion; the rodents are as smart as the human beings to. They learn that this is a poisoned food; I should not be going and eating that. How do they learn? What they do is that by nature they there is a novel flavor that is present, they are a little bit aversive towards eating that novel flavor completely. They go ahead and eat a little bit you, they do not want to avoid altogether because, if you avoid altogether you reduce your palate; you there is no scope for expanding the food palate. So, you want to have keep that ability to expand it right.

So, you want to try out a little bit. If it causes a sickness or some kind of a malaise you do not want to go and eat that. What these two people Garcia and Koelling noted is that this kind of amylase tends to be associated with the flavor more than anything else. Anything else here means the animal does go back to the same place and in search of the food. They eat the other food, but not the poison food that is the key here. The key is you can actually see the danger or the aversiveness of a particular flavor; a particular food is associated more easily to the flavor and not necessarily to the place. Clearly, if you do if the animal goes back to the same place again and again and all kinds of flavors do end up

having poison, they do they will not go there ok. That is, it is not that they cannot make an association with the place at all.

But, instead what it turns out is that the inclination to make that or the threshold to make that association is higher for certain stimuli such as space compared to stimuli such as flavor alright. So, how would you test in a laboratory sitting?

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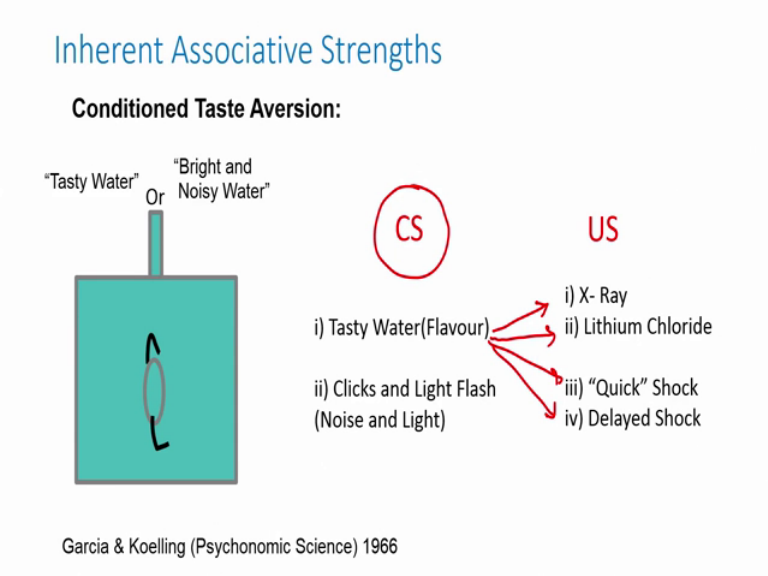

What they did is that they took these animals and then train them; they called it as tasty water or bright and noisy water. So, what it amounts to is that the rat here is allowed they are water deprived and they are allowed to lick on a spout. And, in response to that lake multiple things happen: one is that the water droplet comes in, this water droplet could be flavored; you call it as tasty water or in response to that lake there is a flash of light along with the noise that triggers on into the into the chamber. So, when the whenever the animal gets a taste I mean the flavored water they called it as a tasty water stimuli.

And, whenever you get a flash of light and a noise you call it as a bright and noisy water stimuli. After training them in this scenario for a few days where, they acquire their ability to actually go and then lick on that spout of the water to act take this water. They say they asked now hey look I am going to take this as my conditional stimulus and then try to pair it alright, pair it with different kind of stimuli ok. I am calling them as US. So, naturally they are having an ability to elicit a natural response. For example, X-ray here

is known to cause systemic malleus. If you take an animal and then extradite in certain dosages, they can they can cause gastrointestinal disturbances and nausea.

So, the animal does not like that, I mean it is a discomfort that they tend to associate with is known to associate with food. They are similar to that of the discomfort that is caused due to the bad food. Lithium chloride again the same thing, it causes stomach upset even though it tastes pretty much like sodium chloride, is a salty water. It is known to cause stimuli stomach upset. The other US'es are a quick shock, inside this cage there is a floor or a grid of steel rods. What they what they have done is they have wired up to the to these steel rods such that whenever the animal licks on that spot, if required one can present electric shock a mild electric shock. You can do that right away or in a little time later.

So, they called it as quick in their paper they refer to as immediate shock ok. I am going to reserve that immediate word for something else which they have the effect of which they do not know about in 1966. So, what I am going to call them or rephrase them as quick shock ok, there shock is delivered reasonably immediately ok. The other option is that you delay that delivery of the shock a little later.

So, clearly there are different kinds of users each of them can elicit the response, but they are different kind. So, the idea here is I am going to take this and then combine with this, take this combine with this or any of this. And, then ask how well does the animal associate or remember when I say how well an animal associate, we are talking about CS acquiring an ability to elicit a response alright. The elicits a response independent of US that is what we call it as an association ok.

So, I want to make sure that is clear; in here there could be different kinds of responses, but the point here is whatever the response that we are talking about that response did not happen before the CS is presented along with the US ok. CS once you present to it the response develops and how well is that response developing that is what we are measuring good. So, what did they observe?

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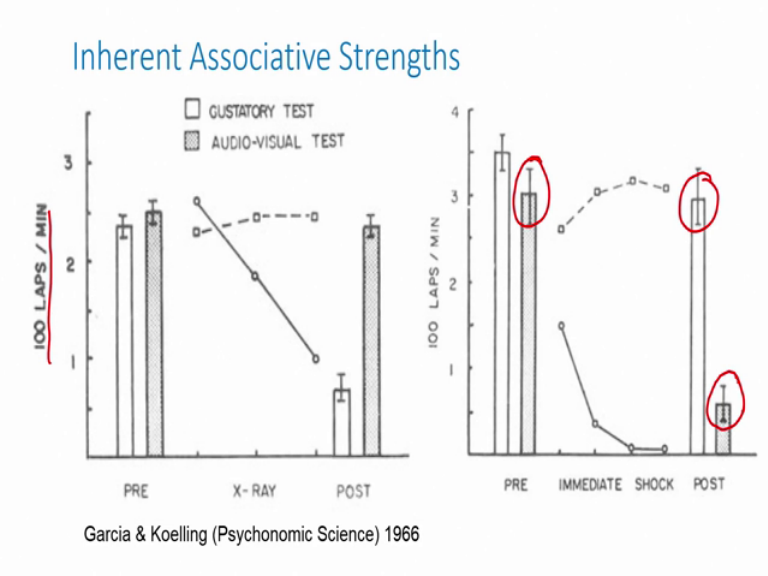

They went ahead and did this a pre-training, which is a training in which you are the animal is presented both this flavored water and the plain water which is the bright noisy water they called it. And, asked is there any difference between the flavored versus the bright and noisy water. So, they do that by two kinds of test which one is one they call it as gustatory test and the other one they call it as audio visual test.

It is nothing but, you can take it as a audio visual test is when the animal is kept inside the chamber is going to lake. And, in response to that lake plain water is going to happen and you have a flash of light along with the tone ok. Gustatory test is when the animal is going to get a flavored water in response to its lick alright. What you see is that they are both equally preferred, it is not the amount of water intake is pretty much similar.

So, how do they measure it? The measure that you see on the right hand side, I mean those on the left hand side axis is from an electronic lick-o-meter. It actually measures how many licks the animal is doing per unit time, in here it is per minute. And, you can see the rate of licking is pretty much the same for in both the tests. This is before taking this US and then pairing with any of the CS'es.

So, for pairing with different US'es there are four different options we have talked about and let us look in; so, there are four different groups of animals they were using. So, let us look at one of them which is X-ray; when you do that you get when you are again looking two kinds of animals here. The animals with the squares here represents the

animals which do not have any reinforcement, which do not have any X-radiation ok. Just you are taken and then the animals are brought back after 3 days to the same chamber. Again you measure it, brought back to the same chamber again you measure it, but these animals the circle animals.

So, these guys alright those guys are the groups which in between this time underwent an X-radiation treatment, X-ray radiation treatment which means the next time when they come in they tend to take less amount of water ok. Clearly, here they are presenting only the flavored water and in the in response to that licking and they are progressively taking lesser and lesser amount of water.

Now, what they want to ask is I am going to now test, having exposed these animals to this training paradigm wherein, you can lick. In response to the lick I am getting a flavored water, after this exposure I am this animals are taken and then given an X-radiation that causes stomach malleus. And, they waited for about 3 days; the reason why they waited for about 3 days is to let the animal recover from any malleus that is induced by this X-radiation. And, then let us see how their memory gets encoded or association gets developed alright.

So, you do that now, I am going to test it. How I am going to test it? I am going to bring the animal back to the chamber and then offer them these two choices: flavored water alright and do this audio visual test too. And, what you see clearly is that they associated the in the post test they have associated the X-ray radiation stimuli with the flavor as you can see from the gustatory test.

So, when you are testing you are provided with the flavored water or a bright and noisy water. So, if you if you are checking for the bright and noisy water they are good. If you are checking for the gustatory, I mean a flavored water they are not drinking that much water. Now, they said this is all good what if I go with this what you kind of expect right. Now, what if I go with compound stimuli alright they had to do that.

Because, if they were to combine the CS with different kind of shocks, we are talking about that quick shock or the delayed shock then this has to be contingent on the animals response right. If the animal does not go and lick on the plain I mean on the spot with the bright and noisy water, you cannot deliver a shock right. So, there they in this combination the way the experiment was done is the apparatus consisted of two spouts

now. A spout which can deliver let us say bright and noisy water and the other spout that can deliver the tasty water. Once you do that then you can actually ask you can combine them and then ask, hey look how well do they do in the pre-test and you give a shock. When you do a electric shock, they tend to associate this electric shock more with the tone or the bright and noisy water then the flavored water.

So, you can see here the amount of consumption of the bright and noisy water has come down compared to this, while that of the flavored water stays exactly the same. Clearly, the electric shock has a higher propensity to be associated with the auditory and the visual stimuli than the flavor right because, you see every lick during the acquisition phase every lick in these animals produced an electric shock.

So, they could have easily associated with the flavor or the tone and the light. But, that when you are actually pairing them with the shock what you see is that, they associate more easily to the electric shock, that the tone with the electric shock. Suggesting that different US'es have different propensity of association with the CS though from this paper it is not very clear the exact details of X-ray irradiation experiment.

But, later studies have shown that you can actually combine the lithium chloride group right. So, you see here in our experiment you can combine this lithium chloride group or they call it as a salty water experiment along with the shock. So now, you have a possibility of compound stimuli and the multiple US'es right. And, then ask hey look what is happening here and the results described in this paper you can too you see that stomach malleus you the US of stomach malleus has a higher propensity to be associated with CS'es of taste while, the electric shock has the higher propensity to be associated with the US of CS of tone and light. The point that we want to drive across is that, not any two stimuli cannot be associated in all degrees right.

They have different propensities, some of them have a easier association and some of them can form these association easily while, the others take require a higher number of trainings or have a higher threshold. That being said we have now addressed two of the criteria's that determine the associative strength. One is the contingency, number 2 is the nature of the US and the CS, third and one of the most important experiment that really determined the basis of the framework that we are planning to develop here for understanding the associative strengths in learning and memory is done by Kamin. What

he his question was: what role does prior learning play in an compound stimuli presentation.

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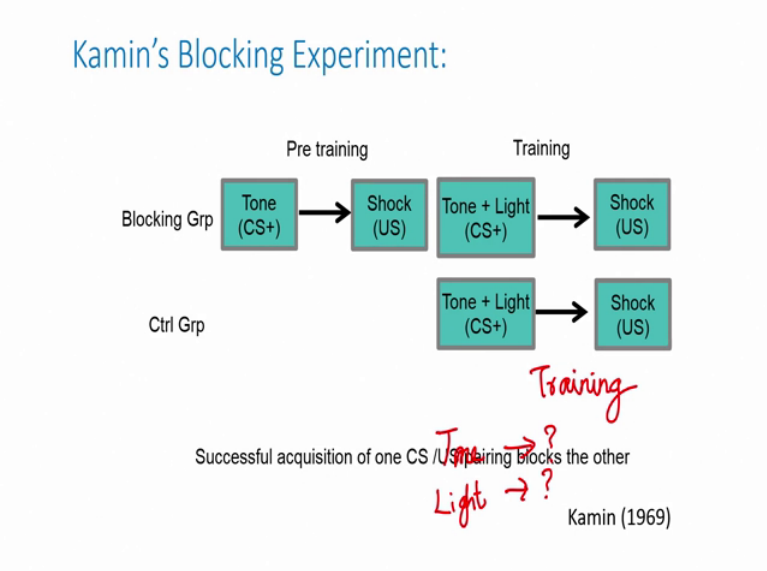

So, in order to address that he was doing this experiment wherein, there is a tone and the light used as a compound stimuli and then associated with the shock. When you do it time and again what he realized is that both later on and what you can actually do is this is the training phase, later on you can go into the testing phase. During the testing phase you can either give a tone and ask what is the response or you can give a light and ask what is the response. What he found was both of them show a similar amount of learning, both tone and light is capable of forming or developing a response when paired with a US of shock electric shock.

In this another group what he did was he pre-trained the animal wherein, he presented the tone and the shock repeatedly until a point where the tone by itself can elicit a response. Took these animals and then presented them with the compound stimuli having tone and light together. Idea here is, if the animals have learned this tone and sharp paring before now, does it help or hurt the association of light and the shock when presented together. What he saw was that when you do it after pre-training, the light could not develop a response, could not form an association with the electric shock at all; now that was an astounding result.

Because, what you see is the it is not that the light by itself cannot form an association, but the light whether the light will form an association in a compound stimuli or any stimuli for that matter will form an association depends on the rest of the ability of the rest of the stimuli to elicit a response before itself. Suppose, if I had trained the animal in light and shock granted it is a little bit harder, but if you can do that and then did this same experiment, the prediction here is tone would not be able to form a association with the shock.

So, whether in the compound stimuli why would an animal pay attention or pay develop a new response, if it already knows one of the stimuli is going to get associated maybe that is why it is not forming a new associations. That was the reasoning Kamin was giving, when such a kind of reasoning are very useful and insightful it would be more purposeful and useful. If you could develop a framework, a mathematical framework description that can encompass all of these observations and maybe allow us to make new predictions that would not have been possible without that framework.

So, what I am looking for is or what I am going towards is to how do we summarize all of them in a nice crisp mathematical descriptive manner, mathematical framework in through a mathematical framework that gives you a description that which can explain Kamin's experiments, Garcia and Koelling's experiment and Rescorla Wagner's positive Rescorla's positive zero and negative contingencies. Rescorla and Wagner two of the prominent scientists went ahead and developed these frameworks. What will do is we will just take a glimpse of the framework. And, then in the next lecture we will see at length what this framework is all about.

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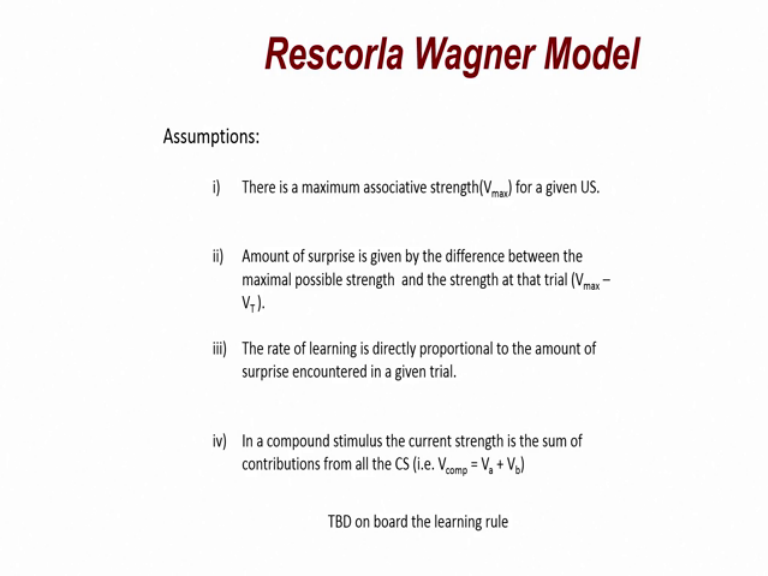

The framework goes as follows, they said looking at all of these observations there seems to be a maximum amount of associative strength that the animal can develop and this seems to be dependent on the US alright. If it is a electric shock of a particular current strength, then that has a V max of say 0.45 or some unit ok. If that electric shock changes in current value then the V max will change but, then for a given strength of the electric shock that is the maximum amount of learning; no matter how many times you keep repeating it. Once, it reaches there it just stays there and it saturates.

Second this realize that the amount of learning in each exposure right you are you are not learn I mean many times we do not learn in one trial right. We keep repeating it again and again, in such case we want to know when we repeat it again and again many number of trials as we proceed forward how much is the learning, how much is the contribution of this trial to the learning. So, that they said is dependent on a quantity that they defined as a surprise and the maximum amount of learning here is directly proportional to the surprise that is the statement here.

So, the surprise is quantified by the difference between my response at this point in time and the response that I could have at max right. So, for every US I can develop a response every US strength I can develop a response to a particular strength right that is what this first hypothesis or a first assumption is; let us call that as V max. And, surprise is simply my response difference the V max, to be precise it is defined as V max minus V

t where, V t is my present response. The sign is important here, if you depending on that you can learn you can increase your response or decrease your response.

You will see that you know when we talk about specific examples. On the third main thing is that when you are presenting a compound stimuli right, like the stimuli of Kamin right tone, shock or stimuli of Garcia and Koelling flavored plus the bright shiny brightness noisy water. So, in such cases the compound learning is a sum of learning from individuals or in other words whatever the learning that in that gets incurred in a compound stimuli is distributed among the different CS'es ok. So, let us keep that in mind and when we come in the next lecture we will precisely state, what this in a mathematical form.

And, then through few examples we will see how Rescorla Wagner models, the model that we are proposing to state their has explained things that are apparently non-intuitive in a very tractable and a possible way. The hope is after that I would be able to highlight some of the predictions that would not have been possible just by looking at individual experiments; the predictions from Rescorla Wagner.

Thank you.