Artificial Intelligence:

Understanding = Fulfilling Expectations

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Module – 05

Lecture - 01

Ok so we are looking at knowledge representation and so far we have no paid attention to what are the predicates we will use for representing certain facts. So we have happily chosen predicates like man, mortal and whatever we need because we have focused more on the reasoning part. So I want to spend two lectures looking at representation and it's a effort which was done as you can see in this slide by Yale university under the supervision of Robert Shang, there was a period of close to 10 years there were 15 PhD students who implemented all this stuff. Their goal was to understand natural language stories and be able to reason about them. So the question is what do you mean by natural language stories. What we will take in here is you should be able to map it into some logical representation. So if you have a set of predicates for representing certain facts then if you map certain sentences onto representation then you have in some sense understood what a sentence means and then based on that you can answer some questions and things like that.

So their theory is also called conceptual dependency theory also known as CD theory and we will spend a few lectures looking at that. And this was done quite long ago before most of you were born and but it's a very interesting piece of work because it does to what you might call as deep semantics or semantics of languages. Now a days its more fashionable to do a surface level processing so you have text analytics and everything you know which looks at lots of text and apply lots of algorithms to try to figure out various kinds of things. Whereas this approach was towards a canonical representation of whatever you are talking about.

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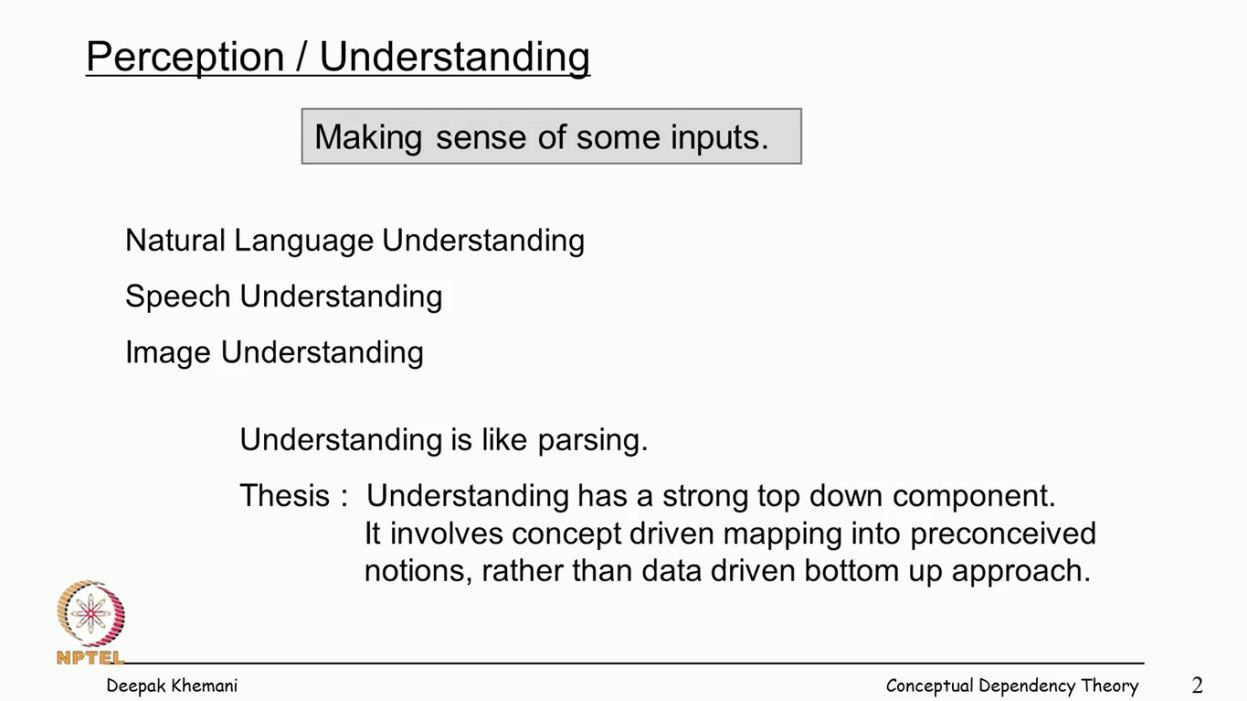

So we are looking at this problem of perception and understanding. This is a problem not only in natural language but also in vision and speech and touch you might say. Whenever you get input from some sense in your system how do you make sense of it? How do you understand that? So we will be focusing on natural language so understanding is a little bit like parsing. You can process word by word you can do something with some representation which scans for the meaning of the word and things like that. But one thesis that this group puts forward and we will also look at is that understanding is a top down process it is not a bottom up process in the sense that you don't take in the words put them together and then somehow make sense of the meaning. But its rather that you have a lot of knowledge in your head which helps you to understand whats coming in. so understanding is like trying to fit incoming information with existing knowledge representation into your system. And this is a theory which has been increasingly adopted not only in natural language but even in places like vision so in vision its not that you process the pixels then you extract the pattern, you extract edges then you extract objects and then you make sense of the scene. Its rather that you are expecting to see something. And you try to best match what is coming in in terms of what you think you are seeing.

It's a very interesting hypothesis. It involves concept driven mapping into preconceived notions as written here, rather than data driven bottom up approaches. So we will start with a short story I will ask you to read this story. So as you can see there is an angry young man called John here. Now you as a reader of the story or listener of the story, at this point we have stopped telling you story

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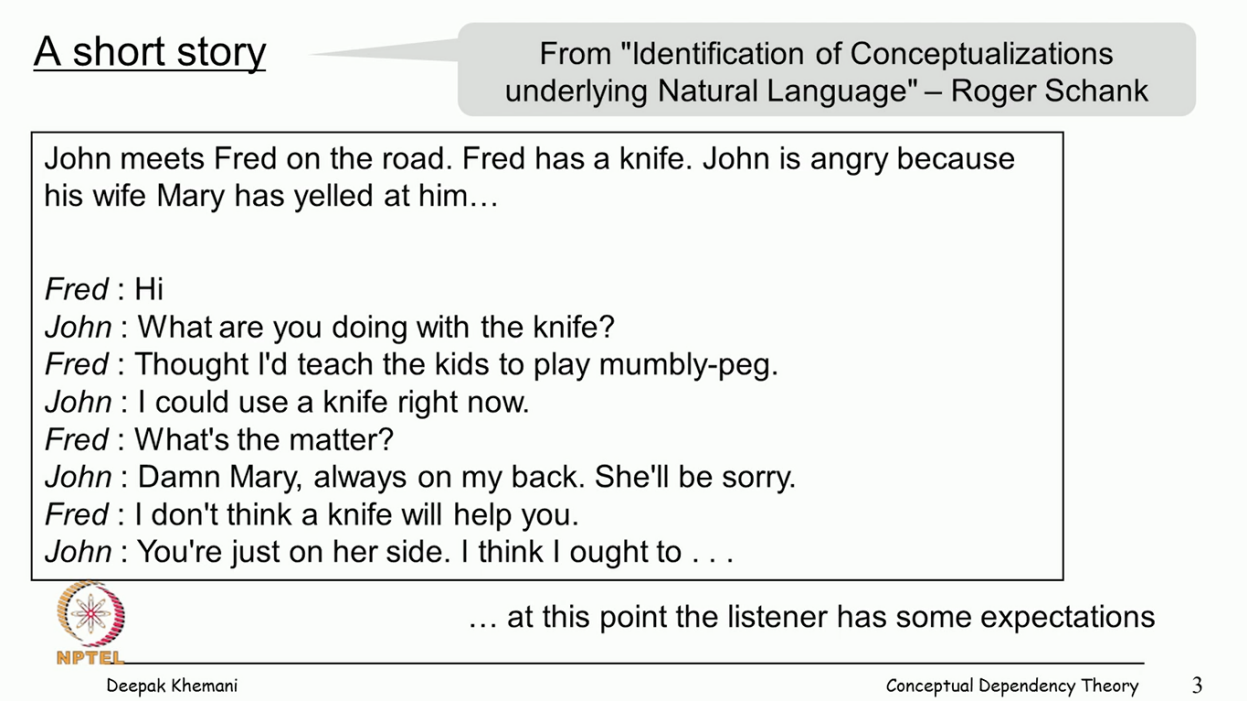

But you have certain expectations that you have in your head as to what is that you will follow next. What do these expectations come from? They come from existing knowledge into your head. So you already know how people behave and all that stuff and based on that you have expectations. So this story I have taken from this article Identifications of conceptualizations underlying natural processing by Roger Shrank. So what are the expectations that we have. We get expectations from various sources. So first of all we may have a knowledge of syntax of the knowledge that we expect a verb to appear after that. So from our knowledge of meaning we expect that okay he will talk about something which we will call as conceptual structure which is what we will be looking at.

In terms of context we can expect that he is going to talk about an action. A context will kind of delimit the range of actions that you expect to hear. So for example you might say end relation or hurt someone or go to some place or just emote or something like that. From the conversational perspective we know that people talk for a certain reason. May be to arouse sympathy, to inform about intent or may be to get votes whatever depending on what the context is. You always have certain purpose, intention behind communication. In fact there is a whole book I can show you which is called intentions and communications. Then the world view of listener. Do you know that john is convicted murderer for example then you would expect something like that from him or if he known to be a pacifist then you would expect something milder from him. So these are all the sources of expectations that you have at the point where we stopped listening at the story.

Also the culture, in different culture people do things differently. So that will also generate an expectation. So our question is what kind of knowledge representation

or knowledge structure is in the memory of the problem solving agent would generate such expectations. If you can generate such expectations we will have some handle on trying to understand stories. Today we will focus more on representation but a little but later when we look at structure knowledge representations and things like frames we will come back to Shang's work and look at what he called as scripts. So here is the story and here is you were thinking I think I ought to and if you were to hear I think I ought to go and eat some fish then you would be really surprised because that doesn't meet your expectations. And in fact such violation of expectation is the foundation of the basis on which jokes are told. So you start telling something and the listener builds up some expectation and suddenly that is violated. May be that you find funny also. But because you find it, it strikes you as something which is funny and it is based on violation of expectations.

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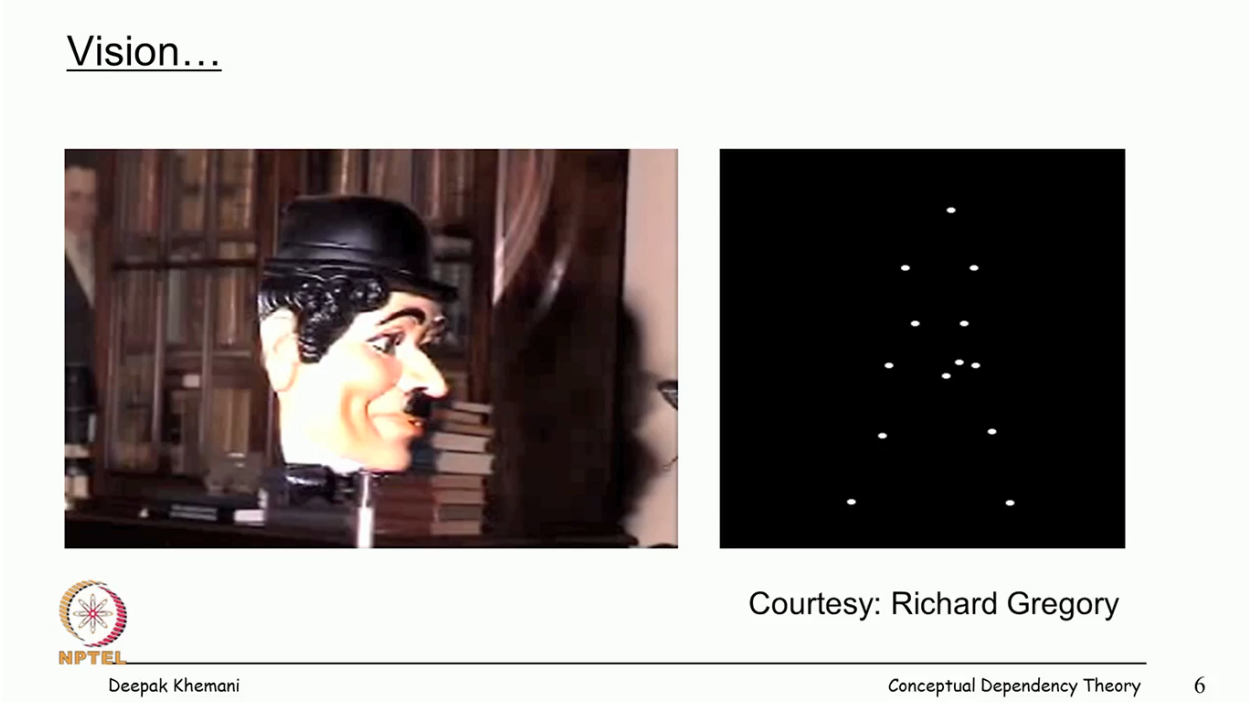

So at this point I will want to show a couple of movies. Oops I started It already. Anyway the point of the movie was that if you can just look out those dots which are there on this page then ofcourse after having seen the movie we are talking about a person but if you were to simply look at dots then there is no way I mean you can guess that it represents a person or something like that. But when those dots start moving as was happening in the movie then you can see that the.

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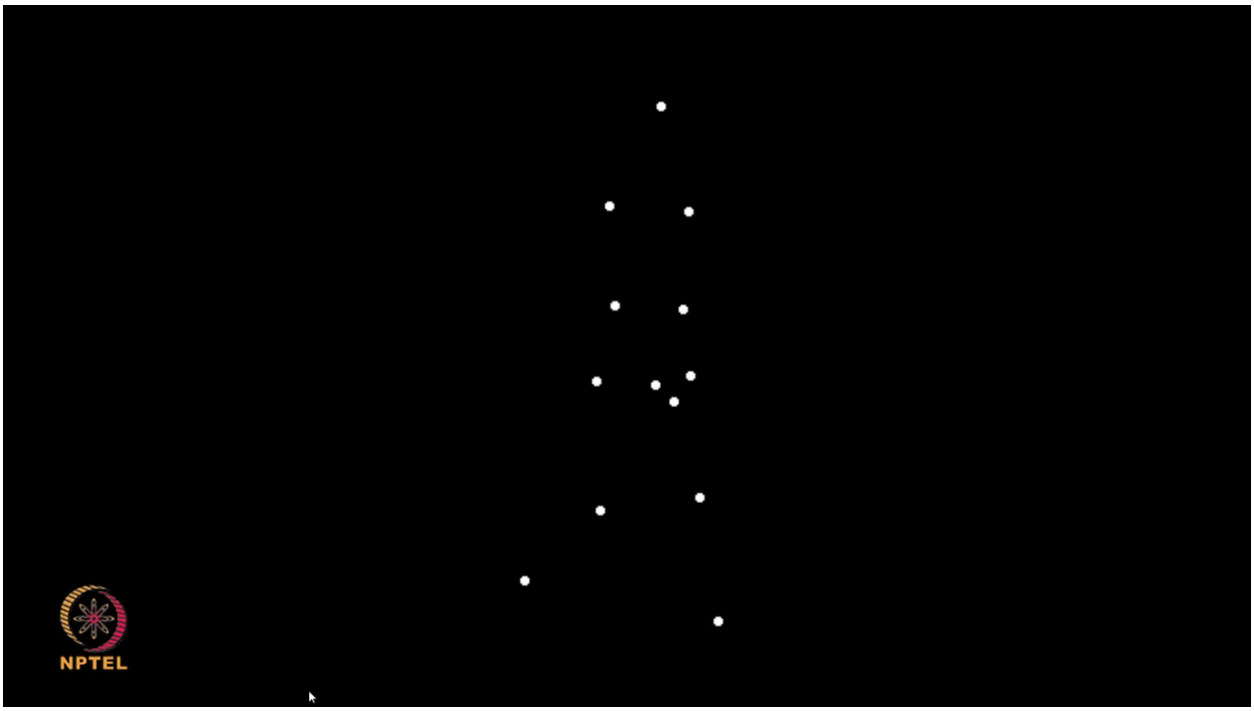

Too many gadgets. Both these movies I have got from somebody called Richard Gregory. May be I will mention once I start and who was visiting IIT and he works in design. So If you just look at these set of dots they probably don't mean anything. They could mean a constellation of starts or something like that its very difficult to say what it stands for. But the moment we animate these dots that it starts moving then you see a person. Now the fact that you are seeing a person is not the bottom up process. Its not the dots which are somehow being converted into a person. Its that somehow the combination of movement of dots triggers the notion of a person in your head and you see that. So the idea that this is a person is really in your head and not so much in the dots themselves.

The other film is even more stronger in this person. So you see the name here Richard Gregory he is the one who gave me these two films and made them himself. So this other film is about this what should I say statue or mask of Charlie Chaplin. I am sure you all know Charlie Chaplin. This is even more striking in the fact that what you think you are seeing in constrained in a significant manner by what is there in your head. So I will let you see this movie and may be later we will discuss it again.

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So you see your brain is controlling what you are seeing.

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Okay so as professor Gregory was saying simply because you have seen so many you know that this is how a face is. A face is a convex object in which the nose sticks out you are unable to see as a hollow face at all. However hard you try and may be you can see the movie again and again its really difficult to see it as a

hollow face and it really as he himself also said it emphasizes the fact that it's a top down knowledge in our head that we have about faces that really determines what do we think we are seeing.

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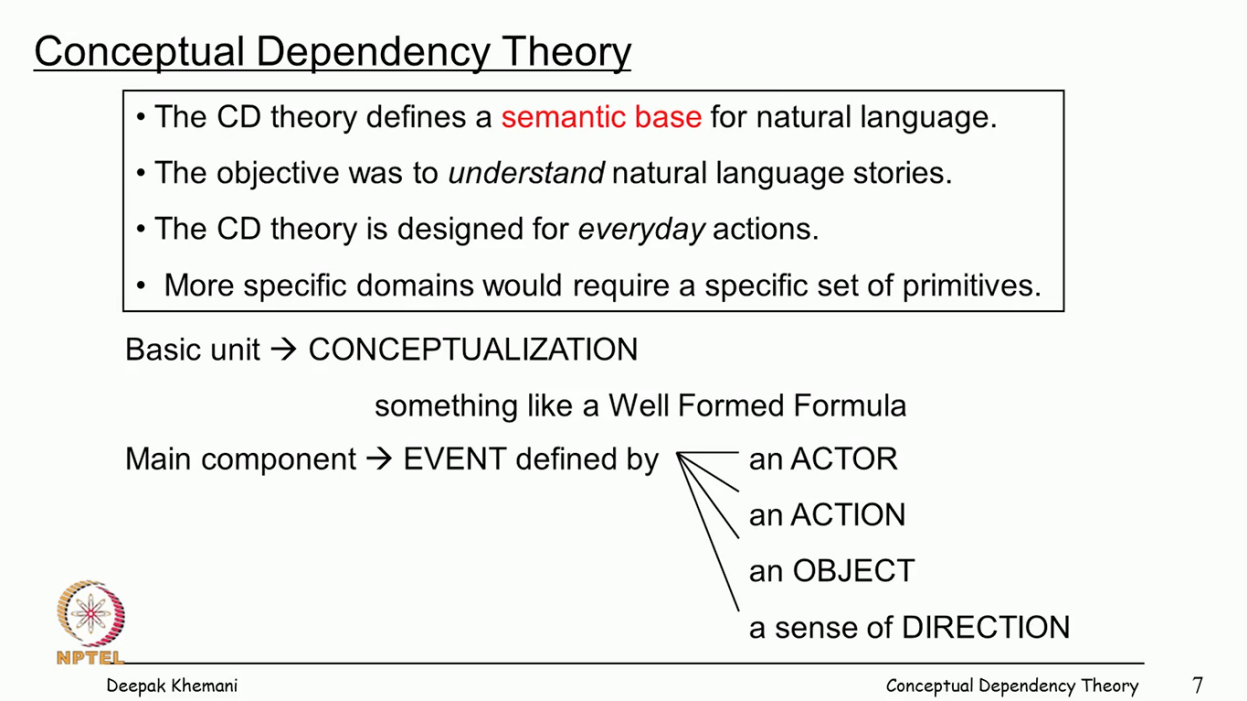

Okay so coming back to more prosaic thing which is we are looking at conceptual dependency theory or CD theory. It determines the semantic base for natural language. The objective when they designed it was to understand natural language stories. It is designed for everyday actions. Okay now what CD theory gives where we are concerned is essentially a choice of predicates and what is interesting about CD theory is that a choice of a small set of predicates depending upon two different sets that it talks about either 11 predicates or 14 predicates which they use for basic CD theory. But there are other things like states that we will talk about.

So more specific domains will require more specific sets of this thing so the basic unit in CD theory is called conceptualization. Its something like a well formed formula in first order logic and the main component of a conceptualization is an event which is defined by an actor, an action, an object and a sense of direction. So conceptualizations are made up of concepts and relation between concepts which is what logic is all about. You have categories and relations between categories. Now in CD theory concepts are of different types. One is called nominal which are basically corresponds to nouns in our language and they called it picture produces so we will use a term PP picture producers for nominals. Then we have actions which correspond to conceptually what are actions like eating, drinking and so on and so forth. Then there are modifiers. There are two kinds of modifiers, action aiders AA and picture aiders PA they correspond roughly to verbs and adverbs respectively. Action aiders may describe actions in little bit more detail so for

example instead of saying he ran to the canteen it will say he ran fast to the canteen so fast is the adverb that you are using here. Picture aiders are likewise adjectives and they may describe something in a little bit more detail. The nominal and the actions are governing categories, these are linguistic terms so if you have studies linguistics you would talk about governing and dependent categories. Governing categories are those which can stand alone by themselves whereas a dependent categories needs a governing category to make sense.

So lets look at conceptualizations. Nominals and actions can exist as independent notions. Nominal stand for objects and people. Actions are acts of nominals. Modifiers give additional information on the nominal or actions. A dependent concept predicts the existence of a governer. Remember we are talking about predictions essentially, generating expectations. What you predict you will hear next. Or what should go into a sentence and things like that. A conceptualization is a two way dependency it's a collection of concepts and relations in which there is a two way dependency. Both are needed to explain what is happening, it tells you something about the world. And the CD theory defines the set of actions that can be done by the people. And it can be described in a logic like sentence for example if you look up the book by Chamiak and McDemott on artificial intelligence, they have described CD theory in a kind of syntax which we talked about when we were looking at unification algorithm. Or it can be developed by C diagram, concept diagram which is what we will do which is what we will borrow from what Shang and his group did, so some sort of a graphical notation.

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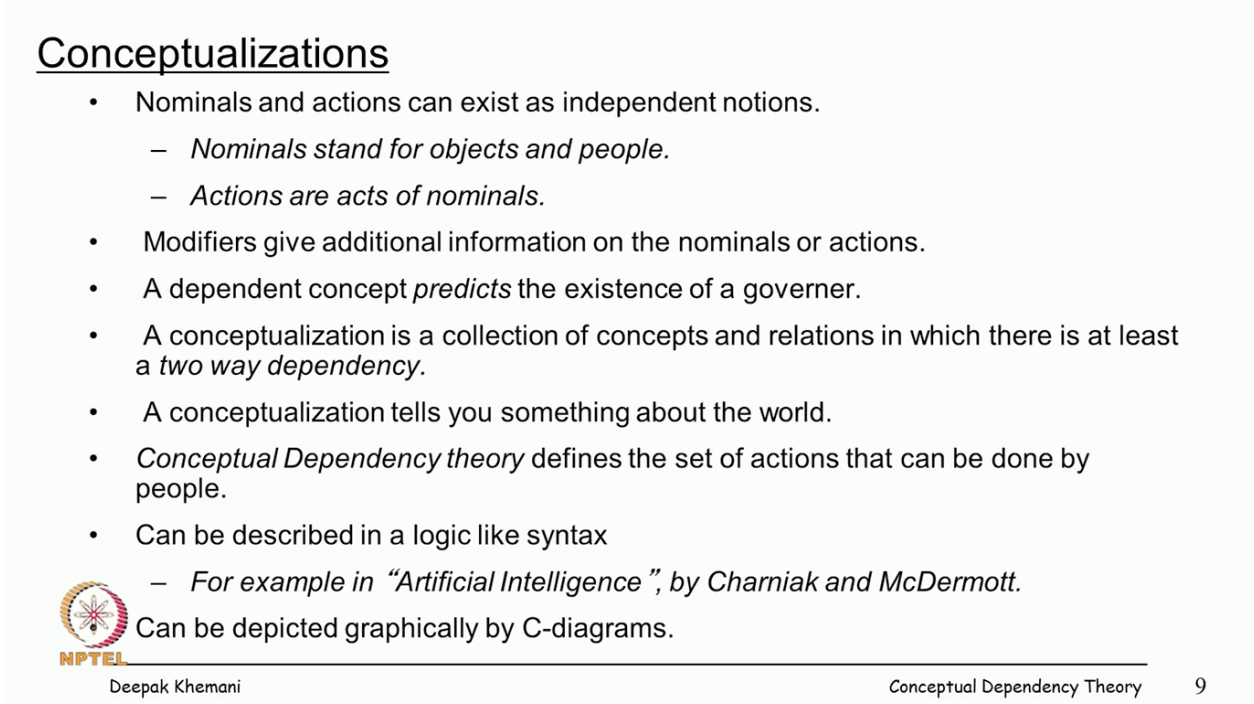

So lets start with a simple sentence. John hit is little dog, how do we make sense of this. So parsing this sentence as we will see in some later time you just assume you are reading the sentence from left to right and you parse it bit by bit or word by word. So John is a picture producer, a picture producer can be understood by itself so we know what john stands for in a concept and we know hit for example stands for some action and between so when you say john hit then we have some story going on or something is happening, an event is happening, a two way dependency. So that's the core of the conceptualization. Then the dog is also a picture producer but it can only be understood in relation to conceptualization that we are building. And the relation is called objective dependency and it is a fact that dog is the object of the action.

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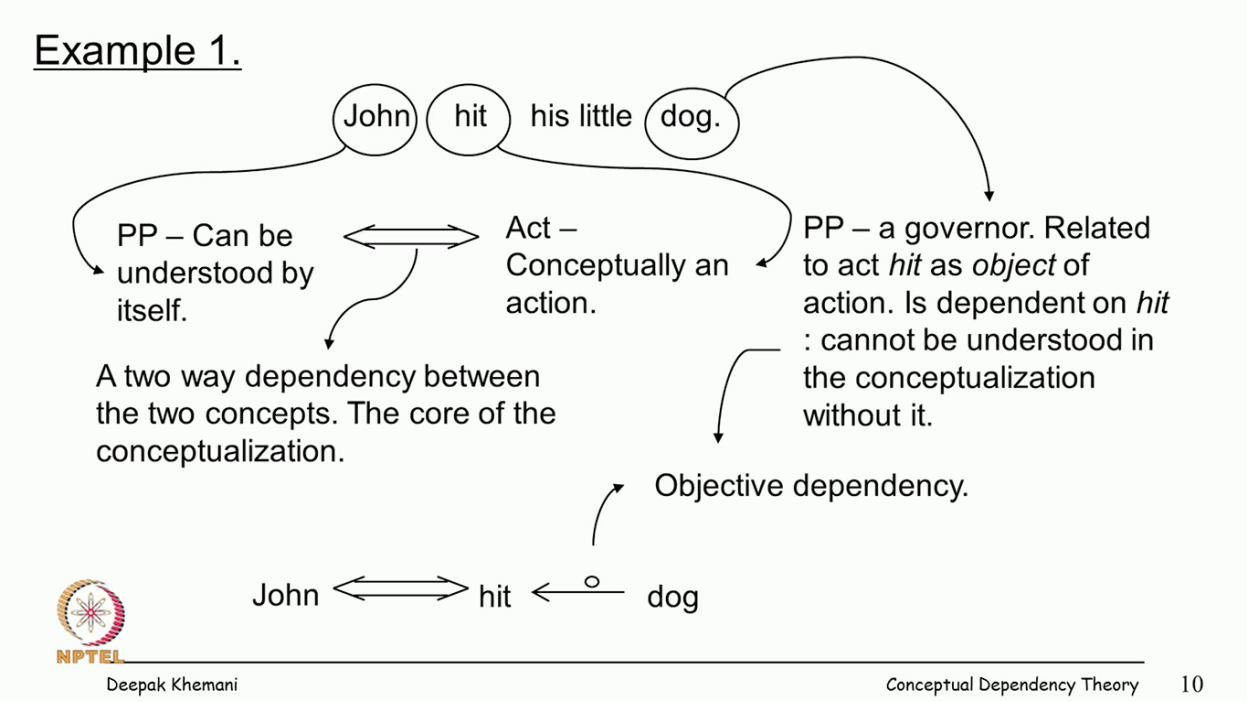

And we represent this in this fashion that john hit object dog. You could write this In some sort of a textual representation and is being done by Chamiak and McDemott. So if you look up their book you will see that. So far we have made sense of John hit dog. Now obviously you can see that some sort of memory would be required where you would have temporarily stored the word his and little. You are unable to make sense of them because you know unless you know what is going to follow. So you will need memory where you would temporarily store stuff and process it again. So lets see how other two words are handled.

The word little is a picture aider, it's an adjective and it has a relation which we will call as attributive dependency so it's the attribute of the dog so its not just a dog, it's a little dog. His is a little bit more complex because first of all it's a pronoun so we have to find out that it refers to John and secondly it denotes a dependency here which is called prepositional dependency which is in this case possessed by. So we

add as another kind of attribute as you might say that the dog is the dog which is possessed by John.

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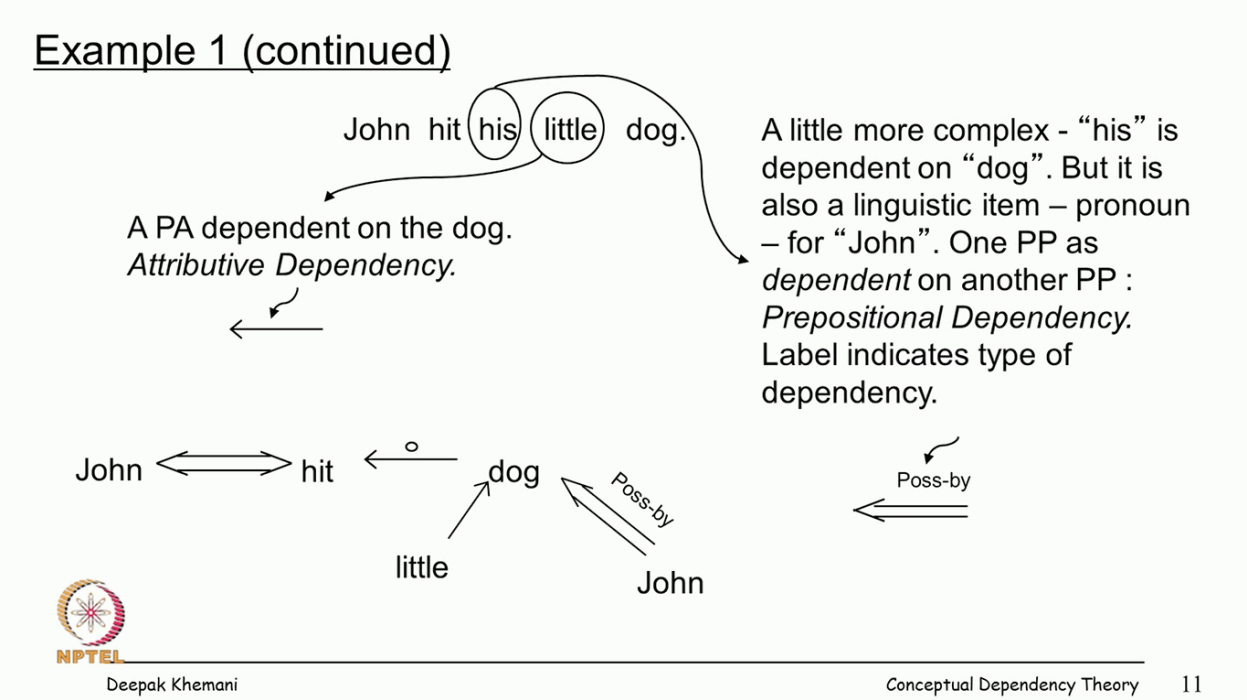

So these are the kind of conceptualizations which will be talking about. What we have seen so far for example is that John hit so a PP can do and act, that's one form of conceptualization, certain PPs can act. Or with those three line double arrows we can say that PP and a picture aider can form a conceptualization. For example I could say John is tall, then I have a conceptualization. So the first one is talking about action, the second one is talking about state. So they are stative in that sense. Then acts will have objects as we have already seen that John hit his little dog. Acts may have a sense of direction for example john went to the canteen. Acts may have recipients for example john gave a book to Mary. Acts may have instrumental acts, there may be high level act and there may be a low level act which is instrumental in carrying the high level act. We will see example as we go along. I mentioned some examples here but these are things that we will introduce as we go along. Mtrans is mental transfer, it requires conceptualizations have objects and Mbuild has its own object type. So instrumental act can be mtrans.

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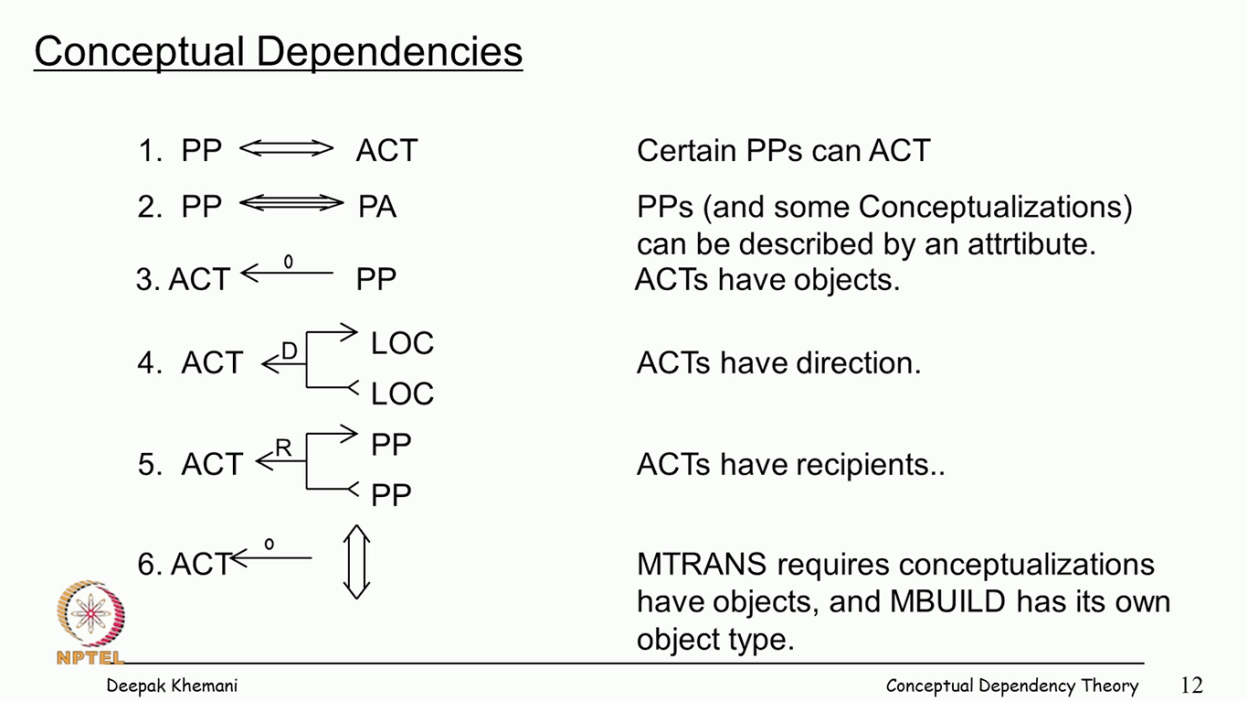

we will see about this as we go along. Acts can have instruments which are instrumental act. PPs can be described by the conceptualizations in which they occur. For example the dog who was watching the water flow by. Which dog? The dog which was watching this particular event. Likewise it could be watching the state so the dog who was watching the sun set if you can think of that as a state. They can have times so concepts can happen at specific time and they can have location, where did this event happen?

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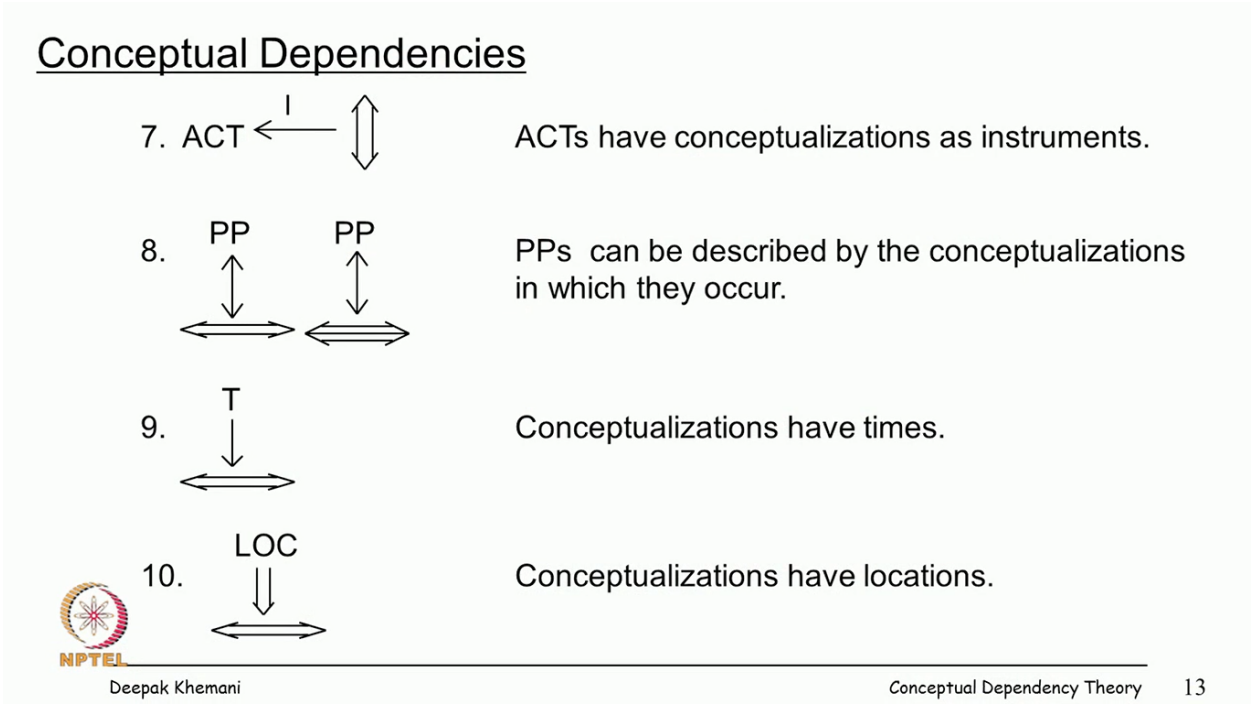

Then something more interesting so we can have causal relationships so the conceptualization as you can see on the top here. The conceptualization so we are talking about this number 11 here.

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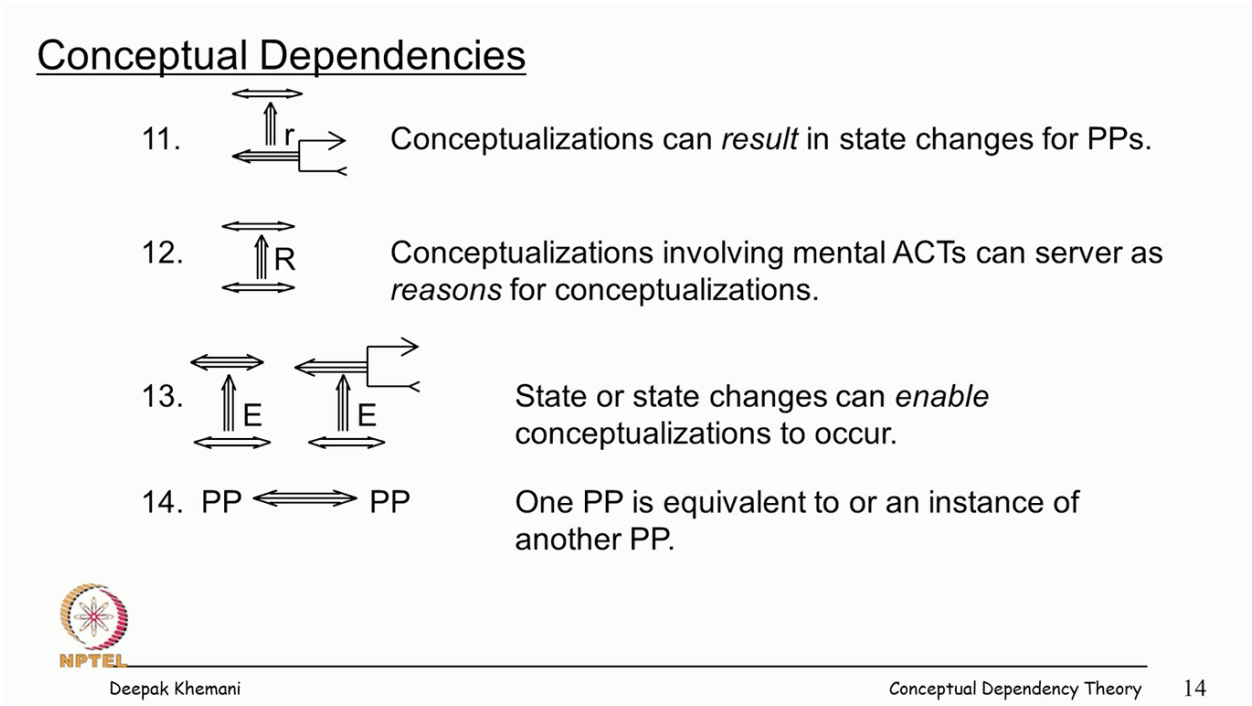

So a conceptual act causes a state change. So what we see below that is a state change. So this is a conceptualization. This triple arrow is a causal relation between

the conceptualization. And this stands for state change. So we have a causal relation between some act. If you do something and as a result of it something may happen. So if I drink off this bottle of water then the bottle of water may become empty. Likewise conceptualizations can result in reasons for other conceptualizations. So john shouted at mary and therefore mary hit him something like that. One conceptualization can be a reason for conceptualization.

Likewise states can cause conceptualizations to happen events to happen. So the first one which is this says that a state causes some event. So for example he called the fire department because he saw the burning house something like that. So he saw the burning house and therefore he called the fire department. Or you can see some state change, because some water is leaking from the tank and the tank was becoming empty so he called the plumber something like that. Then conceptualizations, so concepts can be related to one another. For example you might say something like John is a doctor something like that. And acts can have action aiders that we have already seen or we will see again.

Then we have this notion of state variables. We have talked about conceptualization of actions but we have to talk about states so they have this vocabulary for states so for example there is a variable called Health. And it goes from -10 to 10. So what you see is a list of words and phrases, dead, gravely ill, sick, under the weather, all right, tip top, perfect health. As you see they map to different values of this variable called Health. So the basic idea is that everything that is talking about health will eventually get mapped to this variable called Health. His state of health was minus 3 and then he had some medicine and his state of health became plus 2 so you know we don’t want to talk about he was ill and then he became well but instead we want to talk about the same set of variables because the smaller the set of predicates you have the lesser the rules of inference you will need. So Physical state is similar to Health except it applies to inanimate objects or it could be animate objects, dead, harmed, injured and so on.

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State Variables

HEALTH : goes from –10 to +10

Examples:		
	dead	-10
	gravely ill	-9
	sick	-9 to -1
	under the weather	-2
	all right	0
	tip top	+7
	perfect health	+10

PHYSICAL STATE: goes from -10 to +10

Examples:		
	dead	-10
	harmed	-9
	injured	-5
	broken (for objects)	-5
	harmed	-1 to -7
	hurt	-1 to -7
	OK	10

Then Anger goes from minus10 to 0 and you could map various words like furious, enraged, angry, upset, calm and so on, different values in this state variable. Mental state which is also called Joy in some of the implementations but in particular of the implementations called Margie goes from minus 10 to 10. So at the minus10 level you may be catatonic or depressed or in the positive side you may be happy or ecstatic.

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State Variables

ANGER : goes from -10 to 0

Examples:		
	furious	-9
	enraged	-8
	angry	-5
	irked	-3
	upset	-2
	calm	0

MENTAL STATE: goes from -10 to +10.

Examples:		
(same as JOY in MARGIE)	catatonic	-9
	depressed	-5
	upset	-3
	sad	-2
	OK	0
	pleased	+2
	happy	+5
	ecstatic	+10

This all will get mapped to something called mental state or joy depending on which implementation you are looking at. Fear goes from minus 10 to 0. Terrified, scared, anxious, calm. Consciousness goes from 0 to plus 10. So from unconscious to awake which is 10 and then may be to something which is more than 10. We have some higher level of consciousness. Surprise can go from 0 to 10, surprised, amazed, astounded and so on. Hunger can go from minus 10 to plus 10. So all the different phases which you can think about which will talk about hunger, being hungry or stuffed or satisfied or raven or could eat a horse or you will get mapped to some value essentially. Disgust can go from minus 10 to 0.

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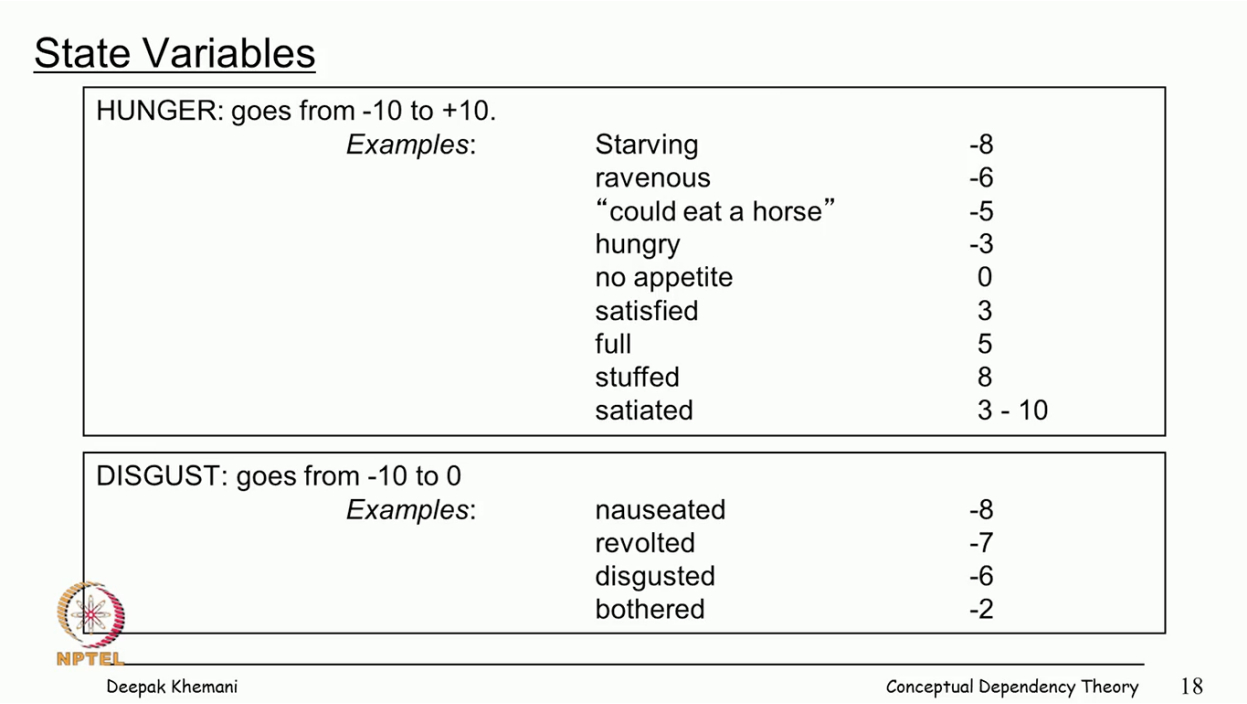

So revolted, disgusted, bothered all these things. Then you can combine these variables to form what you will call as compound variables. So shocked could mean that surprise level is high and disgust level is negatively high. Calm or I might say cool could be that there is no surprise there is no disgust. You are talking about someone like a Buddhist monk no fear no anger but the consciousness level is higher.

So I will just show you example of this program called Margie. And what you see as input is a sentence which was parsed.

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Margie : Inference mode

INPUT	: John told Mary that Bill wants a book.	
OUTPUT 1	*:*	*A book about what?*
OUTPUT 2	*:*	*Mary knows that Bill wants a book.*
OUTPUT 3	*:*	*Bill wants to come to have a book.*
OUTPUT 4	*:*	*Bill wants someone to cease to have a book.*
OUTPUT 5	*:*	*Bill wants to read a book.*

So it is not just work or one person but whole team of people working on that. So the input was John told Mary that Bill wants a book then the program could make sense of the sentence parse it into conceptual dependency and generate outputs which are you know kind of randomly generated paraphrases or questions sort of so it might say a book about what? Mary knows that Bill wants a book. Bill wants to come to have a book. All this comes from the fact that you are reading a sentence and you have some world knowledge. So if you want the book then you want to have the book that kind of very explicit detail can be worked out. You can also write plausible inferences like john wants to read a book , its not said anywhere. All that is said is john told mary that bill wants a book. But we are kind of making use of our world knowledge to say that bill wants to read the book.

Here is another example. John gave Mary a beating with a stick and obviously you can infer that a stick touched Mary, Mary became hurt, John wanted Mary to become hurt. You might even ask why was John angry? Okay so I will stop here. In the next class will will continue by looking at conceptual dependency theory and in fact we will continue by looking at some inferences that Margie can make and then move on to how to represent different kinds of concepts.