Cognition and its Computation

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Lecture - 53
Problem Solving

Hello and welcome back. Today we are going to talk about Problem Solving. Now what is problem solving? Today we are going to discuss how we solve problems, how we what are the strategies that we take, how we look into each problem and why do we look at problems in different ways via the individual differences and what are the what are the neuroscience behind problem solving. We will take a brief look at that, but today we are going to solve some problems in the class itself.

So, I will give you some problems, you can pause the video go through them try and solve them and before you look into the solution. So, to start with problem solving how many problems did you solve today. So, when I ask this to most of my students they will tell me that well I solved a mathematical problem, I solved an engineering drawing problem or a chemistry problem and so on.

But, believe me that you are paying attention to this lecture and you are going to do certain tasks as the lecture proceeds that is the part of problem solving activity, when you look for your key and when you are trying to fix it to the lock while coming out of your room that is the part of the problem solving activity. So, in everyday life we use problem solving strategies in almost everything we do.

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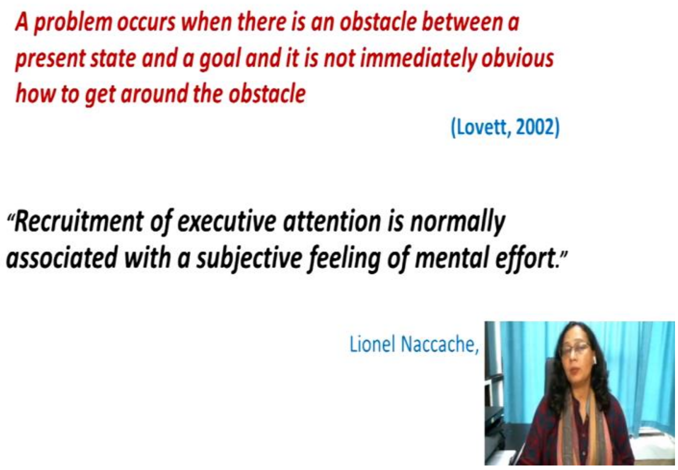

But, then what is problem solving as per the technical term. So, a problem occurs when there is an obstacle between the present state and a goal and how to reach that goal is not immediately obvious.

Now if we look at it from a more scientific point of view as Lionel Naccache said in 2004, "It is the recruitment of problem solving is the recruitment of executive attention and is normally associated with a subjective feeling of mental effort". There are of course, a slight variation with it. There are some problems that we solve without our conscious knowledge; come let us take a look at it.

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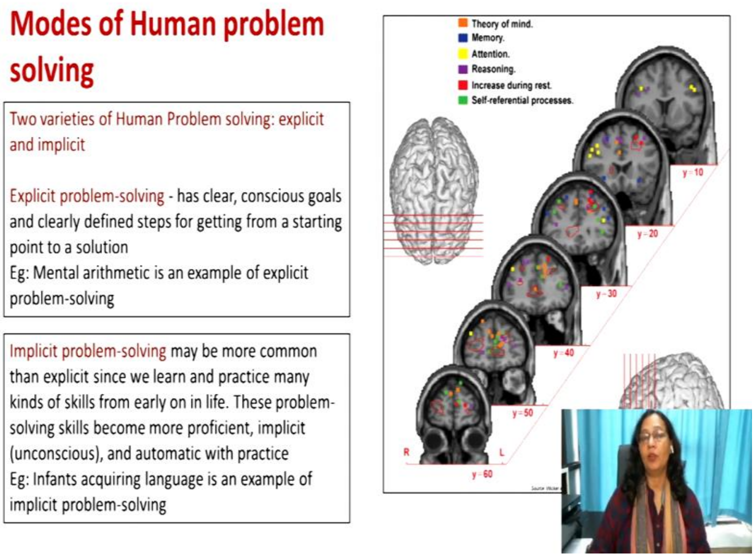

So, the different modes of problem solving are implicit problem solving and explicit problem solving and in explicit problem solving there are clear conscious goals and clearly defined steps from the start to the solution and if you follow these steps properly then you will reach the goal.

An example would be solving a mathematical problem, doing a mental arithmetic. Implicit problem solving on the other hand is more common, but we are hardly aware of it why? Because it happens without our conscious effort just now I was telling you that well there are some problems that we solved without our conscious effort and this is because of the skills that we have developed through experiences in life and these problem solving skills become more proficient make may make us do more automatic activities with practice and.

So, a classic example would be speaking two languages together a child acquiring an language is an implicit problem solving task, but especially the rules of grammar.

The child does not consciously not necessarily always learn rules consciously, but say if we if I start talking in another language right now while talking in English you will be able to understand that I have shifted a language and there may be some break say a word or two break, but when I come back to English again you will sort it out, you will solve it as per my gestures or the intonation that is also a problem solving task.

If you are familiar with the language switching the language if I switch from English to German, the switching of my language from one to the other and coming back again to English, it will not disturb or deter your information processing. Now why does that happen? It is because of the skill sets that you have learned in these two languages that have made your profession to transfer from one to the other very flexibly.

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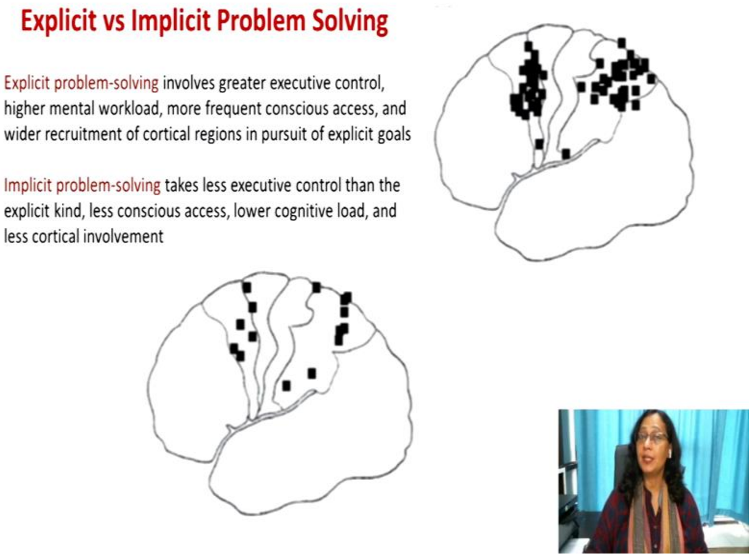

So, in explicit problem solving we see greater executive control, higher mental workload and more frequent conscious access and wider recruitment of cortical regions in pursuit of explicit goals, while in implicit problem solving that takes lesser executive control and is has less conscious access is a lower cognitive load and has less cortical in involvement.

What does that imply that when we are doing a and you know task at the back end or rather I should say that there is a back end processing of a task that is going on in the brain that would be that would take up less cortical involvement.

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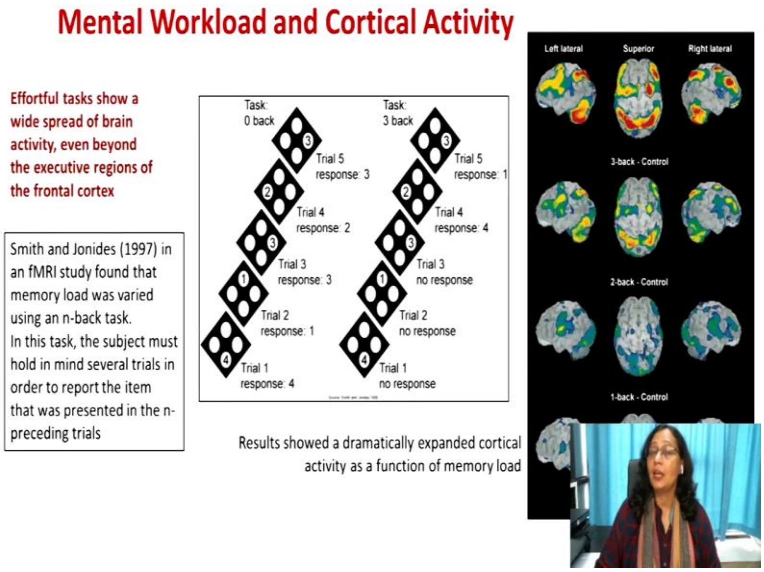

So, less cortical areas that are engaged and it would be of a lower mental effort or lower cognitive load and as compared to higher cognitive load or higher mental workload in explicit problem solving. So, this works implicit problem solving works at the back end. So, what it does is it improves our abilities and that is what actually makes the difference between an expert and a novice. We will come to that little later.

So, what is mental workload and what is cortical activity and how does this differ. Now let us look at a study that was done with n back ok. n back is a cognitive test that is used as tasks for checking out cognitive activities especially with working memory and this experiment showed by Smith and Smith and Jonides in 1997. In fact, they look wrote a book on this in 1999.

They showed that effortful tasks have a wider spread of brain activity even beyond the executive regions of the frontal cortex. We studied about the executive reasons, these are the frontal areas of the brain especially the prefrontal cortex areas and the this Smith and Jonides in their fMRI study they saw that memory load was varied especially when you are doing a smaller n back. So, if there is a 0 n back. So, n back task is when you have to remember what was said in the last session.

So, that in the last trial what was before that that would be 1 n back 2 n back and 3 n back ok. So, 3 trials earlier what was said. So, say it is a different configuration that one has to remember. Now they showed that as the complexity of the task increase there were more areas in the brain beyond the cortical areas that were activated. So, we know the executive cortical areas, the executive cortical areas we know that they are engaged in thinking activities.

And we also know that generally these are the areas that are involved in working memory, but when there is an effortful task the whole brain seems to be active. You look at these three images there is a lot of firing in the occipital lobe in the frontal lobe in the parietal areas, so even in the temporal areas.

So, there is a lot of active firing because the brain comes when it is an effortful work the brain gets engaged in solving the activity in the task in a more integrated fashion. Now, one very important thing to note over here is this is more with tasks that are more explicit. In implicit problem solving there are lesser engagements of cortical activity. What happens in implicit thinking?

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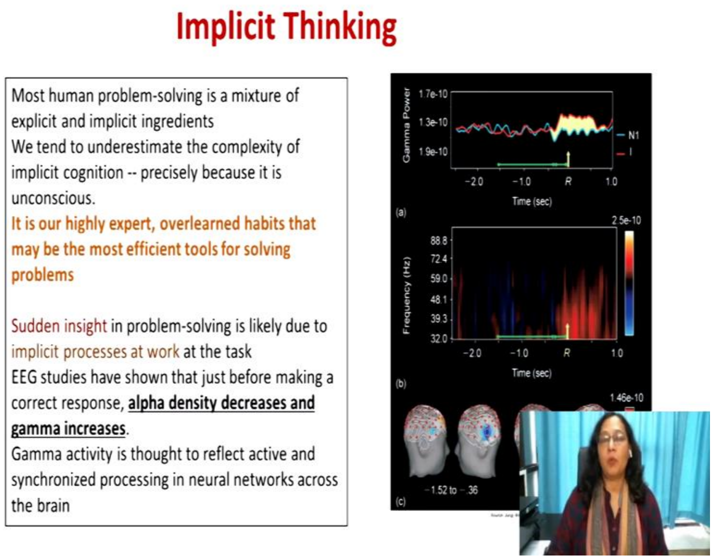

And we see that most human problem solving is a mixture of implicit and explicit tasks or explicit ingredients and it we do not understand the role of implicit problem solving primarily because we are not aware of it its unconscious and it is our highly expert over learned habits that may be efficient tools for solving problems.

For example, expert check clear they can remember more than 7 to 8 configurations for a particular state in the board. So, this as compared to how to depict the subject this is compared to novices is makes the difference of an expert and a novice. Now how do they remember this? Over practice over multiple sessions in time they have this has gone to their long term memory.

And this also helps them for the sudden insight. So, if there is so we have talked about insightful learning earlier and we have talked about trial and error bringing about insight. You see how this is very closely linked with learning. So, sudden insight in problem solving happens when implicit processes are working at the back end and EEG studies have actually shown this and they show that there are alpha density decreases and gamma increases.

Gamma is supposed to be engaged during or active during thinking processes. Especially when there is active reflective thought. So, this shows that even when you know when an individual is doing implicit processes the brain is at work it is just that it is not so effortful. Now let us look at a couple of problems.

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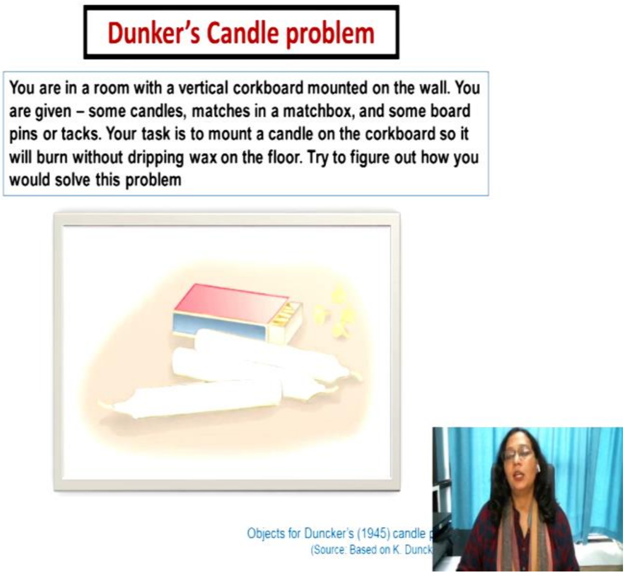

Let us look at before we get on to what are the ways that how a problem solving affected, how can we improve problem solving and how is it hampered. What are the properties or what are the factors that affect problem solving? So, before we get on to that let us look at this Dunker Candle problem. It is a very famous problem given by Dunker in 1945 and what he did was he gave this problem.

You are in a room with a vertical corkboard mounted on the wall and you are given candles matches in a match box and some bold pins or tacks. Your task is to mount a candle on the corkboard. So, it will burn without dripping wax on the floor, how would you solve this problem? Pause the video over here and try and solve this problem before you get on to the answer, I will move on.

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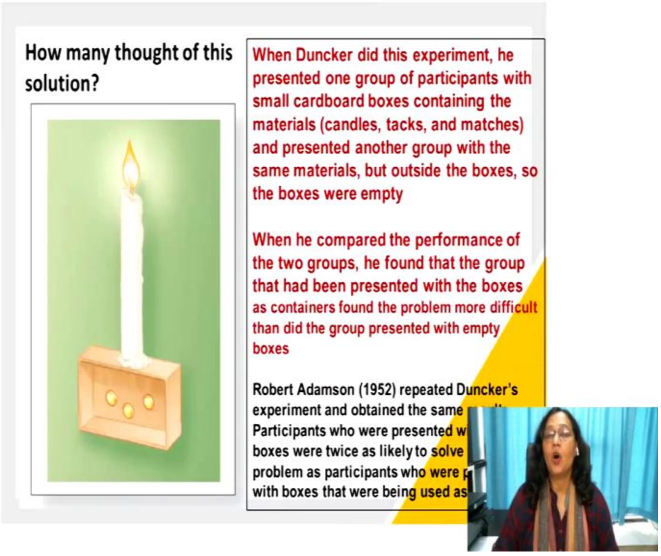

So, how many thought in this solution of pinning the match box opening it taking out the match stick pinning it on the wall and putting the candle over there, when Dunker did this experiment he presented two groups of participants with two separate states. So, what did he do? In one he gave a cardboard box full of candle stacks and matches.

And in another group he gave the same materials, but outside the boxes. So, the boxes were empty. So, the match sticks were not in the box and when he compared the performance he found that the group that have been presented with the boxes as containers found the problem more difficult than the group presented with empty boxes.

So, if the match box will give in as empty with the match stick outside they could think differently. So, it is very important as to how the problem is presented and Adamson in 1952 repeated Dunkers problem of 1945 and he received or any for similar result. So, this is you know this brings us to another very important factor for problem solving.

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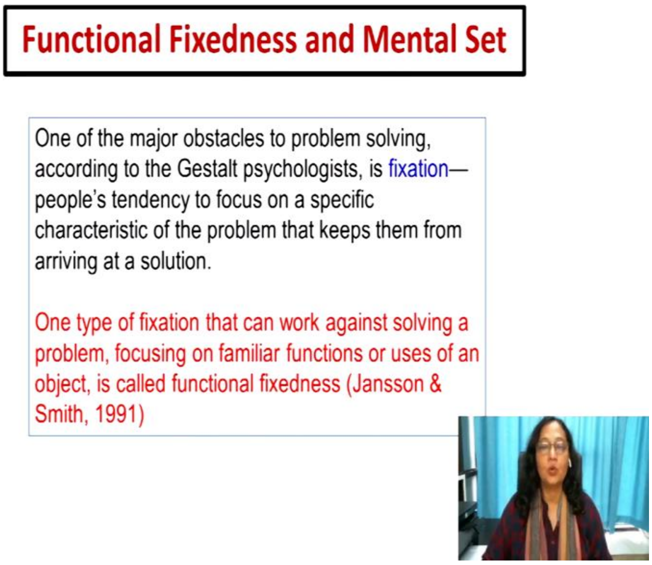

And that is functional fixedness and mental state. We will come to problem representation once again, but again. So, how we look at the problem affects problem solving ability. The other is how we if there are a prior ideas may also hamper problem solving. If you just go back to your; you know just think about the lecture on forgetting and learning memory and forgetting. So, you will see that we spoke about interference and we spoke about proactive and retroactive interference.

Proactive interference is when the new task that you are learning is affected by what you have learnt in the past. So, if you give the example of riding a motorbike and driving a car. So, if you use your left leg for the gear in the motorbike when you come back and learn a car when you start learning a car the automatic response is to try to press the gear with the left leg, but so what happens is learning to drive the car may take longer as compared to somebody who does not know how to ride a bike.

So, this is because of again this is the same process that happens in problem solving or it is known as functional fixedness or a mental set. Mental set can actually help problem solving, but it helps when as we just discussed about the chess player when the moves are known when the problem is similar, but when the problem is not similar then the prior knowledge may act as a hindrance and this is one of the major obstacles to problem solving.

And this is this was propounded by the gestalt psychologists who did a real a lot of work on problem solving and insightful learning and so one type of a fixation that can work against solving a problem focusing on familiar functions or uses of an object is called functional fixedness.

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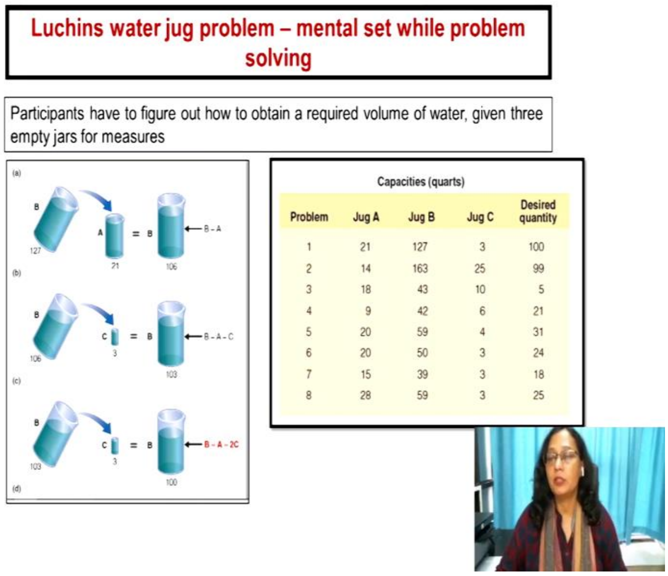

Problem	Jug A	Jug B	Jug C	Desired quantity
1	21	127	3	100
2	14	163	25	99
3	18	43	10	5
4	9	42	6	21
5	20	59	4	31
6	20	50	3	24
7	15	39	3	18
8	28	59	3	25

Now, let us look at an example. So, this is again a very common problem classical problem I should say Luchins water jug problem and this shows how mental set a previous mental set a prior mental set can affect problem solving ability. So, if you look at this first problem. So, participants have to figure out how to obtain a required volume of water given three empty jar for measures.

So, you have three empty jars and you have a pond from where you need to pick up the desired quantity of 100 litres say or 100 quarts whatever. Now the for this 100 unit of water you have a 3 jug, 1 jug has a capacity of 21 litre 21 units the other of 127 units and the third one of 3 units.

Now, how do you make it as 100? I have just given the solution over here. So, you can try and do it yourself for all these problems. So, the easy way would be that for 127 you pour it on the jug which can hold 21 units. So, now, what do you have? You have one you have 106 units and you have to get 100. So, you pour 3 units twice in jug C, got it.

Now, I have given the demonstration of it over here. Now let us move on to the next problem. If you look at the next and the next and the next and then on you will see that it uses the same strategy. Why do not you do something you, try and solve this for yourself. Now you will see pause it here and try and solve it.

Now, you will see that after a certain series of problems there is a change say in 6 problem number 6 the strategy is different. Now what happens try and do this yourself do this experiment on yourself or on anybody else. You will see that as the individual become familiar with the strategy the time taken is less. So, by the time you are doing the 5th problem you are doing it fast much faster than the amount of time it took you to do 1 problem number 1.

But when it comes to a newer strategy so in 6, if you start with 6 you will see after 5 if you go to 6, you see that you take much longer ok. Now how will you know that the complexity of problem 6 is not making you take longer time? Give this problem with say try and do it with two different people.

So, with one person you start with problem 1 with another person you start with problem 6 and then you give 1. You will see that this time 6 if you do a similar problem without this prior knowledge of 1 to 5 without this mental set of solving a problem in a particular way.

Then you will take this problem of solving this time of problem solving problem 6 and the duration from for solving problem 1 will not be very different, but if there is a mental set already created because of solving problems of the similar fashion the moment this strategy is changed it takes longer. So, this is the cause of mental set or doing problems in a similar way. Now, just to now this is what affects thinking out of the box.

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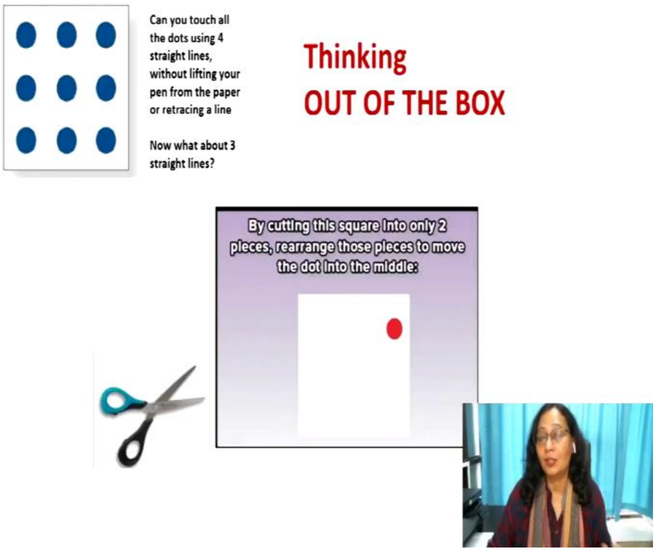

Now, let us look at how thinking we can think out of the box. Now if you look at these nine pins or nine circles can you touch all the dots of the using 4 straight lines without lifting your pen and without lifting your pen from the paper or retracing a line; now can you do that with 3 line? Ok now pause over here and try and do this. Many people do not move out of these circles. They try and solved this within the circle that is why, why do we do that?

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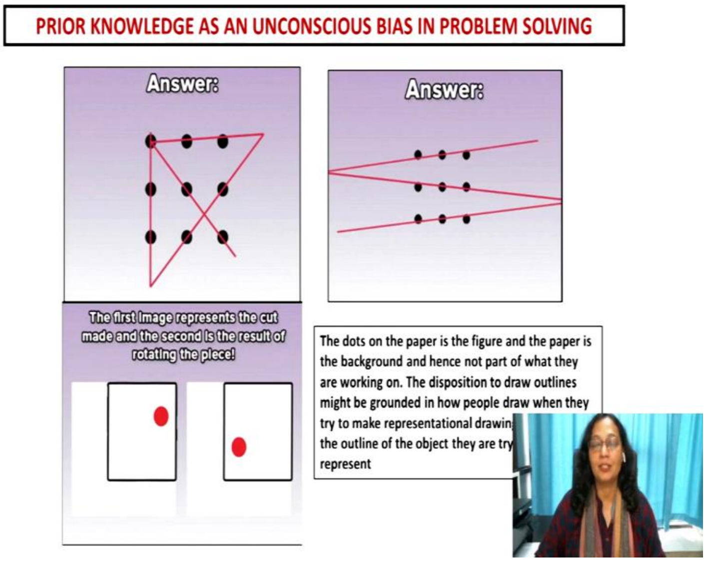

Because we have been trained to keep our writing keep our diagram within these four boundary. So, we do not we do not think out of the box. So, one solution is this and the other with three lines is this. So, you see one has moved out of the box. Now, you know what one of one child whom I had given this problem, what she did was she put small dot of the pen and he took a broader pen broader marker and put it straight across all the 9 dots were small.

So, it covered the whole thing in one straight line that is creativity. She had not restricted herself to thinking that it has to be done within these lines. Now because this was a small girl she did not have that you know prior mental set of putting things within the box. So, sometimes functional fixedness does affect our thinking or does affect our problem solving strategy. Now look at this by cutting this square into only two pieces rearrange those pieces to move the dot into the middle.

If you look at the solution ok, the dots on the figure and the paper is in the background and hence does not is not part of what they are working on. So, what you need to do is you just put this the first image represents the cut and the second is the result of the rotating space.

So, you cut this part of the paper this part of the paper and simply turn it around. So, you just you followed the strategy of cutting the paper and putting the dot in the center. Try this on your friends and see how many could do it or whether you could actually do it as well.

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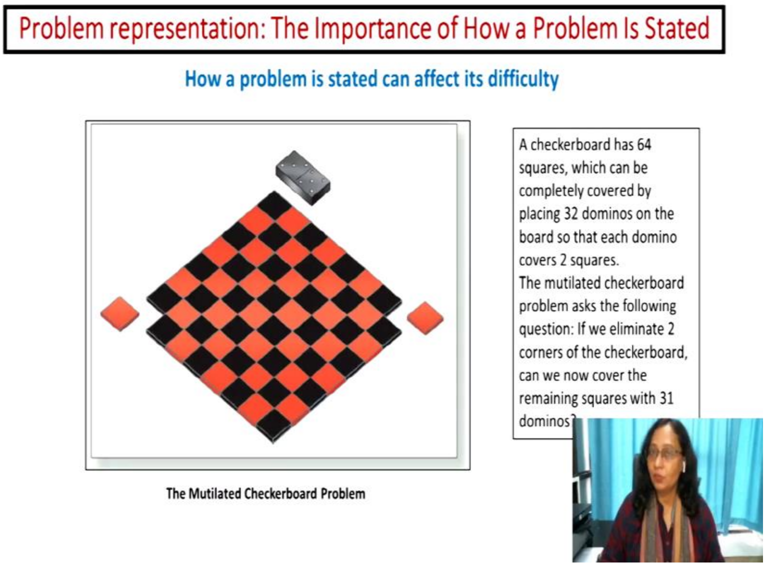

Now, coming back to problem representation: So, we spoke about functional fixedness is one of the factors for problem solving, the other is functional the problem representation. So, how a problem is stated the first thing that we saw was how a problem is visualized.

Problem representation how a problem is stated also affects the way we visualize the problem. Now this is the mutilated check board problem and here there are as in a check board checkerboard there are 64 pieces 64 squares and of you know of two colors. Now the mutilated check code supposedly has two missing squares of the same color. The problem is that the if we eliminate two corners of the check board of the same color can we now cover the remaining squares with 31 dominos.

So, what is it? The problem it is like a checker board has 64 squares, which can be completely covered by 32 dominos on the board. So, that each domino covers two squares. So, if I put a domino here two squares are covered another cover two squares another two squares and so; obviously, if there are 64 squares it will be covered by 32 dominos.

Now, if two squares are removed from the corner then so it becomes 62, then can 31 dominos fill in all the square. The obvious answer is yes; let us look at the solution.

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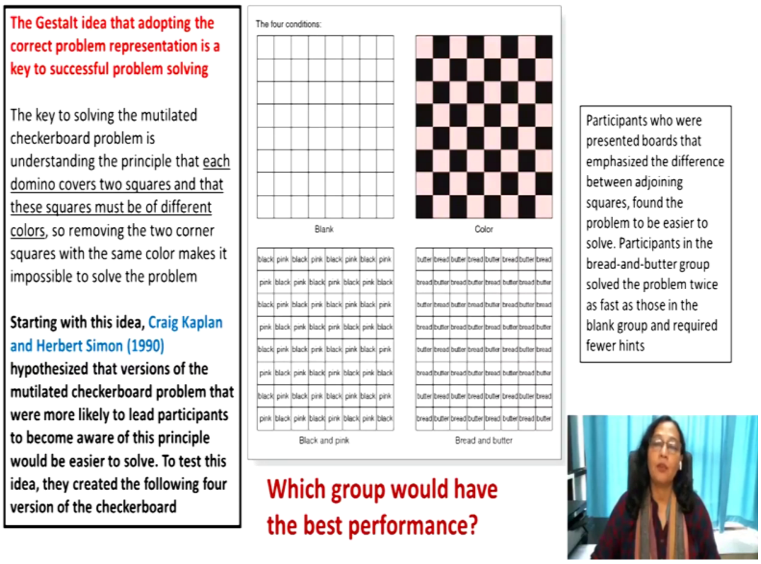

Now this problem was given by the Gestalt is and actually and Craig Kaplan and Herbert Simon in 1990 and what they did was they gave versions of the four versions of the checkerboard. So, for one they gave a blank checkerboard, one they gave a pink and black checker board like the one we saw.

The other it will written as black and pink and black and pink and the other was written as butter and bread. Now guess who solves this easily. So, actually the answer is that with 31 checker boards you will not be able to solve the problem because when you take out 31 dominos. Because when you take out two sides you are actually taking 2 of the same color.

So, with 31 you are not being able to capture one black. You are just taking two pink out anyways. So, this problem was spotted easily by the people who got this the imagery the problem representation as butter and bread. Now why would that happen? That is because and the worst was the blank checkerboard. Now why would that happen? The reason is that because the presentation of the problem was such that the it was easier to connect with the problem.

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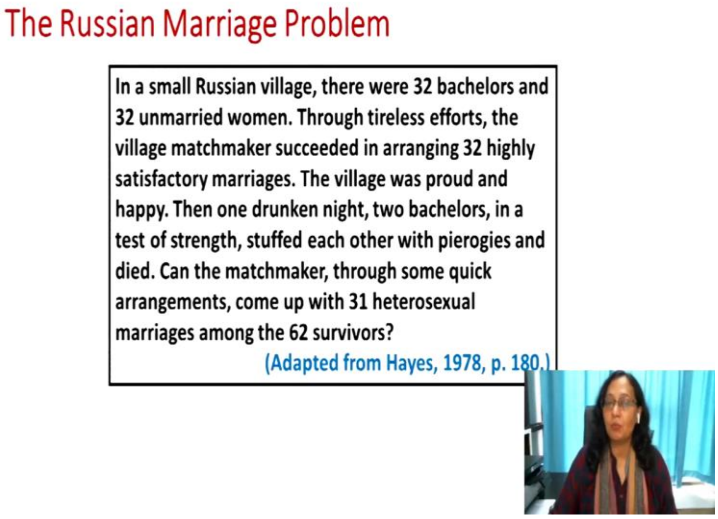

Now, a similar problem a similar problem is the Russian marriage problem and it uses the same concept as the checkerboard, but surprisingly this people can solve very easily why again? Because the there is language and semantics involved and it is easier to connect with this idea.

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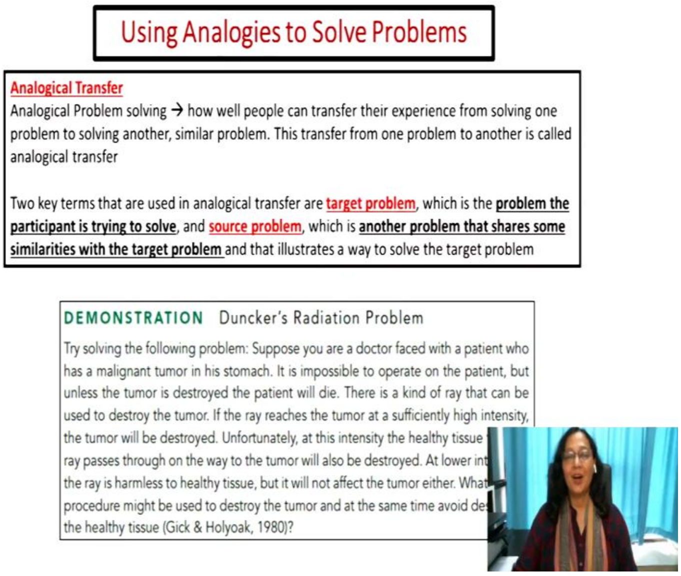

Now, using analogies to solve problems this is another way that we solve problems. So, what is analogy? Analogical problem solving is how well people can transfer their experience from solving one problem to solving another similar problem and this is known as analogical transfer.

So, there are two primary terms used in analogical transfer one is the target problem and the other is the source problem. So, the target problem is what you are trying to solve and the source problem is from which you are trying to draw analogy. So, from the problem that you try to draw analogies and a classic problem is the dunker radiation problem. So, if the if there the if there is a doctor faced with a patient who has a malignant tumor and it is impossible to operate the patient unless the and but unless the tumor is destroyed the patient will die.

So, there is a kind of ray that can be used to destroy the tumor. If the ray reaches the tumor at a sufficiently high intensity the tumor will be destroyed. Unfortunately at this intensity the health would healthy tissue around the tumor will also be affected. If the rays of a higher intensity, but at lower intensity the ray is harmless to the healthy tissue, but it will not affect the tumor either.

So, low intensity rays will not be effective for the tumor also. It will save the healthy tissue, but it will not affect the tumor. So, what can you do to stop to destroy the tumor at the same time avoid destroying the healthy tissue. Pause and try and solve this problem ok.

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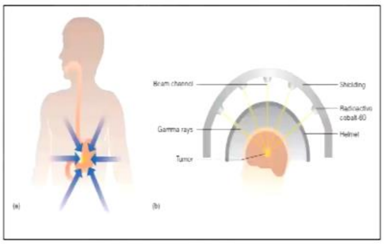

a) Solution to the radiation problem. Bombarding the tumor, in the center, with a number of low-intensity rays from different directions destroys the tumor without damaging the tissue it passes through.
b) Radiosurgery, a modern medical technique for irradiating brain tumors with a number of beams of gamma rays, uses the same principle. The actual technique uses 201 gamma ray beams.

This problem and the solution to this radiation problem is bombarding the tumor in the center with a number of low intensity waves from different directions such that it destroys the tumor without damaging the tissue it passes through. And actually this idea was used this idea of looking at a problem from a you know addressing it through analogies from another section another solving of another problem was actually used by radio surgery.

And today a modern medical technique of eradiating brain tumors is with the number of beams of gamma rays and it the actual technique uses 201 gamma ray beam. So, this problem see the dunker radiation problem was you know the analogy of solving the problem has been used in real sense too. So, this is how one solution can be transferred. So, in learning terms we would call that transfer of learning.

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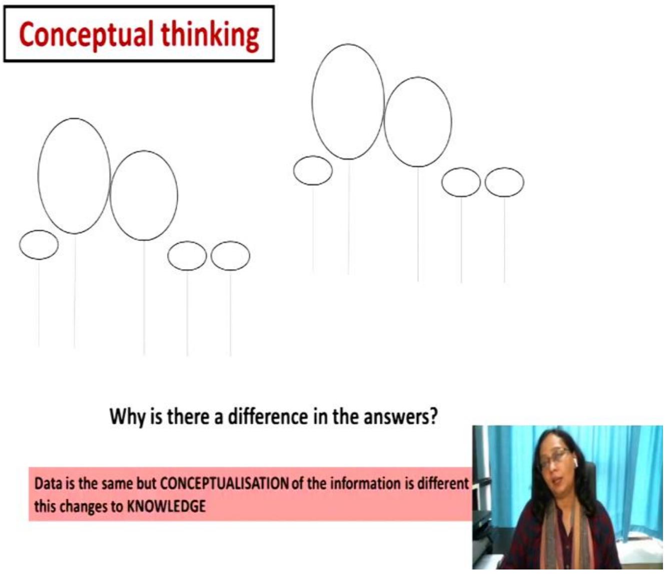

Now, conceptual thinking is another way categorizing things in one way in clubs or in clusters can help in problem solving, but again it also may hamper. Now, let us look at how it helps. So, categorizing things actually make us think faster ok. Now if you take this look at this picture and if you look at this image and you say that well this is the father and this is the mother and these are children then what would you take this as? Obviously, a family. Now let us look at this picture. If you take this as a large tree and a small tree and these are smaller trees.

Now, what would you take this as a forest. So, I if I gave you the same picture believe me it is the same image ok. Now if I told you that these were balloons you would check it. This was one balloon then you would automatically transfer this as a smaller balloon and the smaller one further smaller one, but the moment I tell you that well this is a father immediately the whole transfer is ok.

This is the father this is the mother and these are the children and this is the family. Now, there is a difference why is there a difference in answers. The difference is because of the way you are conceptualizing and this is what makes information different from knowledge and this is where a human brain differs from a machine.

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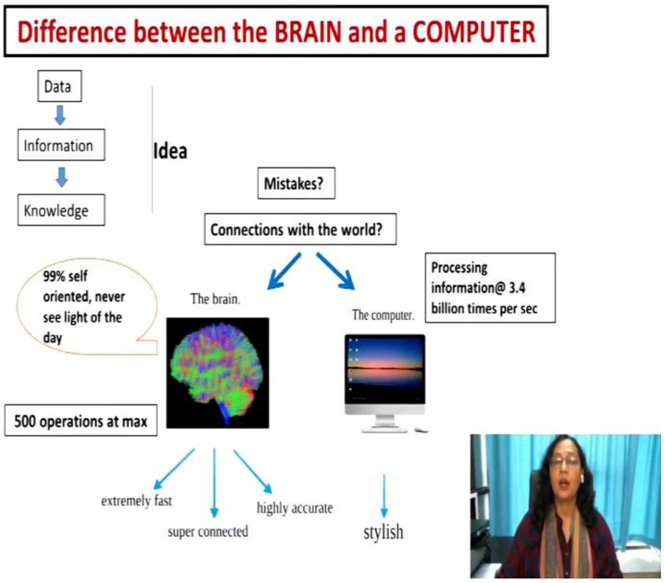

So, in a machine what do you do? You have data that is transferred to information and then to knowledge. The same thing is done in a human brain, but once you clock this data into concepts you can directly go to a knowledge and later on this knowledge is what will affect? Your next group of thinking.

So, again this is your implicit activities implicit problem solving working to categorize things together to form concepts and this is how we develop multiple concepts of colors, animal, shapes, nature food again you have sub concepts, different kinds of food, dry food you know veg food non-veg food whatever cooked food raw food you know multiple types.

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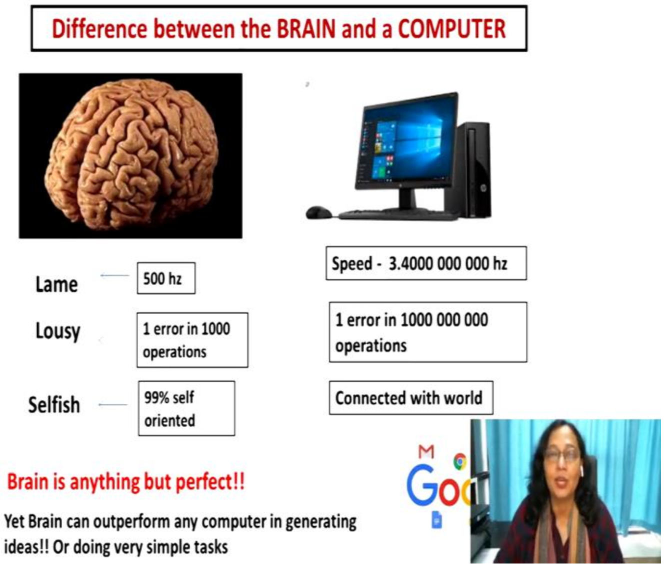

Now, for how does the brain and the computer function in problem solving. So, the brain it has you know different the brain is has many operations that it can do. It is extremely fast super connected and pretty accurate as compared to the computer which processes multiple number of times more than the brain right. So, we can do at the most 500 operations you know per second or not even that.

And the brain does more than 3.4 billion times per second. Now the brain has a processing speed which is much lower than the computer, it has you know several errors, but and you know as compared to the computer and it is quite selfish why it likes to see the world in its own way. So, the brain is anything, but perfect. Surprisingly the brain can outperform the computer in generating ideas and it can do simple tasks in much lesser time as compared to the computer. It requires much lesser data.

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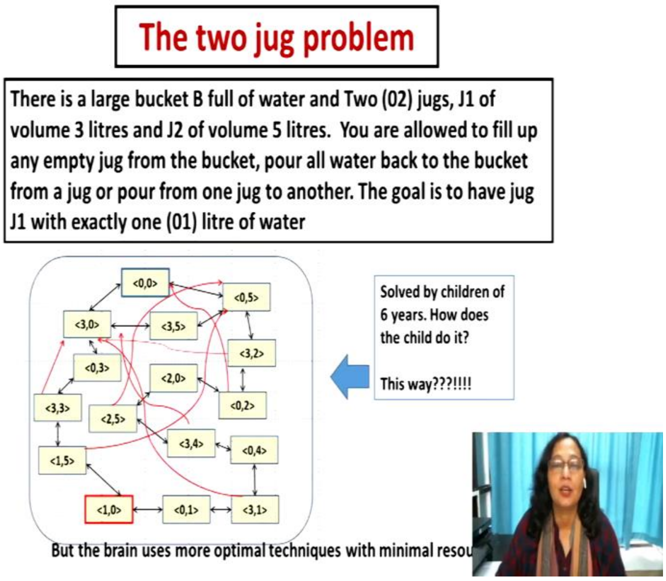

Now, let us look at one such problem. So, look at this two jug problem we were doing the Luchins jug problem. So, look at this there is a large bucket full of water and the two jugs have J 1 and J 2 have to be filled with J 1 has a volume of 3 litres and J 2 has a volume of 5 litres.

And you have to you are allowed to fill up an empty jug from the bucket pour all water back to the bucket from a jug or pour from one jug to the other. The goal is to have the jug J 1 with exactly 1 litre of water. You just solve the similar problem the in the previous section. Now if the computer was to do this problem this is how the calculations would go. So, how the operations would go?

The brain does it do the same way? This is actually a problem in one of the intelligence tests for young children and so these are solved by children of six years who know how to do subtraction and addition. So, the simple basic operations mathematical operations if you know you can solve this problem. So, is the child following this strategy and not so much not. So, much of calculations perhaps, then how does the brain do it?

The brain uses more optimal techniques and you know the errors also happen because we use optimal technique. It also happens in social cognition. For example, if there is a person who wears specs and is very serious and he has a lot of books in his house. What do you think his profession is?

Well many times when I ask this question in my class they will tell me that ok he must be a professor he must be a scientist a lawyer you know why not a sports guy? Well a sports star could also love books yes no. What happens is we have categorized these characteristics is wearing specs having being serious having a lot of books with x y z professions. So, when it is beyond that we you know we have errors we make errors.

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Now, look at this example. So, what are these? You give this to a child, a child will say that well this is the face. If you just show this one image and tell the child that this is the face for the rest of it the child will tell you these are faces. If you give it to the computer, the computer will tell you all the kinds of fruits and vegetables that are involved and how much time does the brain take to get it, how can the brain much faster than a computer.

And the brain also requires lesser number of inputs or lesser number of information to get this data correct; so, to see this as a face and then see the others as the face the brain requires many many more data set as compared many more data points as compared to the brain.

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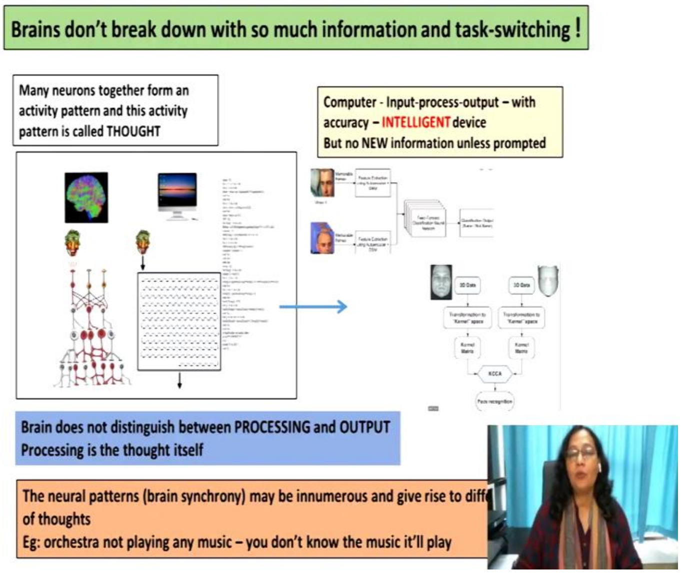

Then how does how can we pick it up so quickly. Now brains do not break down with so much information and start switching. But a computer generally does. So, computer follows an input process output ok. So, all the deep learning and machine learning and all kind of AI tools that go into it I am not going to get into it because my computer science professors are going to argue or criticize me on that point.

But and I know I do not know much about it, but the they agree that the amount of input that goes to get a data to a result correct is way higher as compared to one or two instances by which we can learn the humans can learn.

So, this integrated pattern of activity is what we call thought and the brain does not distinguish necessarily between processing and output processing by itself is the thought. And we see that the brain is ready for any kind of action it is like you know it may be a thought of ok. How would you face a ball that is coming that is an that is out pitch and you know you are a left hand batsman?

So, how would you what is the stance that you would take as compared to, can you do a mathematical problem the brain is ready for to take up either of these activities ok with the repository that is that it has and that repository is dynamic, but to an extent fixed because that is what at this point in time I hold. But look at the for the machine to operate you need to give fixed amount of data points to create to elicit that output a specific output.

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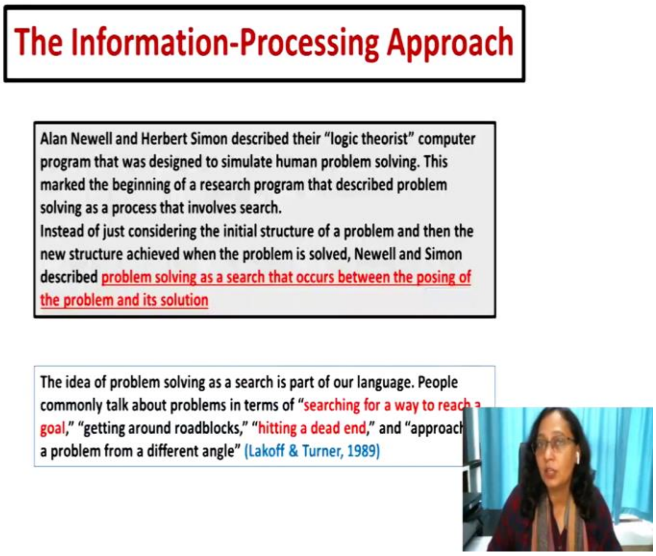

So, the information processing approach or the machine approach computational approach to problem solving was given by Newell and Simon and they said that problem solving they looked at problem solving as a search problem. And nowadays in computational thinking terms of human computational thinking actually looks at problem solving in a similar way that the information person approach did.

So, it is. So, problem solving is as a search is part of our language and people talk about problems in terms of searching for a way to reach the goal getting around road blocks through barriers and hitting a dead end and approaching a problem from a different angle. So, problem solving as a search space as the information process look at. Now what does this imply that there is a state space and it consists of different symbolic states. Now this problem is a tower of Hanoi problem.

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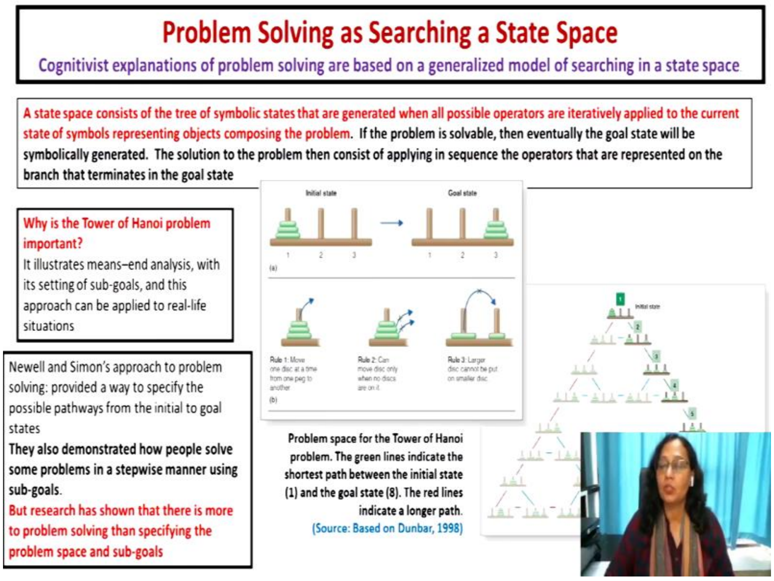

So, there are three towers and so these are the three towers and you have three pegs ok or three discs. So, these discs have to be shifted to here, but there are certain constraints that one has to follow. So, you can only take one at a time and you cannot put a larger disc on top of a smaller disc. So, what strategy will you follow to get all these three in the goal state? So, this is the end state and this is the initial state.

Now, this is what the solution space looks like. So, these are the number of steps that are required and this problem it illustrates as the computer scientists show that it illustrates a means in analysis where you have to set it into sub goals and in some of these sub goals you actually have to go back a step.

We work on problem solving in state space terms in with sliding problems and we have seen that you know once you read when you are trying to solve it as a means and analysis once you reach a configuration state we generally do not prefer going back a step to solve the next stage especially as novel problem solver ok.

Now so this is what the and the computer scientists they showed and Newell and Simon and they showed that the you know this ok this is the shortest path to the goal, but there are options you can move around and you can get stuck and then how do you go back a step and again do it. So, that would obviously, imply more number of steps in a more time. So, these have been the strategies that have been followed or rather I should say steps followed in problem solving approach as by the computer scientist's computational people.

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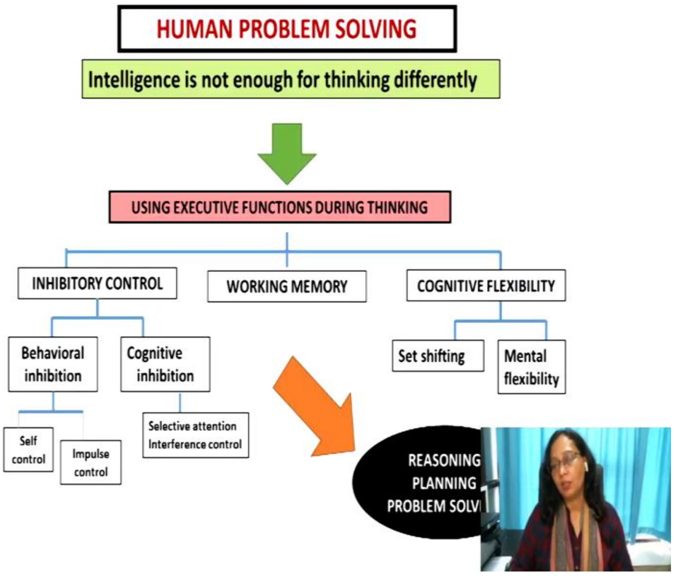

Now, coming back to human problem solving again, we have realized that intelligence is not enough for problem solving. So, there is more into intelligence and what does that require that actually requires something called executive functions and you will see that there is something called the executive network which integrates these functions with other areas of the brain that are active during problem solving.

So, what are executive functions? So, primarily executive functions engage inhibitory control. So, how you are stopping one task one cognitive task and you know shifting to another task that would be the cognitive flexibility how you are transferring; so, shifting from pressing the say an example pressing the gear with your left foot instead of that shifting it transferring it to pressing the gear with your right foot in a car.

So, how quickly can you shift that would be the cognitive flexibility. So, it is a mental flexibility as well as the shared shifting ability. It is also it also requires something called selective attention. So, which problem which one do you focus on? Are you letting distractors, noise, affect your ability to think and of course, a very important factor for problem solving is working memory.

So, working memory how much of your space memory space are you being able to use to solve problems. Now does that mean that? So, this is what entails executive functioning and. So, come coming back to this again that does this mean that if a person has a larger working memory that person will be a better problem solver well.

Computational people do think so, because the computer has a larger memory space it can you know keep for a chest problem say when deep blue the computer defeated Kasparov Gary Kasparov the deep blue had a larger configuration space.

So, it could store thousands of moves for one configuration while Kasparov has a more limited two digit number of configurations that he could store. So, the probably that is one factor working memory is essential for problem solving, but there is something more than working memory, the analogies that you draw.

The networks the connections that you form that cannot be only with working memory and it has been also seen some experiments show that you know in working memory especially when there is anxiety then high working memory space people perform the same way as novel people do ok. So, it is not that just the working memory space is enough. So, coming back to the primary areas that are engaged in problem solving; so, this we will look at the steps in problem solving and look at the areas.

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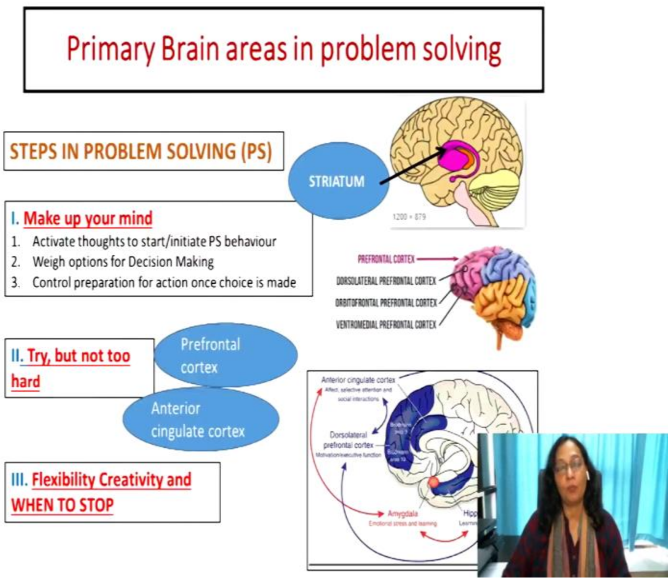

So, first for problem solving first is one has to make up his or her mind to activate thoughts to start or initiate problem solving behaviour ok. Weighing options for decision making and controlled preparation for action. Once the choice is made these require some of the subcortical areas and one primary area that is engaged with this triathlon.

Now, the second step is try but not too hard. So, here you have the thinking areas or the anterior cingulate cortex and the prefrontal cortex that are actually into play and the third is flexibility creativity and when to stop. So, when does one need to stop in problem solving another very important part of problem solving is evaluation of what you have done; so, to improve that helps in improvement of the process also assimilating the key points to your long term memory of this particular task solving ok.

So, this say this is the pathway that is involved and surprisingly in problem solving activities emotion is required. So, the amygdala is very important. Again if there is too much anxiety if there is stress then problem solving ability is affected ok that information goes to the anterior cingulate cortex and also to the hippocampus and then this affects the overall performance.

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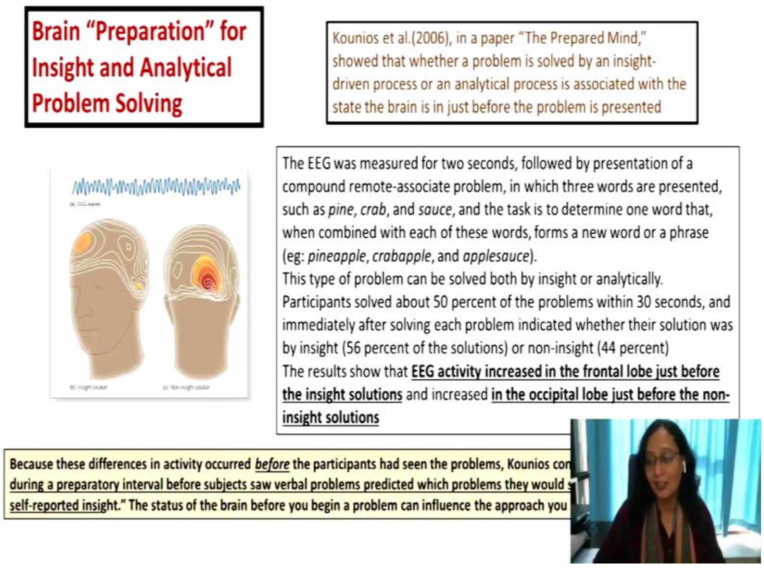

So, now how does the brain prepare itself for insight and analytical problem solving? So, we spoke about insight we spoke about analytical problem solving and research to show that you know what kind of strategy you are going to take depends on the brain state before you get into the problem. And this was discussed by Kounios in 2006 in a paper called The Prepared Mind and he showed that whether a problem is solved by insight driven process or analytical process is associated with the state the brain is in just before the problem is generated.

And here the task that was given was so the participants were provided with words like pine crab and sauce and they were asked to combine with some other words to form a new word ok or a new phrase. So, people could come up with pineapple, crabapple, applesauce and so on and so forth and it was seen that and they were they had to report whether they solved this by insight or by non insight that is using some strategies.

And the easy results show that easy activity increased in the frontal lobe when people solve it by insight and it increased in the occipital lobe when people solved it by strategy.

So, when people are solving these words by strategy they are actually in involving more of visual strategies at work because, this is the visual touch the person is presented with the word. So, the person when he uses more of looking at the thing to solve it is using more of the occipital lobe or the visual areas primary visual areas while when the person is solving it to insight suddenly on ok.

That is more with the frontal lobe activity. So, with the prefrontal cortex surprisingly people who solved it by insight will not be able to tell you how they solved it you cannot put it in semantics. For a non insight task where strategies are used you can say ok I tried say solving an anagram there are some people who can solve anagrams or jumbled word very quickly.

Now, if you ask them how did you solve it they will tell you that were just came while people who are novel amateurs like me would combine a consonant with a vowel change the positions of all the letters and see how to use different strategies to solve the problem. Now so insight again is something working at the back end.

So, think about implicit problem solving that we were talking of. In insight there is something working in the back end ok and that is why it is because that back end process is on the sample activity and back end is unconscious we are not being able to express it semantically.

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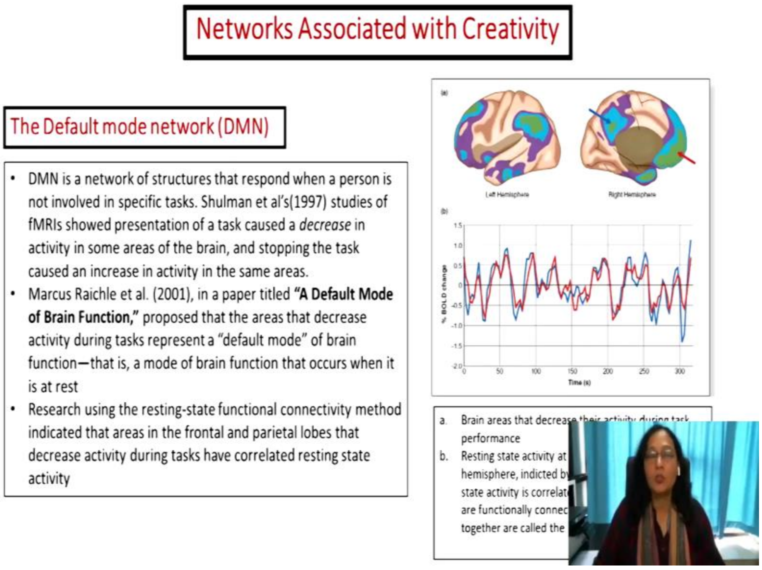

So, now let us look at what makes us more creative to somebody who is who solves problems easily and who is creative ok. First and foremost all intelligent people are not creative ok. The creative people are definitely intelligent and there have been multiple studies about this. So, coming back to creativity what helps creativity? What helps thinking out of the box? Doing things beyond a functional fixedness it has been seen that the brain is never at rest.

So, actually when we think that we are not doing any activity when we feel that we are at rest, there is a network that is active and that is known as default mode network and this network is active also when we are daydreaming and imagining ok and Marcus Raichle in 2001 in a paper on default mode of brain neck function proposed that the areas that decrease activity during chart represent a default mode of the brain function and that is a mode of brain function that occurs when it is at rest.

So, he saw that actually Shulman did the initial work in 1997 when he looked at the FMRIs and saw that a presentation of a task decreased activity in certain areas, but increased activity when the when there is a stopping of the task it increased activity in the same areas. So, somehow these two areas seem to be connected. So, Raichle actually worked on Shulmans idea and came up with this default mode network and looking look at this work from Raichle.

So, Raichle in 2015 shows that brain areas that decrease their activity during the task performance that represented in a, while brain areas the resting state activity at two points in the right hemisphere indicated by arrows. Now you see it is the same area when there is a decrease their activity during task performance.

So, it is just similar areas so, there must be some connection. So, that the resting state activity is correlated indicates that these areas are functionally connected. This is what Raichle said and all these were areas together are called the default mode network.

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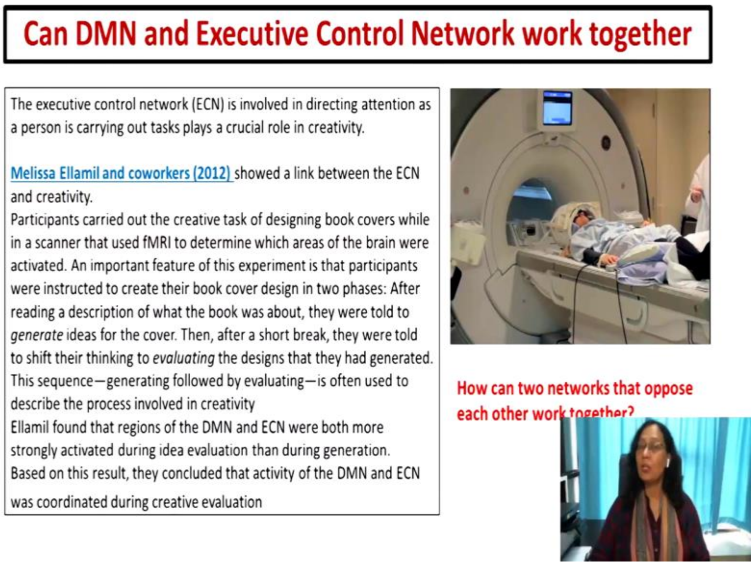

Now so, can the default mode network and the executive control network executive control network is when we are working when our brain is working to solve some problems, can they work together? So, in one such paper in 2012 Ellamil showed a link between the executive control network and creativity. So, what he did was he asked she asked a participants while their fMRI was being taken. She asked participants to design a book cover ok.

And what was what did they have to do? They were instructed to create the book cover design in two phases. So, after reading a description about the book, they were told to generate ideas for the cover that is the first part and the other was then after a short break they were told to shift their thinking to evaluate the designs that they had generated.

So, this is an evaluation of what they had done earlier. This sequence generated followed by evaluating generating and then followed by evaluating is what is used in creativity ok. So, when you have done a task and then when you are revisiting the task and then trying to bring out new ways of extracting it. This is these are this is what is used in creativity and Ellamil found that the regions of the DMN that the default mode network and executive control network were both strongly activated during the idea of evaluation than during generation.

So, he concluded. So, she concluded that activity on the DMN and ECN were coordinated during creative evaluation. So, in creative evaluation you are also putting in you are relaxed, again you are putting in an active effort. So, too much of effort too much of active effort does not bring out creativity.

Creativity only comes when you are more relaxed, when you are not doing something with extra effort ok and especially when you are evaluating a prior task. So, there has to be a homework done of trial and error before there is creativity ok. Now which we discussed about novel; so, basically people who are and how they solve problems what about experts?

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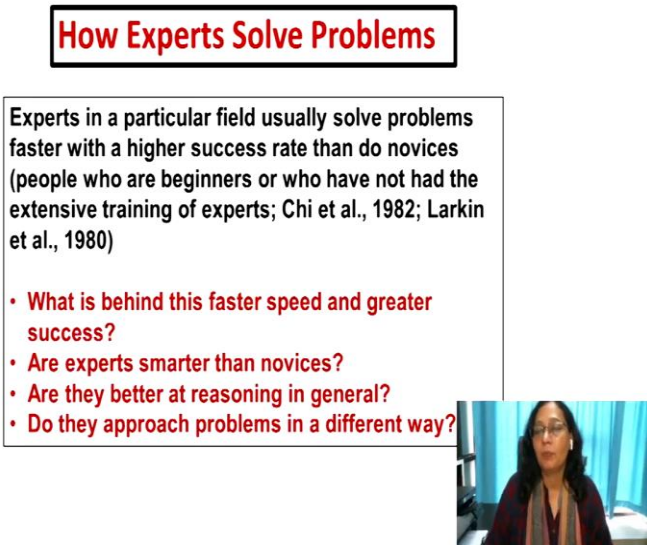

So, how do experts solve problems? Experts in a particular field usually solve problems faster and they have a higher success rate. So, they have more accuracy in their performance than do novices right. So, what is behind this faster speed and greater success. Are they smarter? Are they better in reasoning overall or they do they approach problems in a different way.

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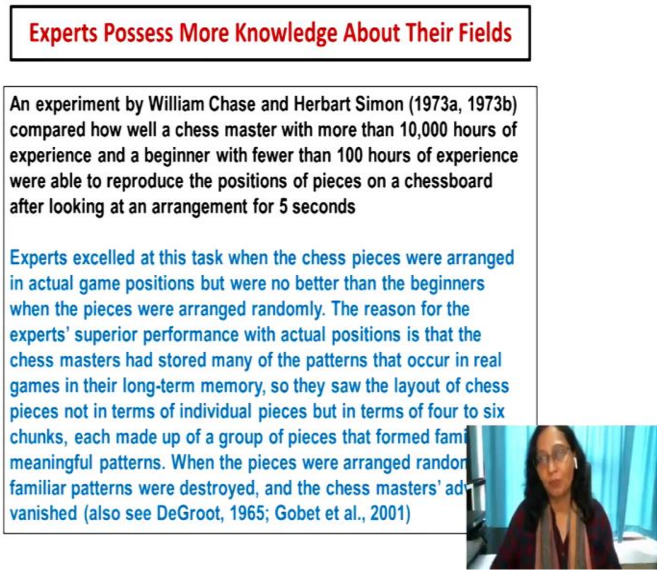

And an experiment by Chase and Simon they it showed it compared how well a chess master with more than 10000 hours of experience and a beginner with fewer than 100 hours of experience were able to reproduce the positions of pieces on a chessboard after looking at an arrangement for 5 seconds. Experts did it very well ok and they did it more accurately as compared to the novices. Now why is that so?

They had the configuration stored as we have already spoken about it and we have seen that the machine can store more number of configurations ok, but if those if the now this is because when the experts are better when the configurations are done in the proper way. So, when the chess pieces are placed in a proper game position, but if they just randomly placed one after the other then we are no better than the novices.

So, there if they are arranged the pieces were arranged normally randomly the and the familiar patterns were destroyed. The chess masters advantage of those prior configurations stored was destroyed and so their performance was no better than the novices.

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So, experts are experts only in their area only in their field do they have an advantage of you know expertise and this was shown by James Voss and his colleagues in 1983 and they posed a real world problem involving Russian agriculture to expert political scientists, experts chemists and novice political scientists and they found that the expert political scientists perform better than the expert chemist ok.

And the expert chemists were actually as poor as or their performance was as you know compared similar to the novice political scientists, expert chemists and novels political scientists. So, if it is a problem that is in their field. So, the problem of the involving the Russian agriculture was within the framework of the political scientist knowledge past knowledge or you know repertoire of studies.

So, it was easier for them to solve while expert chemists they were expert in another area. So, they were equally novice in this. So, a scientist may not be as efficient as Sachin Tendulkar in cricket that is the different kind of expertise altogether ok nor be as creative as Sachin on the field. So, the no matter how intelligent that person is. So, no matter how creative the person is in another area.

So, experts are experts only within their own field and perform like anyone else outside their field. This is said by Bedard and Chi in 1992 and the superior performance of the experts occurs largely because they possess a larger and better organized store of knowledge about their specific field.

So, this is I feel this could go on and it would be a good idea. So, you can train do you can you train your problem solving capacity. What you can do is you can make those networks work better more actively and how do you do that? You practice more cognitive tasks you do more so, one of the aspects of cognitive retraining works on this.

You make the neurons more active you try and develop the connections you activate these networks. What happens is with practice you learn it and that is imbibed as knowledge and that helps in your problem solving capacity way better.

If you travel the same route if you have gone and settled in a new city and you travel the same route the first day when you are going to your office in that city it will be tough, but if you travel the new route for say a month you will be you know much better in finding innovative ways to go to a new place than a person who is just arrived in the city.

Why? Because of that past practice you do not have to that is become automated that implicitly you know helping you to find out novel ways. So, well this is where we end the cognitive psychology part and the rest of the sessions will be taken by professor Sharba Bandopadhyay where, you get to understand much of you will talk he will talk about decision making and then move on to much of the challenges that are faced today in this area of cognition and computation.

Thank you for being with us. Thank you again.