

Artificial Intelligence:
Conceptual Analysis: Mapping English to CD Theory
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Module - 05
Lecture - 04

Okay so we have been looking at the conceptual dependency theory. Its basically a choice of predicate in knowledge representation and we have seen can be expressed using CD theory. Today we will spare a little bit of time in seeing how one can transform a natural language sentence into its corresponding conceptual analysis representation. We wont go into too much detail because it is not the course on NLP but I hope you will get enough idea as to how this happens. So this process this group from Yale they call it conceptual analysis.

And they wrote a program called CA and at different point of time they also wrote a program called ELI which stands for English language interpreter. So these are the programs which basically did the process of converting a English sentence into CD theory. Now at the heart of this process is the dictionary or lexicon. So just like you have lets say oxford dictionary where you have a word and you have its meaning again expressed in English language. And you may have different senses of the word and you may have different meanings. We need to construct a lexicon or dictionary for conceptual dependency. So for every word that we want to handle in our language we need to have some entry in the lexicon. So we will look at an example here which is this sentence I want to go to the park with this girl.

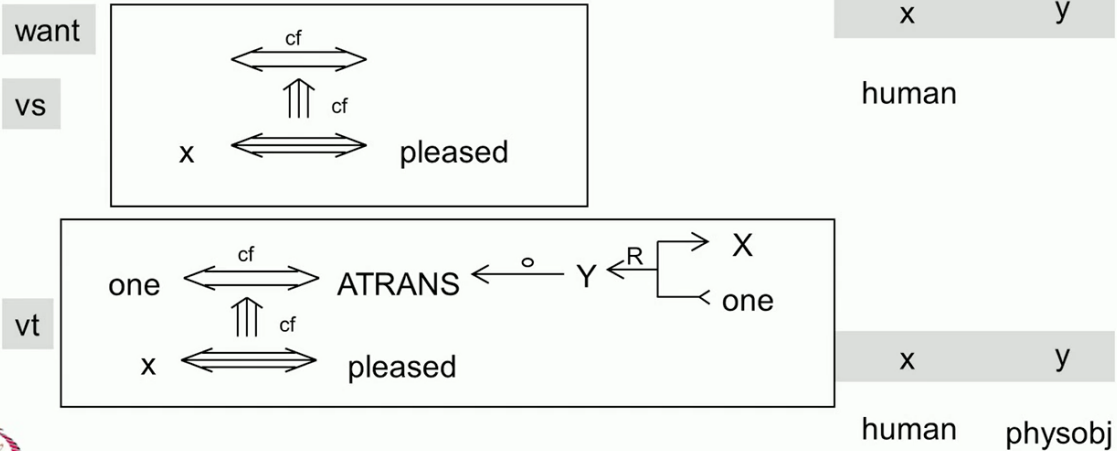
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Conceptual Analysis

ELI

DICTIONARY / LEXICON

I want to go to the park with the girl.



Now the key phrase here is want and we begin by retrieving the word want from this dictionary and what this dictionary contains is some three senses of the word want as shown in different rectangles two of this page and one on the next one. So the first sense which is a kind of a simple stative one is that x would be pleased if something conditionally in the future were to happen. So cf stands for conditionally in the future. And along with this there is also there is information about what are the constraints on the fillers. Now what are the fillers here. Fillers here is one is this x and the constraint on x as seen on the right hand side is that x should be human essentially.

So basically the word want we will associate with human beings and essentially we want to fill in a human type in that slot. So each of these is a slot. There is a slot sitting here there is some slot sitting here so here you will see some action. Here you will see some PP. and these empty slots are the source of expectations. So whenever you hear the word want you know that somebody wants something to happen in this sense of the verb. And the program is designed to look for fillers for that. So for example along with the word want they told us a small rule they used to call as request which says look for a human preceding want. That if you have read the word want and you are processing it you might have read the something which stands for a human which occurs before want. So why do we say preceding here because this is an active sentence. If you are talking about an active sentence then the actor comes first and the actions comes. So john wants to go on holiday or something like that if you say then after you read want you would expect that you would have heard about a human being and there is a rule sitting in the dictionary along with the word want which says look for a human and if you can find a human then fill it in this lot. So that's how expectations are dealt with and generated.

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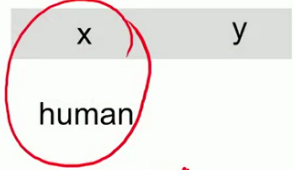
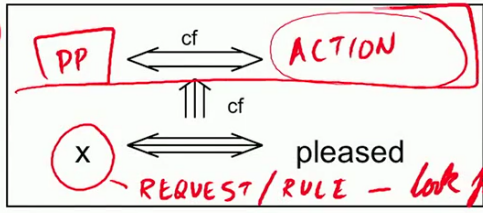
Conceptual Analysis

ELI

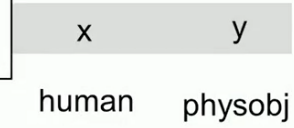
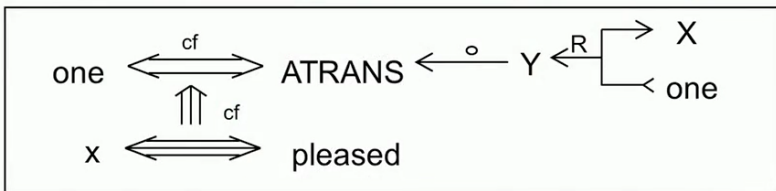
DICTIONARY / LEXICON

I want to go to the park with the girl.

want
vs



vt

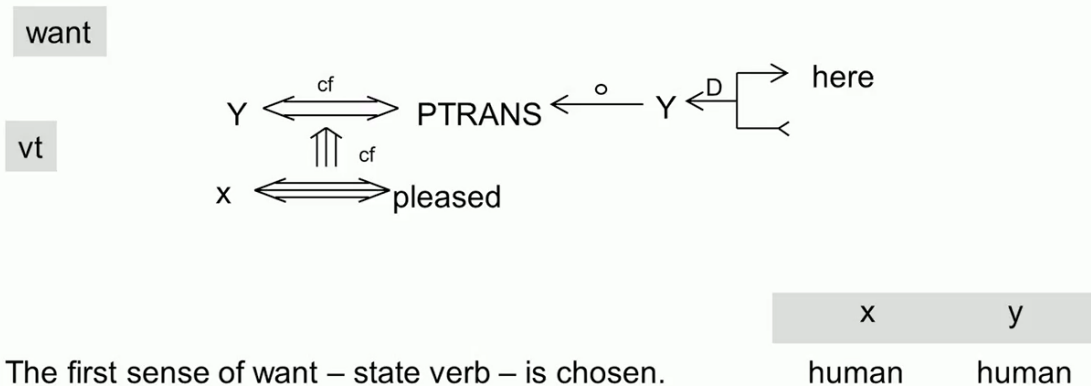


At the same time the program would be expecting something to fill in here because this is a conceptualization which says that an actor is doing some action. So if this is the sense of the word you are looking at then you should the program is expecting to hear something. So we have seen sometime few lectures ago you know this whole thing is driven by expectations. As you hear something you expect to hear some more things. And those expectations are generated by the knowledge that you have about the language and the world and sometime later we will see what situations. We are not talking about situations now. We are talking more in general terms. So there are two or three senses of the word want. One is that x wants something to happen in the future then x would be pleased. Another sense is that x wants to possess some object so this object is y and you can see that y is a physical object here and there is a atrans action already filed in there. So this sense of want says that for example I want a book or I want your pen if I say something like that then essentially I would be happy if you were to atrans your pen to me. So that's a sense of the word want.

And the third sense of the word want is that you want somebody to come. So I want you to come to my office at 3 o'clock or something like that lets say and this is the third sense of the word want. And again the different senses are distinguished by the constraints on the fillers. So in this case both x and y are human beings.

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"want" – a third sense



The first sense of want – state verb – is chosen.
The parser is now on the lookout for a complete conceptualization to fill in.



So you want to use a sense of the word want. So remember that the sentence we are looking at is I want to go to the park with the girl and lets say we will start with the first sense. So typically when you have choices to make in this case there are three senses so one simple way is to just do it you know first come first serve this is like a depth first search. Try the first one if it doesn't work try the second one and so on that would involve some amount of sophistication that you should be able to backtrack and try something else. But at this moment we are just looking at the general idea. We will assume that we start with the first sense which is anyways a generalization of the previous two senses. You can see the other two senses have something filled in for the event that would happen. The first sense is more general. When you read the word Go so you have read I want

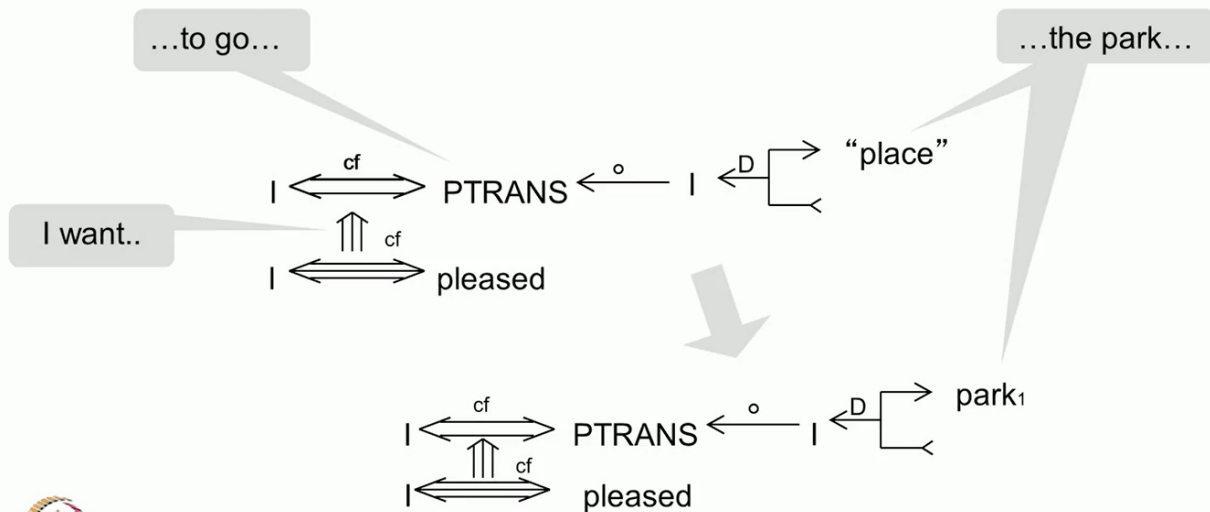
And you have retrieved the conceptual structure for want CD theory representation and you know there are several slots to be filled there and then you read the words to go. So when you read to go go itself has a couple of senses. So the first sense here says that x ptrans x to some place. And the constraint of that is that x is an animal, animated creature can go somewhere the dog went towards the pole or something like that we will say and that sense would apply.

The second sense is that some physical object called x goes somewhere so if you for example go and say I want to order a pizza or something you know that person at the counter might ask you is it to eat or to go. In that sense of word go the physical object has to go somewhere. Now to go fills an expectation we were expecting some conceptualization we say that if something happens then I would be happy. So this is what we had. You had that I want something to happen and then we are hearing to go essentially so we can fill in the details here. That I would be

pleased if in the future I ptrans myself to some place and when we read the words I want to go to the park then we fill in instead of this place we fill in the word park1. So park1 is the specific park the park.

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"to go" fulfills expectation of conceptualization




So by the time we have read this much of the sentence I want to go to the park we have created this conceptual structure which you can see below. I would be pleased if sometime in the future conditionally in the future I were to ptrans myself to the park. That's the meaning of the sentence we have read so far.

And then we read the rest of the sentence which is with the girl. So now you can see that the process that we are trying to describe is kind of online in the sense that as you read you try to construct the meaning of the sentence and the meaning in our case is the conceptual dependency representation. So you have constructed part of the meaning and then you as you read the rest of the sentence you try to you know either adapt that or extend that or do something with that.

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...with the girl

"with PP" has many conceptual possibilities.

1. PP is object of instrumental case (4)
2. PP is additional actor of the conceptualization (3) 
3. PP is an attribute of PP immediately preceding it (1,2,5)
4. PP is an attribute of the actor of the conceptualization (1,6)

Examples,

1. I went with a book to the park
2. I went to the park with the playground
3. I went with the girl to the park
4. I hit the boy with the bat
5. I hit the boy with the girl
6. I hit the boy with vengeance



NPTEL

Deepak Khemani

Conceptual Dependency Theory 101

There are certain sentences which are known as garden path sentences. So I cant think of an example of that but these are sentences which kind of lead you down a path and suddenly you have to change the meaning of the sentence. So these are called garden path sentences. And if you just search for the phrase garden path sentences you will find plenty of interesting examples. So for example I just thought of one which is if I start writing it then you can start reading it and then start constructing the meaning. If I say the old man we have already constructed some representation of what I am trying to say but I write the following I read this sentence somewhere the old man the boat then you have to go back and revise. When you started reading the word the old man then you created a picture of a old man but suddenly after reading the sentence you have to revise your past tree if you want to call it and reinterpret the whole sentence. So there are sentences like that which create this kind of problem. So we will assume that we have some sort of backtracking mechanism in place where you can go back and try something else.

Now this very interesting phrase this with is a very interesting word in the language it can be used in many many different ways and what this group at Yale did was that when you see a phrase like with PP then there are many possibilities which are described here. There are four possibilities. One is that the PP that you are talking about is the object of the instrumental case. So I mark the sentence 4 here which says I hit the boy with the bat.

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*garden path
sentences
"The old man the boat"*



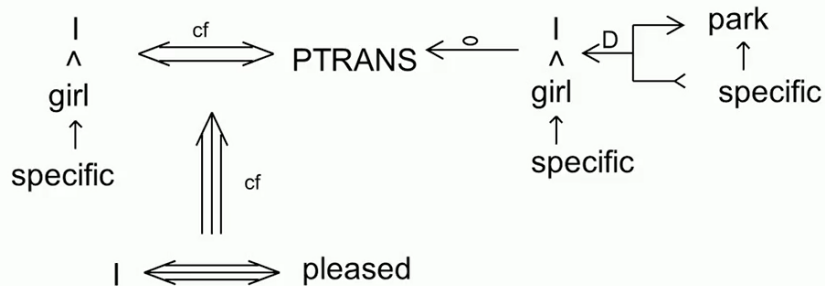
Which means the bat as an instrument of hitting the boy. And we have seen some examples before. He ate icecream with a spoon or he grew the plans with fertilizer. In that sense this is that sense of the word. With and that it has been put first in this order because that's the first thing you want to try out. That the PP is the object of the instrumental case. The second sense of the word is that the PP is an additional actor in the conceptualization which is the sense that we are looking for. When you say that I want to go to the park with the girl it really means or may be it really means that you and the girl you want to go to the park and you want the girl to go with you. So it could also have meant that you want to go to the park where that girl is sitting and eating something quietly.

That's a different sense but the second sense is the one perhaps that we are looking for at this moment. The third sense is that PP is an attribute of PP immediately preceding it. so if you look at sentence 1 when we say with a book then we are saying I went with a book to the park. So I is the PP which immediately precedes this PP which is so one PP is the book other PP is I and you are saying that this is an attribute of this. That I with the book went to the park. And likewise you can see in 2 and 3 in 2 the playground is an attribute of the park the park which has the playground and in 5 I hit the boy with the girl. I really means that the boy who was standing with the girl. It is unfortunately very common nowadays in India cities like Mangalore if you go there. The last sense of the word is that PP is an attribute of the actor of the conceptualization. That so you may be talking about so if you look at the sentence I hit the boy with vengeance then the sense if that this vengeance is describing me essentially the actor in the conceptualization.

So the meaning that you want to construct.

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I want to go to the park with the girl.

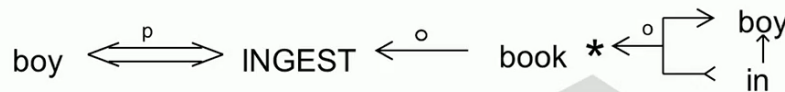
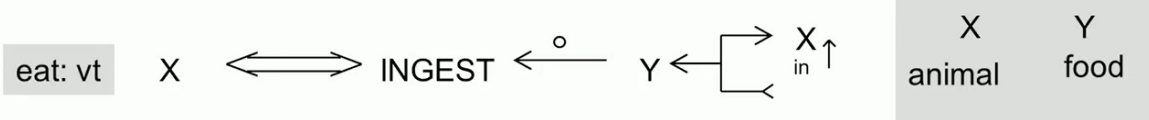


And this will come may be through a process of trial and error. The thing is I and the girl so because it is the girl we have put the marker specific along with the girl. If conditionally in the future we ptrans both the boy and the girl to the specific park then I would be pleased. So that is the sense that we are looking for.

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Conceptual semantics

The boy ate a book



Given that there is no other word sense for eat, one has no choice... but one can mark the conceptualization is semantically inconsistent



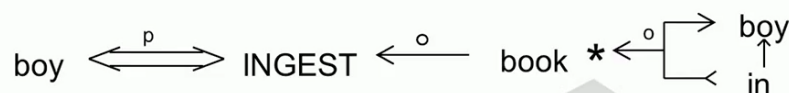
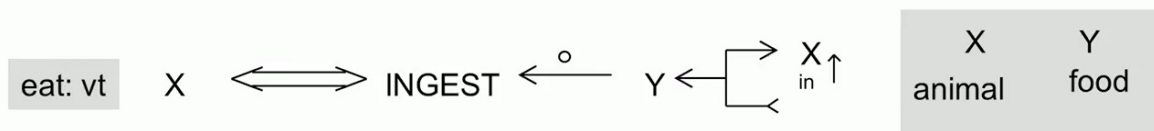
So we have already mentioned that along with the fillers there are semantics that we defined constraints that are defined. What can be a filler for which slot. So you assume that you have some sort of an ontology or taxonomy where you have described for example you know people and cats and dogs and instruments and books and so on and so forth. So if you were to look at the word eat then what you would get from the dictionary is x ingest some object y towards the direction of inside x where x is an animal animate type and y is food type. So you have put constraints on what can be the two fillers essentially. But what do you read when you a sentence saying boy ate a book. You have really no choice but to overrule the constraints and say that yes the book was object of being eaten even though it is not categorized as a type food.

So those of you who have seen Charlie Chaplin eating a boot would accept this kind of a thing in a movie called Goldrush. At one point he becomes so hungry that he eats a boot he cooks a boot and eat it. so if you want to accept such deviations may be you can mark it here we have shown it with a star that we are not sure that book should be the filler here but may be that's the filler that we are looking for. So the whole point of this exercise is that conceptual dependency knowledge is stored in the dictionary. Whenever as and when you read words from dictionary you will keep the corresponding conceptual structures and the task is to combine the different structures that you have retrieved into coherent hole. If you do that then you have in some sense represented the meaning of the sentence that you are reading.

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Conceptual semantics

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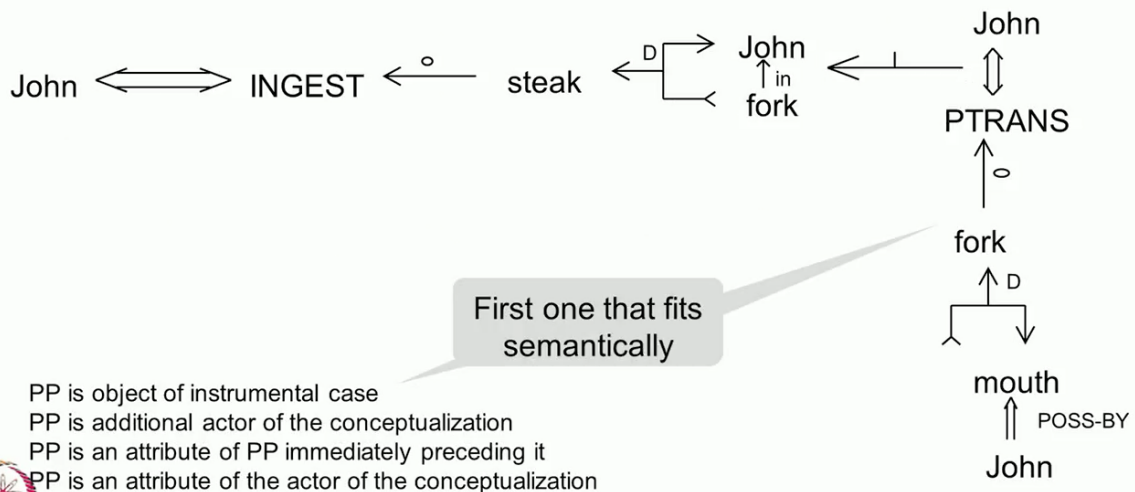


So if we had the sentence John ate the steak with the odor then you can see that this arrow is not quite showing correctly. The first one that fits semantically is this

one actually. So there is a shift in the box here. So the one that really see the first if you look at the first one PP is the object of the instrumental case then you cannot really imagine some odor like a spoon. Odor is not a spoon. You ate odor with a spoon then you can imagine that its an object of the instrumental act. That's not possible because odor hopefully you have categorized it as something intangible and in some sense a smell something like that. Likewise it cannot be an actor so the second sense will not fit in and the third one will fit in and therefore you will accept the third one and then create this representation that we see here. That John ingest the steak and the steak has this smell which we have called as odor.

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John ate the steak with the fork

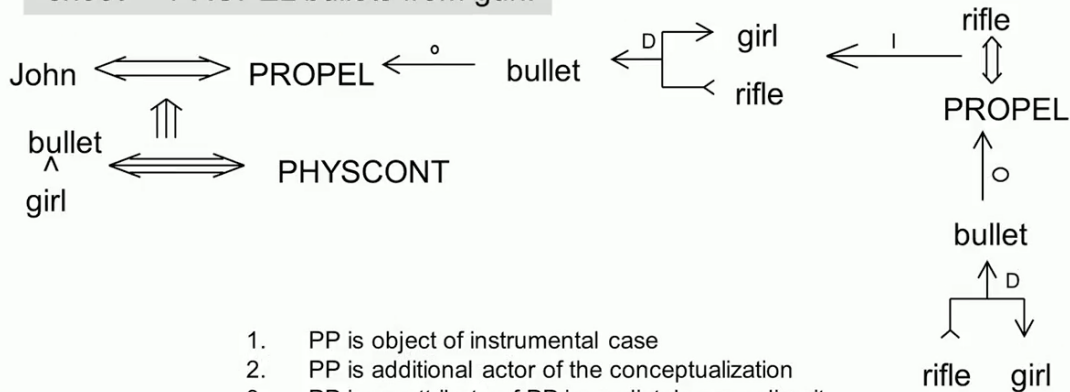


Instead if we had said John ate the steak with the fork then we would have the first sense of the word which matches semantically which is that the fork was an object of the instrumental act. Now that is the most common sense you would expect when you read a sentence like this. We as human beings are oriented towards speaking one sense very quickly as an example I will show you shortly. again you could have thought of this as there were two steaks lying on the table one of them had a fork and one of them didn't have the fork so he the one which had the fork. That's also possible but we will take the first one which matches in our case. Which is that the fork is the object of instrumental act is ptransing something towards the mouth.

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He shot the girl with a rifle

In the verb-ACT dictionary
 "shoot" = PROPEL bullets from gun!



1. PP is object of instrumental case
2. PP is additional actor of the conceptualization
3. PP is an attribute of PP immediately preceding it
4. PP is an attribute of the actor of the conceptualization



Now let's look at this. He shot the girl with a rifle. So in the verb act dictionary which is the dictionary we are talking about the shoot will be stored as propel bullets from the gun. So that's the meaning of the word shoot that would be one of the meanings of shoot would be stored as that. So if you were to fill that in then you can see that the action that is happening is that John propel bullets from the rifle to the girl and the instrumental act was that the rifle propelled the bullets from the rifle towards the girl. So that's the first sense of the four senses that we have. PP as the object of instrumental case but it's quite possible that John was the photographer and it was girl who was standing with the rifle in which case it would be the third case.

Now obviously this particular sentence does not have enough information for us to disambiguate it with certainty because we won't know what is really the sense of. So ideally maybe we should keep both senses alive. And so something like beam search if you have studied the search methods. They have different possibilities that are kept alive at the same time eventually one of them will work. If you can't do that then you have to backtrack and try something else.

So here is one of the most famous sentences known for its ambiguity. The sentence we as human beings do not have any difficulty at all. We just read the sentence and we get one meaning out of this sentence. But in the 60s sometime when people were getting very excited about natural language processing. And they thought that it's just a matter of converting lexicons from one language to another then you can have machine translation systems and so on. And it turned out that when this program was fed to this sentence was fed to a program it came out with four different parse trees. So what is the sense of the word that sentence that we accept Time flies like an arrow. What is time Time is a noun here right. The way time goes by is like arrow flying. That's the sense of the word that we accept. But if you think

of other senses you will find that there are other senses which for some reason we suppress.

We human beings are very good at selecting one particular sense of things and sticking with that. There was this American actor actors actually Marks brothers I don't know whether you have heard about them, very long time ago. One of them called Gaucho Marks had at one time said time flies like an arrow fruit flies like a banana essentially. Now if you look at these two sentences together time flies like an arrow fruit flies like a banana then you immediately tend to think of time as an adjective. So if you think of time as an adjective then you have this kind of flies called time flies and for some reason they like an arrow. So that's another sense of the word which doesn't occur to us as human beings because we somehow don't think of it like that. Can you think of any other sense? So another sense would be when this would be a verb. Now imagine that you are a coach a sports coach and you are coaching a team of flies or something like that then this is a piece of advice that you would give that the way the time flies is the way you would time arrows.

Put a stop watch do something whatever the process is. But time becomes a verb and then object of the verb becomes flies and like an arrow becomes like an adverb. So there are many different senses of the so this kind of ambiguity results both from different sense of words or different meanings of words for example time is a noun or adjective or a verb and they also result in different parse tree. Know because parse trees will if you look at parse trees then typically the NLP people would say that you have the noun phrase and the verb phrase and things like that and you know break it up like that.

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Syntactic ambiguity

Syntactic ambiguity has always been a problem in NLP.

Remember Kuno and Oettinger's "Time flies like an arrow".

Consider a sentence,

I saw the Grand Canyon flying to New York.

Most people are unwilling to accept a flying Grand Canyon and construct an appropriate structure in which one event marks the time of another.

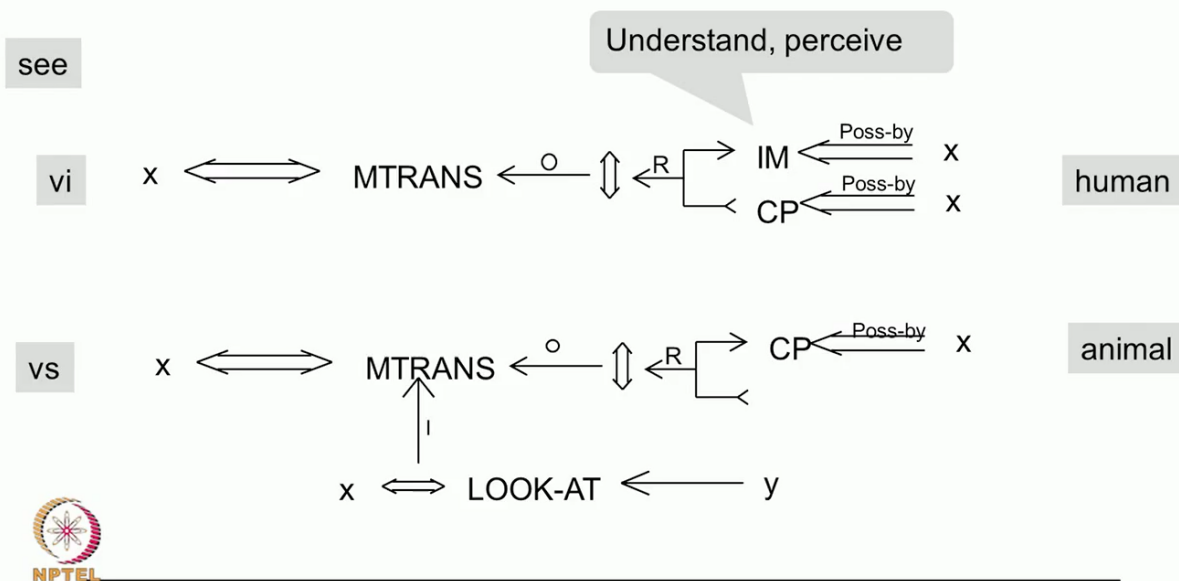


ELI also does this because it uses semantic information.

So lets consider this sentence which is in the middle of this slide. It says I saw the Grand Canyon flying to New York. Now most people would not imagine I mean if you know what the grand canyon is its not something which can go flying all over the place so you don't really think of a grand canyon flying to New York. The sense of the word in this sentence we want is I saw the grand canyon and this happened while I was flying to New York. So if you look at the word See when you say because this sentence starts with I saw so just imagine how this algorithm will work that you will read I you will store it in some temporary memory you know because you cant process nouns directly. the whole thing is event driven. So you see something either state driven or event driven.

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Seeing



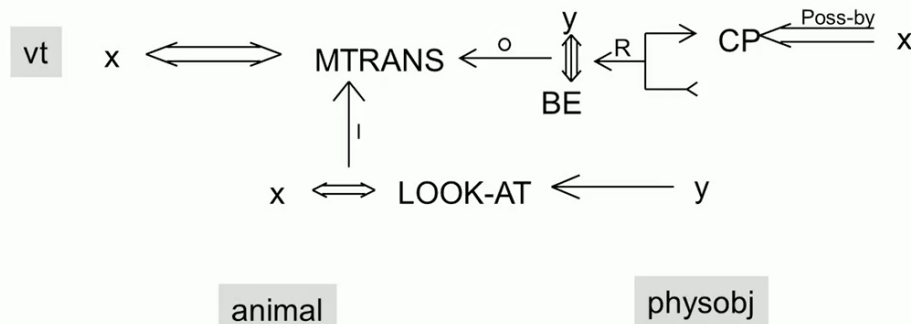
In this case see there are different senses of the word see. The first sense the mtransitive sense says that the word see is in the sense of understanding or perception. So you are explaining something to a friend lets say conceptual dependency theory and the friend says I see so in that sense of the word you say that see means understanding which they have modeled again in their naive psychology based approach. Which its moving from the conscious processor to the immediate memory of the person. That you saw this and then you accepted this and its stored in the memory. And only human beings according to their lexicon have the ability to see in this sense of the word.

The second sense of the word as you can see if that I mtrans something which is an event which is happening towards my conscious processor and I do that by an instrumental act called look at. So we saw something called attend. So I said there are two or three this whole was done over some 5 to 10 years and different people experimented with slightly different set of actions so instead of attend we have

look-at here. Which is only talking about the I. and you can say that animals can look at things happening. And another sense of the word is when you are looking at the state so if you see the object of the mtrans you can see that y is in some state so he looked at the burning house for example.

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See



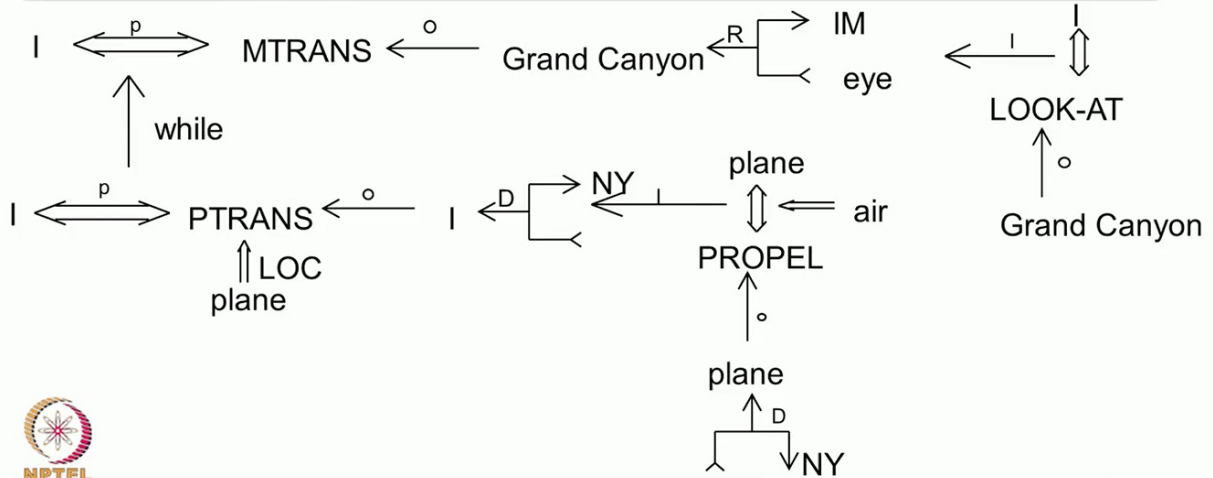
So when you start reading the sentence you will first read I saw the Grand canyon the first thing you construct is I mtrans Grand Canyon and I did it by looking at the Grand canyon which is the instrumental act. That we are familiar with now. Then you read the word fly or flying. Now flying again itself has different senses. So I am just trying to give you an idea of how this is happening that with everything that you every word that you read there may be different senses then the next word you read may be different senses then you have to somehow combine the matching senses together. And that's the task of semantic parsing as some people call it.

So one sense of the word fly is that x ptranses x and it does that by propelling itself In air and x can be a bird or a plan or a insect or may be superman. A second sense of the word is that humans can fly planes which is a transitive verb. Where the human which is x does something because of which plane which is y propels itself. And the third sense of the word is that humans can fly in planes. Which means that x is ptransing x and the instrumental act is that the plane is flying somewhere. So that's a sense that we are interested in when I say I was flying to NewYork basically means that I was sitting in the plane which was going to New York. And by that by using that as an instrumental act I ptrans myself to New York.

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I saw the Grand Canyon flying to New York

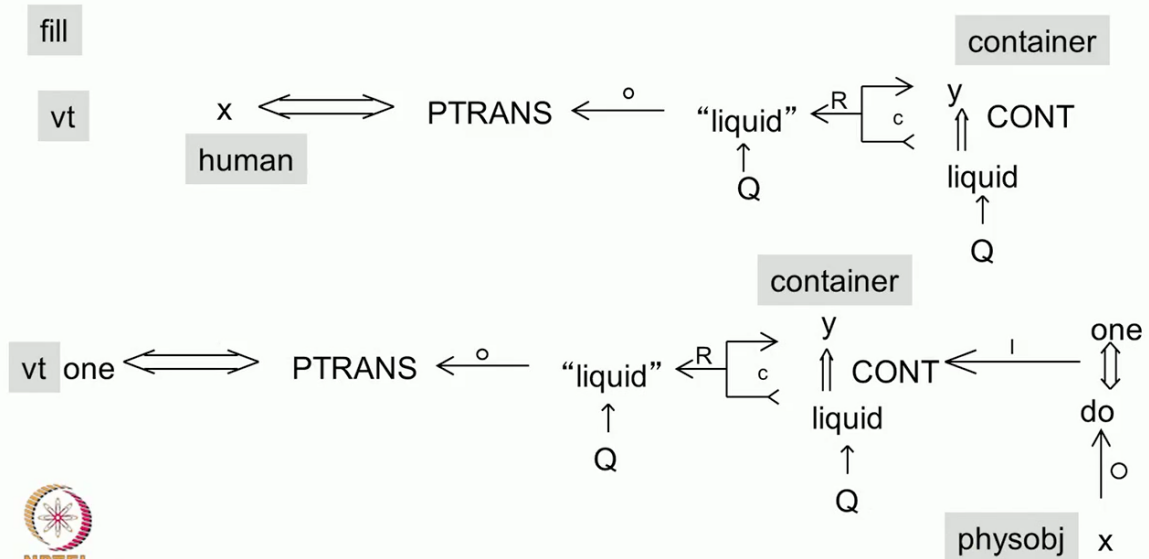
"I" am the only subject in the sentence, so the second or third form of fly must be used An English specific rule says that the second conceptualization marks the time of the first one.



So when you read the sentence I saw the Grand Canyon flying to New York then I am the only subject in the sentence and the second and third form of fly must be used. Either the second or the third. And in this case they end up using an English specific rule which says that the second conceptualization which is that of seeing of ptransing to New York must be a time marker for the first one. So essentially the first conceptualization which is that I saw the Grand Canyon is marked by the time while I was flying to New York in the sense I was sitting on a plane and flying to New York.

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Semantic Ambiguity



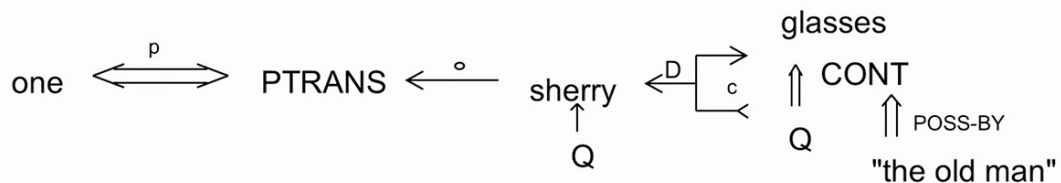
Then we have semantic ambiguity. Words can have different meanings so fill for example is a word which can have a case where a human being fills some liquid into a glass or a bartender fills your glass again or something like that. Or you can talk about somebody some unknown person the glasses got filled or something like that which is a passive sort of a sentence where you are only talking about containers or physical objects. Now if you were to read this sentence again we have an old man's story here.

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Semantic Ambiguity

The old man's glasses were filled with sherry.

Glasses in the sense of containers!



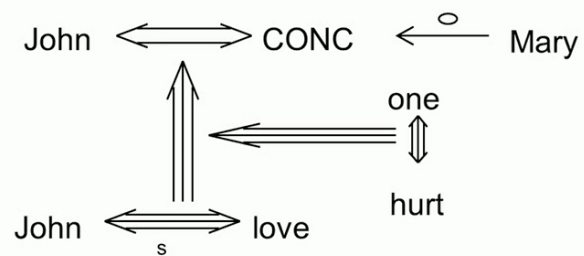
So when you start reading the old man glasses first the impression you have is spectacles because that's the most natural way of thinking of old man glasses but when you read filled with sherry then you have to revise your sense of the glass and glasses are here in the sense of containers and then you can use one of the meaning of word fill which is that the glasses were filled with sherry and the glasses belong to the old man. That's the only role that the old man is playing here. Now one difficulty so there are some schools of thoughts which say you must first do syntactic processing then you must do semantic processing and then as they call it you must do pragmatic.

Now if you look at these two sentences they are syntactically identical John's love of Mary was harmful.

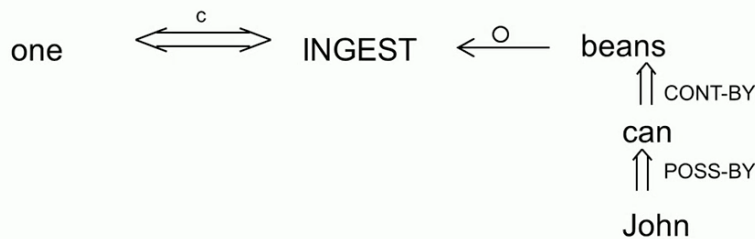
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Syntactic similarity

John's love of Mary was harmful.



John's can of beans was edible.



John's can of beans was edible. Syntactically they look similar. Then only difference is in semantics. If you look at the kind of conceptual structures you are aiming at then John's love of Mary you will see as the part here which is talking about John's love of Mary so remember our notion of love was that it's a state verb when John thinks about Mary then John is the state of being in love. And the second part which is outside the red outline says that that causes hurt to somebody. Was harmful is causes hurt. We don't know who it is harmful for may be it was harmful for John or for Mary or it was harmful for somebody else we don't know. But it was harmful for someone. And that's how we would like to model that sentence.

The second sentence John's can of beans was edible essentially we are saying that we can eat the beans the beans were edible and which are the beans the beans which are contained in the can and the can that was owned by John. So this is a very different conceptual structure that is associated. But the sentences are syntactically identical. So this is the case for saying that if you are doing natural language processing do not say that you will first do syntactic processing then semantic processing and then pragmatic. Pragmatics is basically bringing situation into place. May be after a couple of weeks we will look at that when we look at frames.

OK so I will stop here with conceptual dependency. Our goal of looking at this was to look at how one can make choices of predicates when you are representing first order logic. Now conceptual dependency is basically in first order logic. If you read the description given in Chamiak and McDemott's book then they treat it exactly like the logical sentences that we have written. So the focus is on the choice of words choice of predicates that we want to use. So after this in the next class we will swing back a little bit towards processing. So far we have seen forward chaining and forward reasoning in

the next class we will see that that's not always the best way of doing things. And we will look at alternate way which is backward chaining. So we will stop here.