Lecture 18: Lexical Access

Hello and welcome to the course, introduction to psychology of language. I am Dr. Ark Verma from IIT Kanpur. And we are in the fourth week of this course, as you know we are talking about, word processing word, comprehension meaning deleted words and how do we access the words from our mental representations, all of those kind of things, in the last lecture. We have talked a little bit about word meaning, basically they grounded, the grounding problem and embodied semantics approach. We saw some experiments that seem to give us a better idea, of how the embodied semantics you know approach really works, it tells us that you know, we are probably storing meaning in a system that is outside of this linguistic system. So, in we are probably storing meaning by, virtue of perceptual you know sensory perceptual, representations action based representations that is. So, that is one part we did in the last lecture. We also talked a little bit about, we also talked a little bit about,

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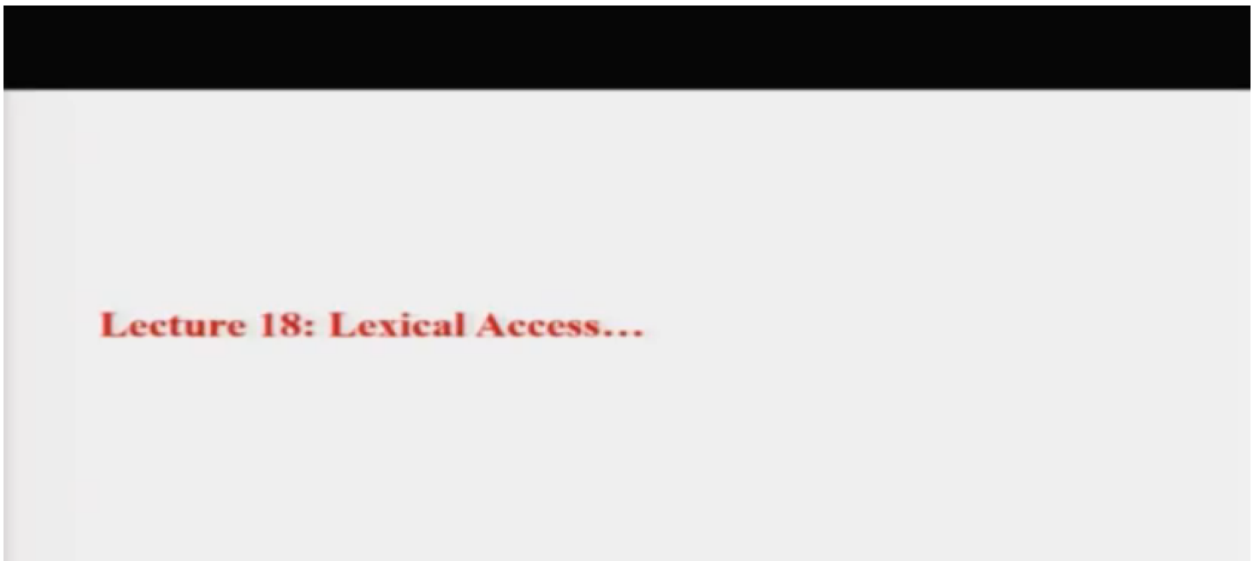

you know models of lexical access. Now again just to give you a bit of a revision, what is lexical access? Lexical access is accessing the words form, in your mental you know a conceptual store. And you access this words form, in a sense that depending, upon the kind of input that is building in whether it is a visual input or whether it is auditory input. So, suppose your hearing somebody say something that is also some source of evidence. So, that evidence your kind of you know evaluating in an incremental sort of the way. So, say for example somebody said cat, you are you know listening to that in, in incrementally incremental fashion. So, cur ate all of that so, first the curse sound and the a sound and the T sound and unless the entire, evidence is there, you will not be able to you know definitely say that. Okay? This is the word that I have heard and obviously if you know that what you can access that words form, the matching form in your mental you representations and then from there go on to finding meaning and other things this is one way. And the other way is say for example in, in written kind of a modality you have to read the word. So, there in the written modality, obviously there is the entire word present all at the same time, but you will need to analyze that layer you know feature by, feature later, evaluated in initial sense, obviously you know after you know how to read that becomes fairly automatic and you know you will read the word anyways, again that becomes very fast as well. We saw some paradigms looking at how a lexical access is modulated with or what is the time, course we saw that this is something which is very fast, as early as 100 milliseconds, you know or say for example if you were doing the shadowing, tasks it can take close, to around 200, 250 milliseconds. Okay? Another thing that we did was a little bit about, the you know, generations of models of lexical access we, we saw the first generation models of lexical access, the low vision model and the frequency or at bin search model as the phobes model and I think the last thing that we did was, the second generation model flexible access that was the trace model, the trace model was a visual model of lexical access, how are you taking in the visual input and how you, you know moving ahead with that majorly that. Okay? So, let us continue our chart about the lexical, process of lexical access and we will in this in today's lecture talk to you about, one more model of you know lexical access that belongs to the second generation. And a couple of models that belong to the third generation. Okay?

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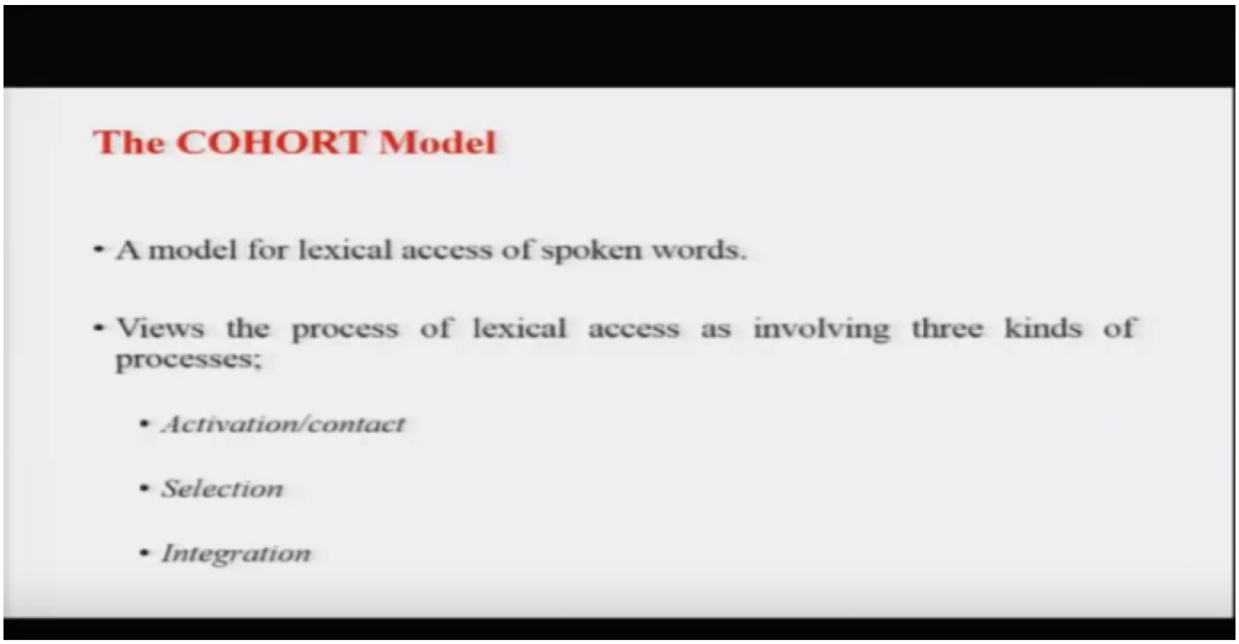

Let's move ahead with this now, we let's begin talking about, the COHORT model of lexical access, now COHORT model of lexical access, basically is a model of lexical access for spoken words. So, as I was saying spoken input versus, written input is slightly qualitatively different with each from each other and also the way we react to this input shall be, a little bit different in both cases, majorly because the spoken input, is something that unfolds in time, incremental. Okay? You first hear the onset then you hear the middle part, then you hear the offset part. So, that is how the you know the spoken input works. Now the COHORT model views the process of lexical access as involving, three kinds of processes. The first process is activation or contact, the second process is selection and the third process is integration. So, there are these three processes into, which you know the model of lexical access is being divided, let us look at look at that in a bit more in detail. What happens in the activation phase,

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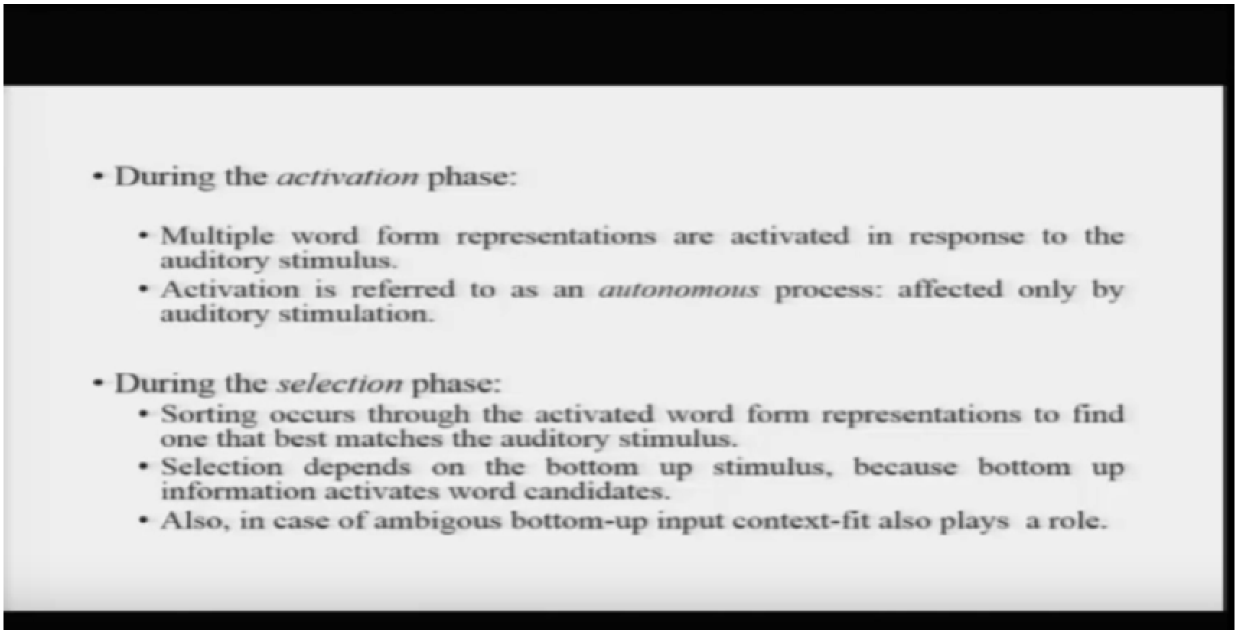

multiple word form representations are activated, in response to the auditory stimulus. How is that going to happen suppose you were you know, listening a word again, you know something just starting from care, now there could be many things that start from care. So, you you're not really sure so it could be cat, caterpillar, cap, candle, you know kin or any of this. So, as soon as you start hearing the input in time, what happens is from the onset onwards, multiple candidates, become activated. So, that is how multiple word form representations will start getting activated, as soon as you start with the as you as soon as you start hearing the onset of the incoming auditory, stimulus as soon as you've heard the onset of the incoming auditory stimulus, this is what will create so, many representations that will all become activated and will start competing against each other, this activation is referred to as an autonomous process. So, it is something that you cannot avoid, I mean obviously you can say for example, you know there are other processes top-down process context or the mind if knowledge that can help you, you know activate a few lesser and you know to you know have more goal-directed activation, but more often than not this is something that is autonomous and will happen, without any of your you know control process, it is affected only by our digital simulation, as soon as auditory stimulation, is there all of those things will start coming getting activated. And you have to kind of sift through this multitude, of auditory word form representations that are getting activated, to actually reach the final goal. So, we will see how that happens, because multiple things are activated, it leads to the necessity for selection. So, the second phase, is as expected the selection phase, what in this selection phase? Now sorting starts to happen, through the multiple word form representations, to find the one that best matches the auditory input. So, what happens is say for example multiple kinds of words will start getting activated. And what you will need to do is to be able to select, which one matches the incoming auditory stimulation, in the best possible manner, remember there will be phonetic feature, variations there will be phoneme variations, they will be M phoneme variation. will probably not happen because, if you are talking about. the same onset. So. there could be phonetic feature, variations and also the input as soon as the second and second part of the signal comes, for the third part of the signal comes, you are getting more and more information and on the basis of this you know fast unfolding information, you will already have you know you know you'll already start, selecting some or the others and you know this is the process that the pyramid you know, starts to get inverted. Okay? So, many of them activated then very few, then made a few and then you finally reach the target word. So, selection depends obviously on the bottom of stimulus, because bottom of my information is activating, these word candidates however in case the bottom of stimulus is not really very clear and there is some ambiguity, context wit also starts playing a little bit of photo, I think context which plays a role mostly all the time, because say for example, I was giving you this example of you know bat and cricket that if I were having conversation, about cricket and if you hearing bear from my mouth, you're probably going to hear the bear which kind of ends with derp and bat, you know and save suppose say for example, there is a little bit of an ambiguity that you don't heard it properly, the context also kind of zeroes, in you know to that for particularly, representation that fits the context also you know particularly well. So, both of these things will happen so, you have activated many candidates, now you have to select from so, many candidates as to what the correct target, word is and a the unfolding input helps you be also the context to a kind, of you know tries to help you in that process.

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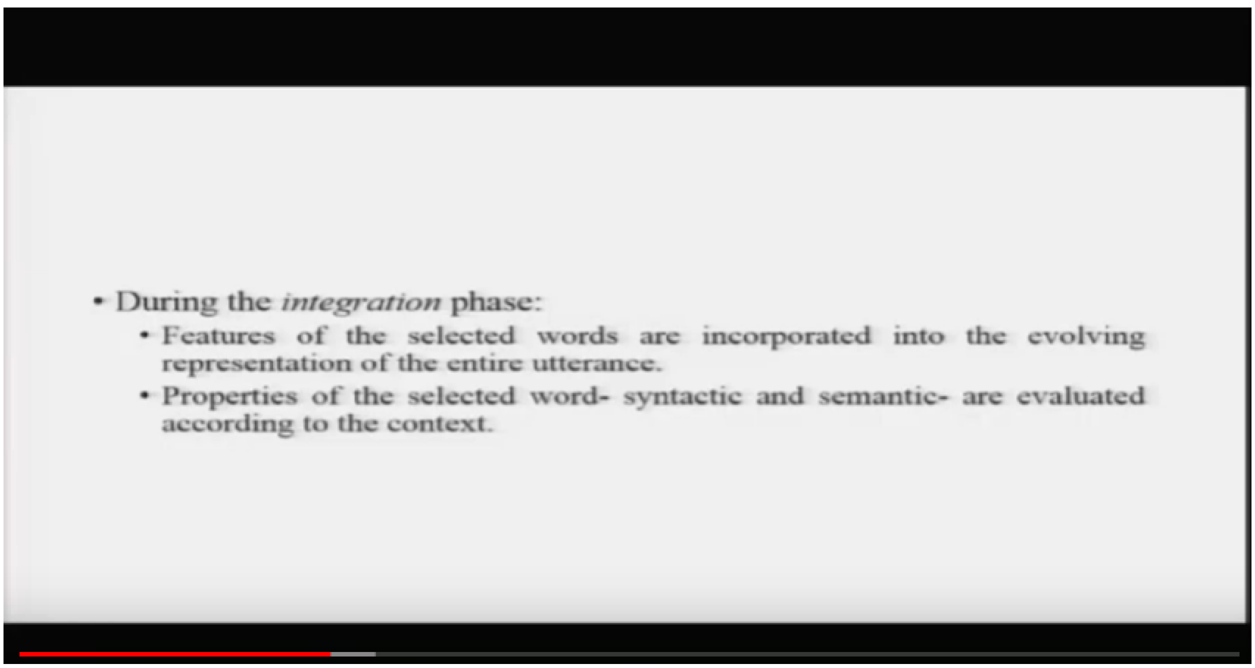

And the third in the final phase is the, phase of integration. What really happens here is the feature, of the selected words are incorporated, into an evolving a representation, of in dire utterance. What is it that you were talking about, the entirety of that utterance. Okay? And the properties of the selected words, syntactic and semantic features are also evaluated, according to the context and that all that together with whatever was happening earlier, will help you zero in on the correct candidate. So, in the integration phase, you're taking in much more information than just what the bottom-up input was providing you, you're kind of reaching something that could be, appropriate is the best guess so, on and so, forth but also you will evaluate the syntactic fitness and the semantic fitness, of the target words, of the many words that are activated, to the entire utterance and that is what will lead you to figuring, in you know to zeroing in on the correct candidate. So, as I said in the beginning, the entire process of lexical access can we looked at, as activation, selection and then this integration. Alright?

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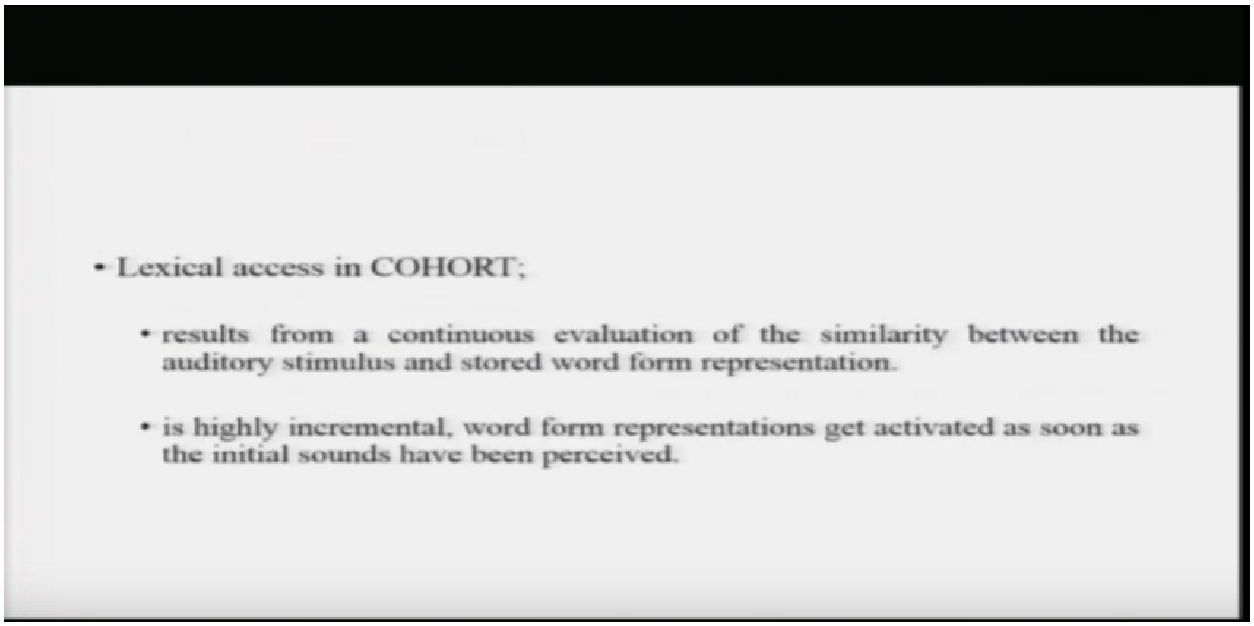

So, moving further how does this really work out. So, results from a continuous evaluation of similarity, between the auditory stimulus and the word, stored word form representations, this is how a lexical access really works with. Okay? It is as I said highly incremental, word form representations we anyway start getting activated, as soon as you first hear the input, then this is how this will kind of move further.

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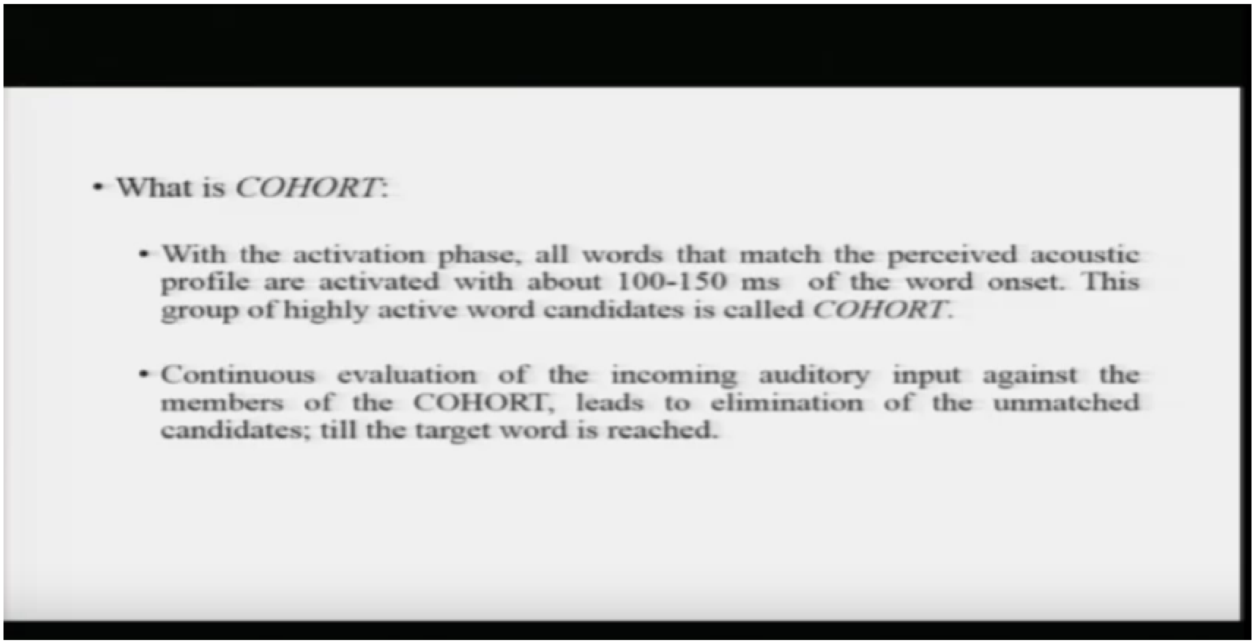

What is this cohort? So, somebody asked me about how does this why is this model named at COHORT, COHORT is basically all of those have word for my representations that were activated, in the first phase. Okay? So, 30, 40, 50 word candidates that are all activated, this entire set is referred to as the cohort and this activation basically builds up, in the initial 100, 250 milliseconds of you hearing the auditory stimulation. Alright? So, with the activation phase all words that match the perceived acoustic profile, are activated within 100, 250 milliseconds of the word onset, this set of activated candidates, is referred to as the COHORT, continuous and then what happens is you are continuously evaluating, as the signal is unfolding in time and these representations you are kind of matching, each of these representations. So, the signal that is unfolding in time and you kind of you know eliminating so, many things and you know, zeroing in on something here, as you said in the integration you're also considering the syntactic and the semantics Fitness, all of that kind of leads, you to keep on going with, it till the target word is, selected and everything else is eliminated that is how lexical access, is happening here.

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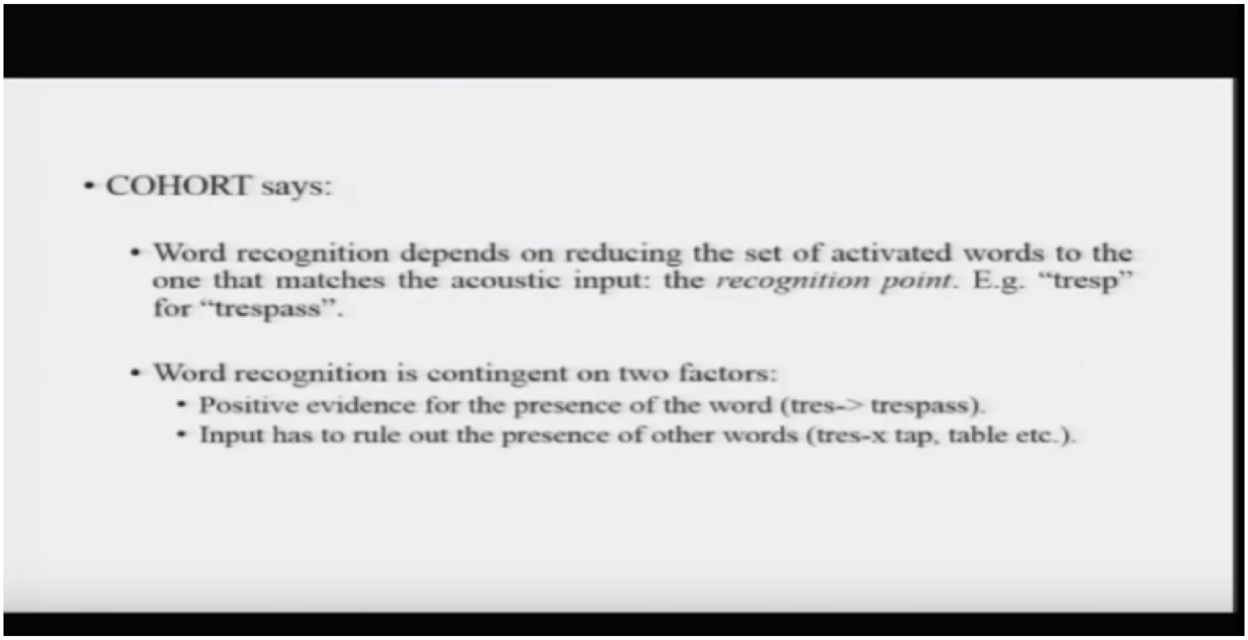

Now record model says that the word recognition basically, a successful word recognition basically, depends on reducing the set of activated, words in the code, to just one that matches the incorrect, incoming representation, this point wherein you have eliminated, all other possible competing representations. And you have zeroed in on the correct target word, is referred to as the recognition point. So, in this unfolding stimulus in time, what is the point that you will know that. Okay? After this there are no more candidates available, this is certainly this particular word. Okay? Suppose say for example, you are talking about the word trespass, now trespass basically, when you start with tray you can be talking about, trade you can be talking about, trespassing and so many other things, but as soon as you reach stress, this is where you kind of know that. Okay? There is no other word that has stress and you can kind of move, into a different direction. So, this the SP point here, is referred to as the recognition point, where you're very sure of. Okay? This is the word that I am hearing. Okay? So, then basically, what happens is the word recognition the process, of successful word recognition, according to the COHORT model, is then sort o contingent on two factors, what are the two factors? First is positive evidence for the presence of the word, the incoming stimulus. And the second is the input has to rule out the presence of other words, there should be nothing else that is activated at that point in time, both of these processes, converge at a point, in time when you are hearing the signal that is what is referred to as the recognition point. Okay?

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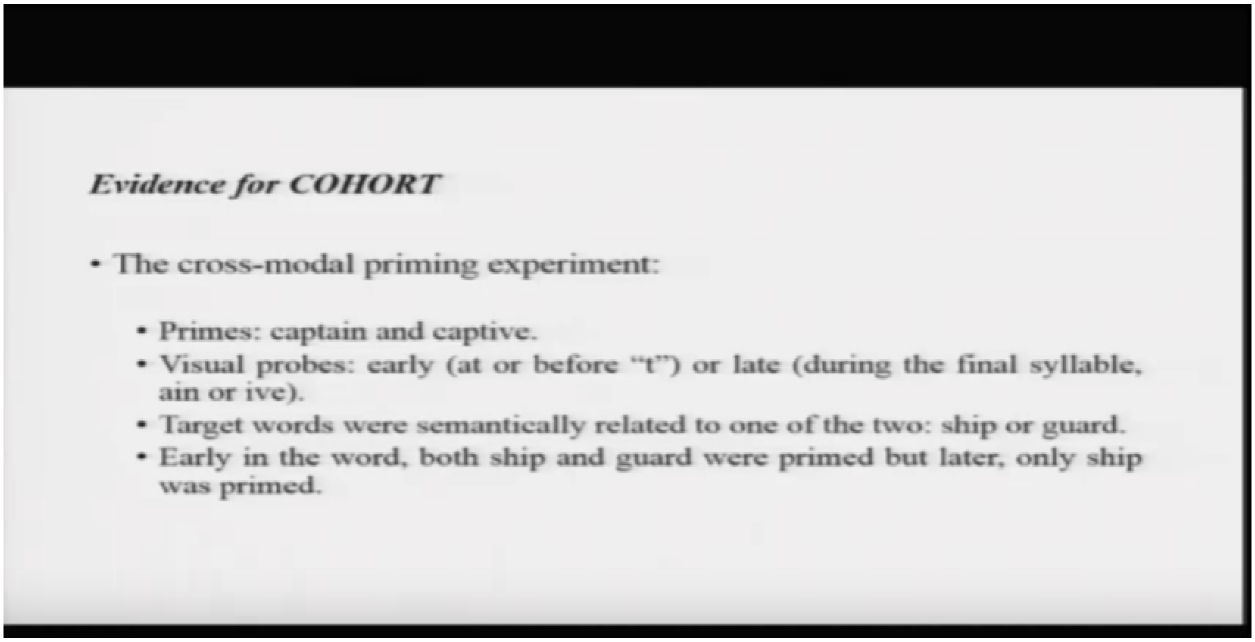

Now is there any evidence for the COHORT model, yes there is there are a lot of experiments that people have done. We will discuss a couple of them here, one of them that going to talk about there's a cross model, priming experiment, what was there was they, they wanted to use these auditory primes, were to be presented on the headphone. And the parts weren't had to take a decision about something that was presented visually. So, the primes were captain and captive, and the visual probes were could be presented at an early time or a late time and what were the probes, the target words were semantically related, to one of the to say for example, the word ship or the word guard will be presented. Okay? Now if you can see captain, is related to ship captive, is related to guard. So, that is the game here, now what happens is if the visual probes are presented early, both ship and guard were found to be activity, because at the point of cap, you know at least at the point of capped, you don't really know whether I'm talking about the captain or a captive. So, if the visual probes were presented at that point in time where I'm reaching capped, then both of them have an equal chance of being related to this one. So, both of them receive equal amount of priming, however if the visual probe, is presented later after the entire word is there then only ship gets primed, if captain is the word or only God gets trying if captive, is the word that is exactly, what happened here? So, it tells you that there is certainly something like the recognition point,

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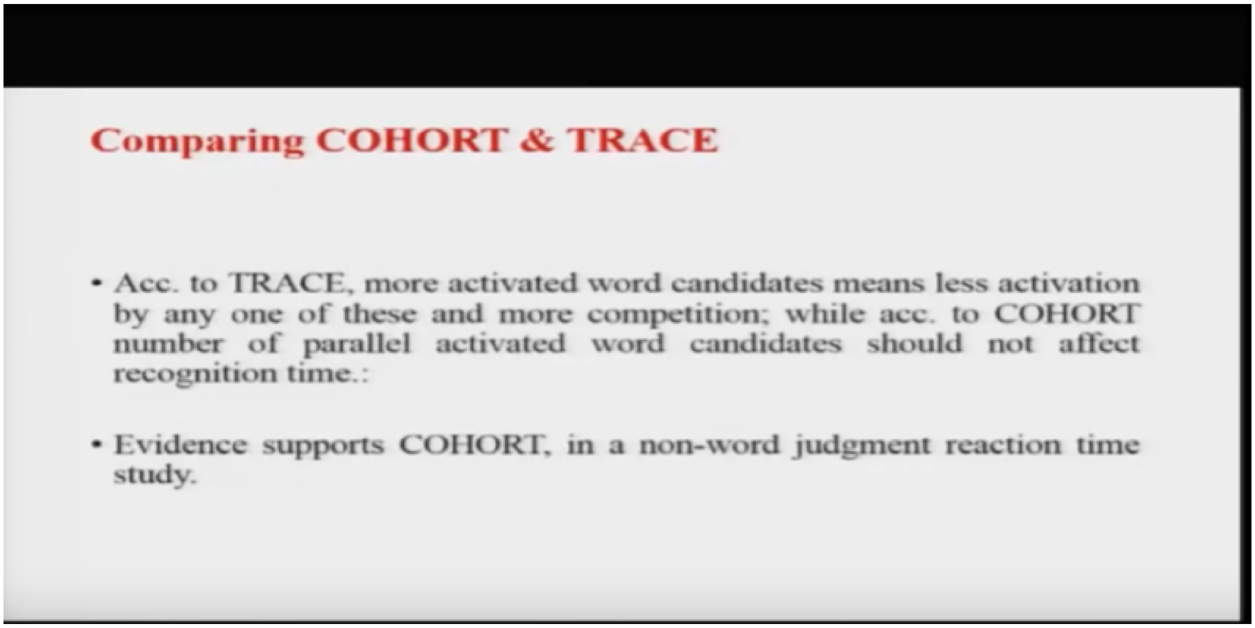

where the person is sure of what is really happening here. Okay? Now if you see this is basically, these were two of the second-generation lexical access models. The trace model that we talked about, in the last section of the previous class and the COHORT model that we just talked about today. Okay? So, let us compare them little bit just for, zooming in a little bit into how they function. So, if you look at, at the trace model, more activated word candidates in the trace model meant, less activation by any of these. So, basically what happens is in the trace model if there are 20 words activated it, basically means that the activation, is evenly distributed, amongst each of these or even if it is not evenly distributed it basically means less activation for each of them. Because the activation is shared, in the COHORT model, what happens is because the input is a new is unfolding in time, multiple activate candidates, actually does not really diminish, the activation of any one of them and all would activate, all word candidates, are sort of activated to equal degrees. Okay? What also it happens is the number of word, candidates that are active, does not have any effect on the reaction time, whereas the in the trace model, the number of word candidates that are that are active at any point in time, we'll have some consequence some kind of slowing down, for the reaction time, for the target word. So, this is something which is important. And this kind of has been shown that in the non word judgment reaction time task, the cohort model gets does not get affected by the number of possible, competing candidates, whereas the trace model, does get affected by the number of possible, competing candidates. So, that is that is one thing.

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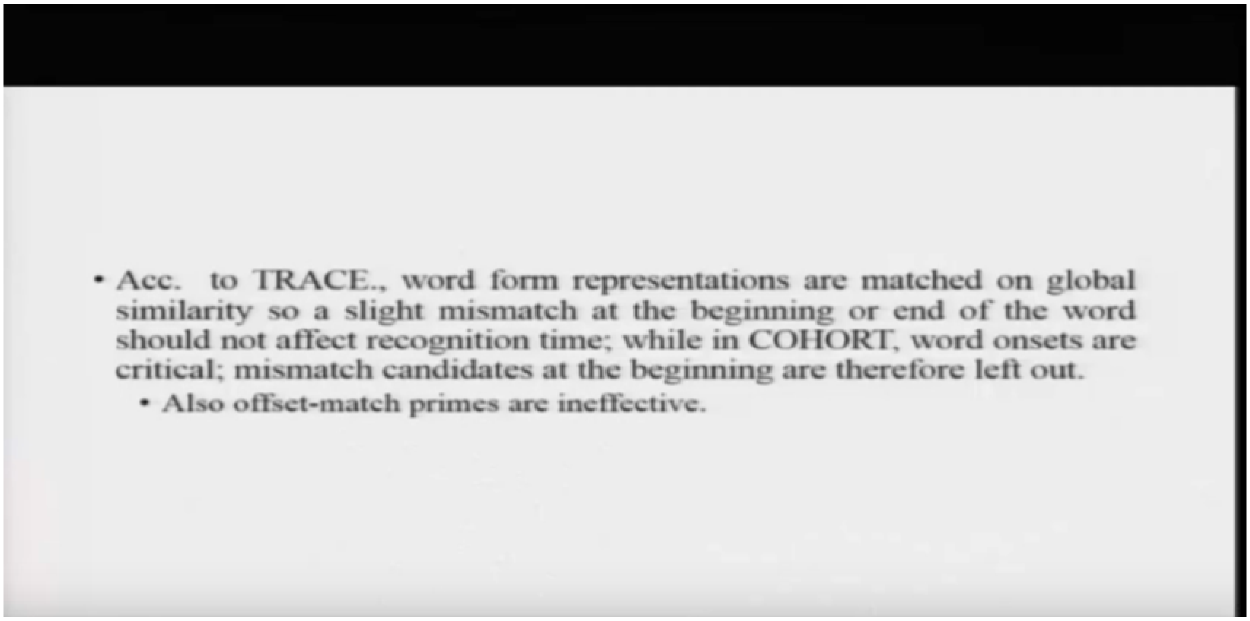

Moving on according to the trace model, word form representations are matched on global similarity. So, a slight mismatch at the beginning or the end, should not really matter, because you will have the entire word, at the same time, word is not an unfolding signal in time, as long as it is visual, however in the COHORT model that is basically, the signal is unfolding in time. So, if there is a slight mismatch in the beginning, you can lead to a very different word. Okay? If there's a slight mismatch in the middle versus, if there is a slight mismatch in the end, the amount of disruption would probably be lesser. So, what happened in the COHORT model that onset mismatches were more disruptive, were found to be more disruptive, as compared to the middle or the Etna offset mismatches, however in later experiments, they have basically I will talk about that in a later experiment,

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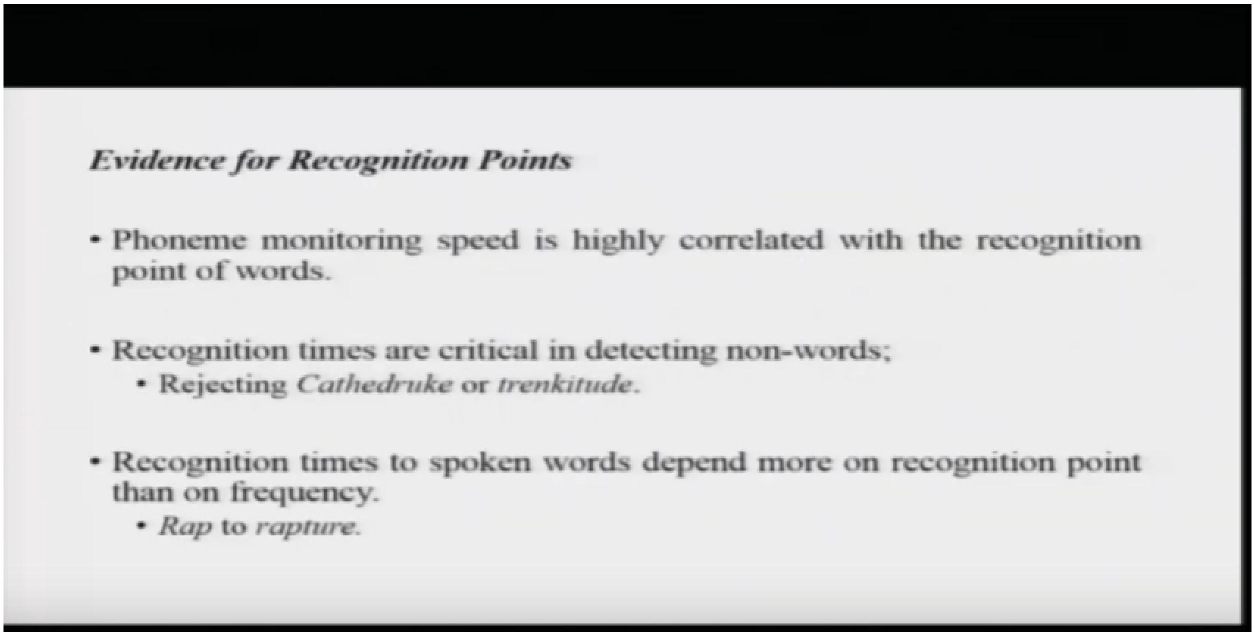

they have kind of tried to see if offset, matches are also useful or not. So, we will talk about that in a separate section, now is there any evidence for recognition points or is there more evidence for recognition points, if I ask they have used some tasks, to check that, one of the tasks that they have used, is the funny monitoring task, what is funny monitoring tasks, as the name suggests you have to monitor for the presence of a particular funny. Okay? And this basically has been shown to be highly, correlated with the recognition point of the words. So, how does this really go, it has been shown that recognition times, are critical in detecting non-words, suppose there is a longer word, its recognition time comes later. So, we'll take that much more time to reject, it as a word or a non word if the recognition time is earlier, you can very quickly, tell that whether it is a word or non word. So, that is the difference. So, they basically did this study and they had non words, which seems like words, but the non words were something like Cathedral so, the word was cathedrurke, made from Cathedral. So, till the drill part you don't really know whether, it is a word or non what you say probably thinking maybe, the word is Cathedral and that's why you will kind of wait till the entire, thing finishes to really reject it, trenkitude is easier to reject, because the recognition point, comes much earlier. So, till the point you restrain you already know that, you know the recognition behind this earlier and there is no other candidate, no word, there and you can kind of already quickly reject it. Okay? So, people are faster in rejecting, words like trenkitude, which do not really mean for which the recognition time as much earlier, as compared to cathedrurke, when the recognition time is slightly later, recognition point is slightly later. Okay? Also they found that recognition times, two spoken words depend, more upon recognition point than on frequency. So, this is also something very interesting that, this kind of recognition point, correlates very highly with your recognition time that you finally take, to you know say whether it is a word or a known word. So, these two measures are probably you're not talking about, similar things and hence are very closely correlated.

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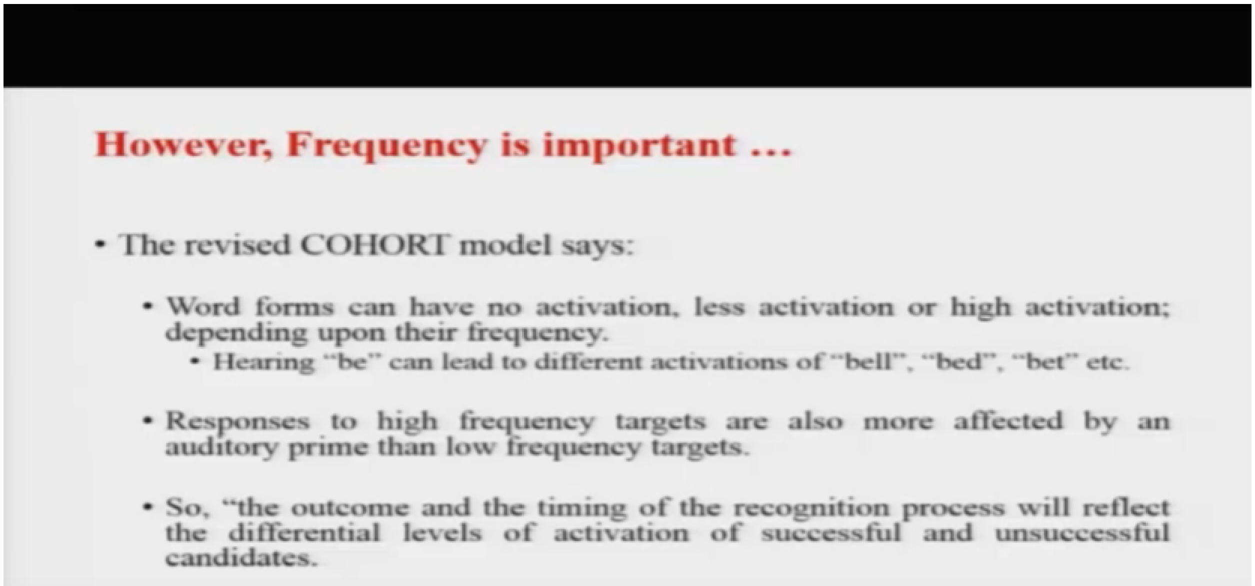

However it has also been shown that this parameter of frequency is also important, you're talking about, in the last thing that recognition times, correlate more closely with the recognition points, even more than frequency, but in frequency is, also very important, it has been shown in a number of studies. So, they do revise the COHORT model and they say that word forms can have either no activation, less activation or high activation, depending upon the frequency, and this activation, I'm talking about, is you can look at it as some sort of a residual activation. Suppose , you read a particular novel, those the activation of all those words, the activation of all the words, in that novel will be at a slightly you know higher, level because you've just read that model, as opposed to if you've not read that novel. Okay? So, hearing, something say for example, can you know lead to less evidence or more evidence. So, basically if the residual activation is high, then you will need less evidence, to activate that word, if the residual activation, is low you will basically need more evidence and hence more time to recognize that word, this is where frequency comes in, suppose you're hearing something from starting from B. So, B it says Belle, bad, bet, etc depending upon the frequencies of each of these words, you will need more or higher, time to actually recognize them. Okay? Respective of their recognition time, because the recognition point, here is very similar for all of these, these are all small words. So, they have shown their responses to high frequency targets, are more affected by an auditory prime, than low frequency targets. So, and that's the basic thing about residual activation. So, what they say is the outcome and the timing of recognition processes, will reflect the differential levels of activation of successful and unsuccessful candidates. And this differential levels reactivation basically depend on their frequencies.

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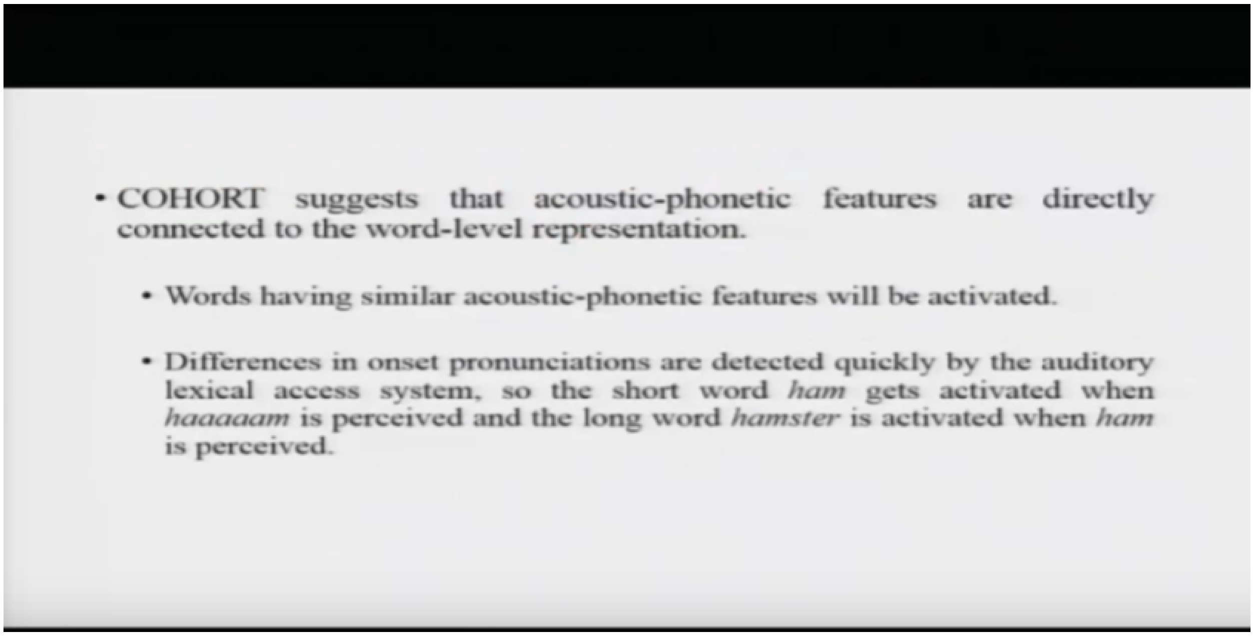

Further on COHORT, has suggested that acoustic phonetic features, are directly connected to word, level representations, say for example, I keep giving this example differences, in onset pronunciations are detected quickly by auditory lexical access system. So, the short word ham gets activated when ham is perceived and the long word, hamster is activated when ham is perceived. So, ham and ham, ham it leads to hamster or hamburger, the shorter ham is basically also. So, then what I'm trying to say, is that there is a way that the auditory lexical system, can distinguish between hamster and hamburger Okay.? So, this distinction is very quickly made and the system kind of latches onto the correct representations, rather quickly.

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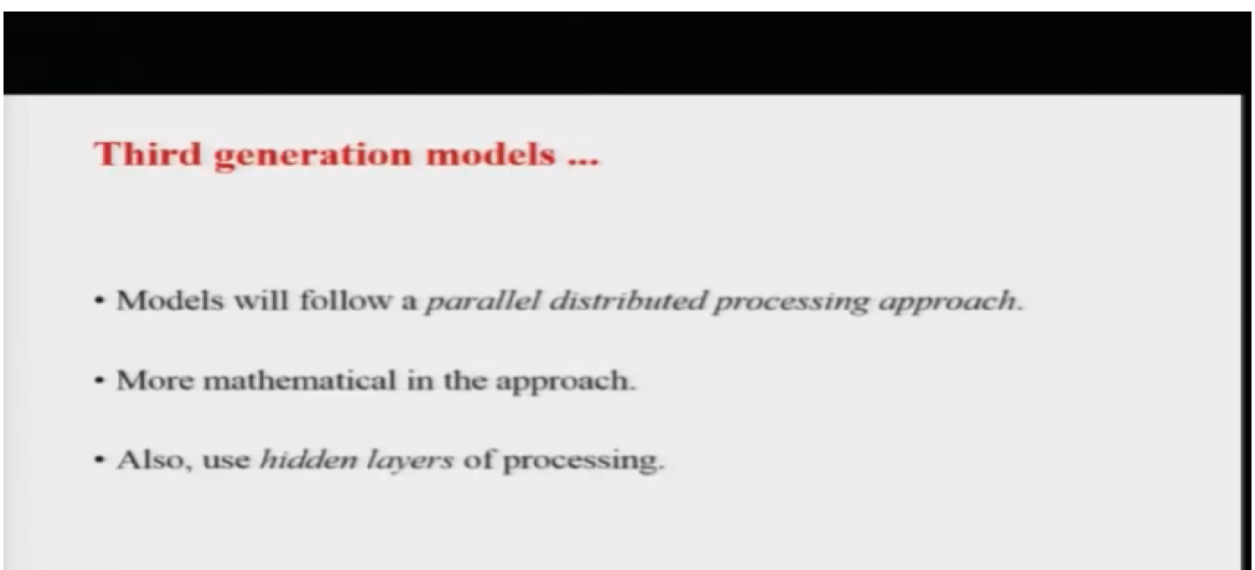

Let us move so, this was all about the second generation of lexical access models. Let us move now to the third generation, of these ones we will talk about, two models, we will talk about Jeff Elements simple recurrent, Network model and we'll probably talk about, yeah we'll talk about another model as well which is the distributed cohort model. Okay? One of the things that is notable about these third-generation models, is that these models usually follow something refer to as parallel distributed processing, approach this was a new approach, in computation and has a lot of caveats to it I'll talk about that in a bit and these models were also much more mathematical, in their approach. Okay? They're much more calculation based, also they use what is used in machine learning or neural networks called something like hidden, layers and hidden layers are basically layers, of processing, which accumulate finally do the computation. So, there is an input layer output layer and then the hidden layer this is where all the processing happens. Alright?

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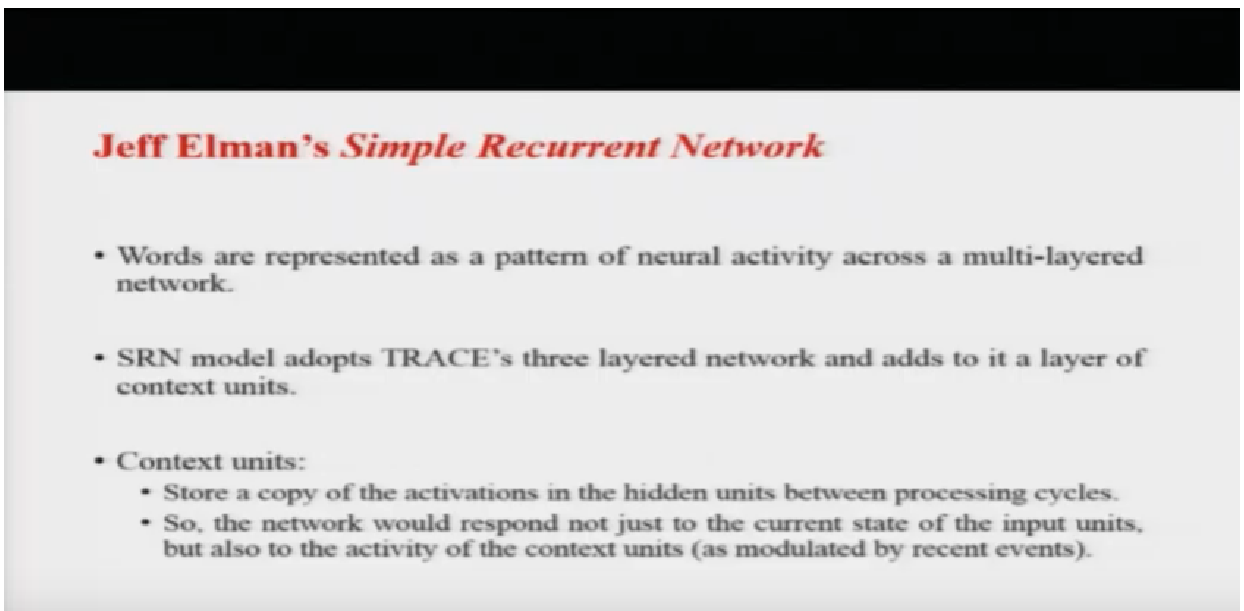

So, let us look at Jeff elements simple recurrent Network model. Now in simple recurrent network model words, are represented as a pattern of neural activity, across a multi-layered Network. So, basically you can imagine this as a network, of neurons and this network of neurons, will have differential activity to store different kinds of words. So, for example if there is this bunch of neurons 1, 2, 3, 4 ,5 and there is a word, the word is represented as 10% activity in 1/20 version activity, into this much activity here, this motor activity here. So, this particular pattern of activity very basically be the signature of this word, same network of neurons, can store a different word, with slightly different levels of activity. So, this basically is the one of the concepts that you have to remember, words in the symbolic current model, are stored as a pattern of neural activity, across a multi-layered set of neurons, you know as this structure and this pattern of activity can change, even though the set of neurons may or may not be received. Okay?

This is one, also the simple recurrent model, kind of adopts the traces, three layered Network. So, trace had three layers it has features, letters and words, simple resident model, also kind of follows a similar architecture, in addition to this in addition to what trace had, the SR n basically has something called,' Context Units', what our context units? Context units are units that a process or entertain information that is incoming, from the environment and this basically is stored in the hidden unit. So, it basically stores the copy of the activations of the hidden units, between the pre-processing cycles and basically, what happens is this is supposed to simulate the effect of context. Okay? So, the network would respond, not just to the current state, of inputs what is coming, but it also takes into account the residual differential activation that basically, makes up context frequency, familiarity the environment, all of those kind of things.

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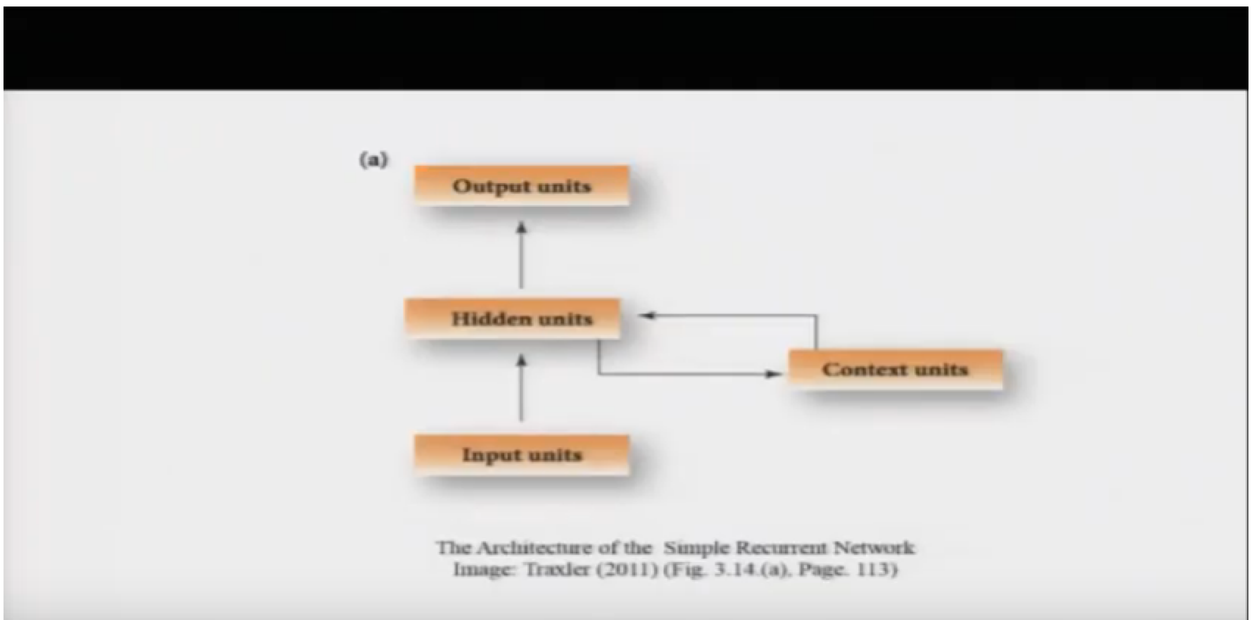

This is a very simple, idea of how the simple recurrent model looks. So, you can see output units, input units, in the middle there are these hidden units and then they're the context notes that are basically modulating this activation in the hidden layers.

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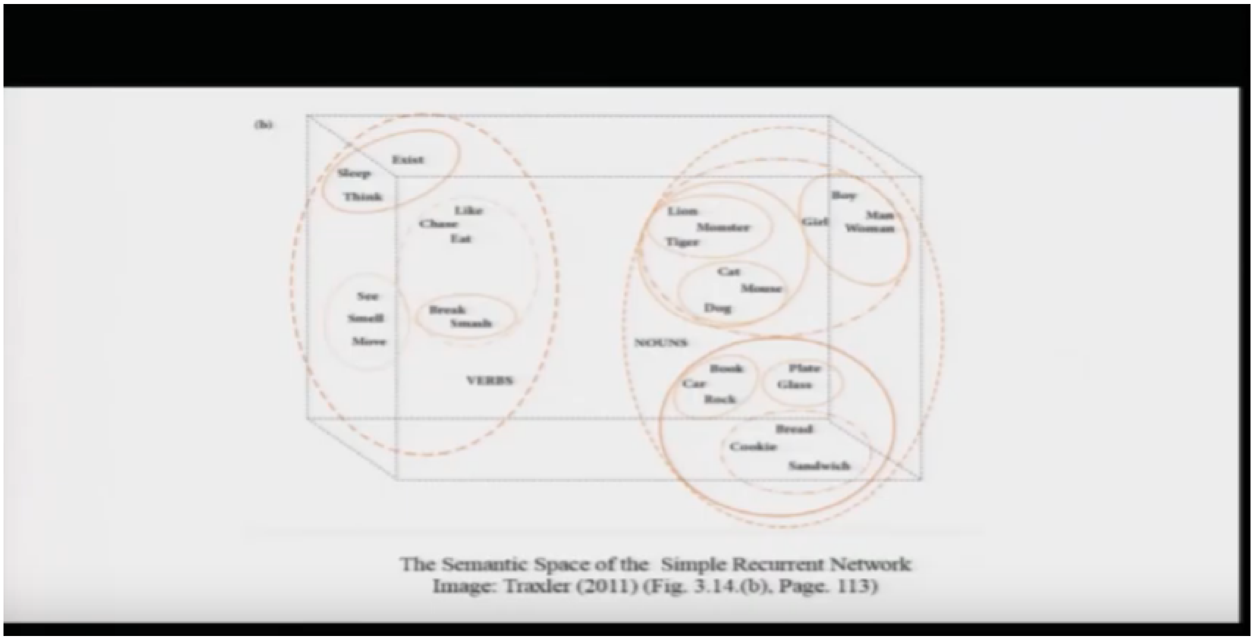

The Semantic Space of the Simple Recurrent Network
Image: Traxler (2011) (Fig. 3.14.(b), Page. 113)

This is how the model if after, if it runs after in multiple iterations, this is the kind of semantic space it gives you, you will see broadly that it is putting together words that are similar to each other, some of them sometimes, not say for example it at least separates about the nouns and the verbs and then it puts together similar nouns and similar verbs together. Okay? So, this is basically their model classifying, your semantic space, after a number of iterations let's talk about how processing really happens here.

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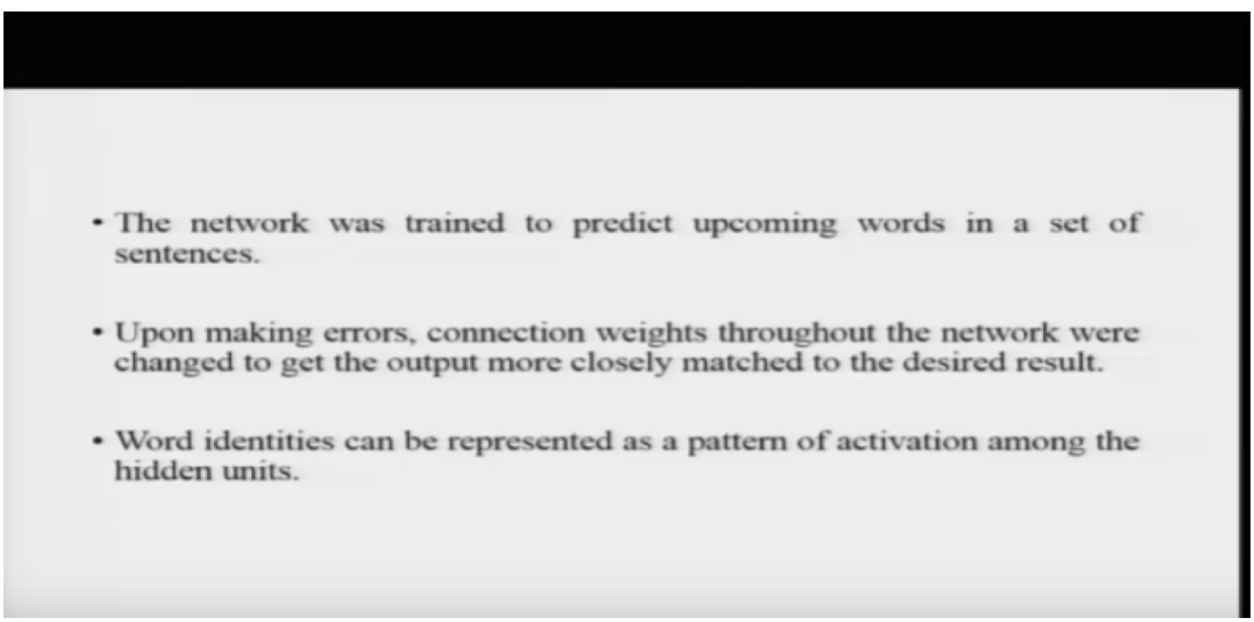

Now what happens is this kind of network can be trained to predict upcoming words in set of sentences, on the basis of crossing earlier words, upon making errors in these predictions the connection, waits throughout the network are changed, to get the output more closely. So, there are certain parameters that the model must be banking, on and those parameters have certain weights, weights you can think of as contribution, to the judgment and the contribution to the judgment or the weights can be adjusted, say for example in the first psychic something very different, it's been you know some very remote output is presented, in the second psychic slightly closer, in the third cell you cite it closer what can be done, is you can keep adjust the weights. So, as to you know facilitate the model to come to the closest, input to what the desired input and closest output, to what the desired output is. So, in the model makes errors, people can connect, change these connection weights, throughout the network and basically to in order to get the network, to learn better and to reach the output more closely, now word identities, can be represented as a pattern of activation, among the hidden units which word, came basically can be represented in the pattern of activity in the hidden units. Okay?

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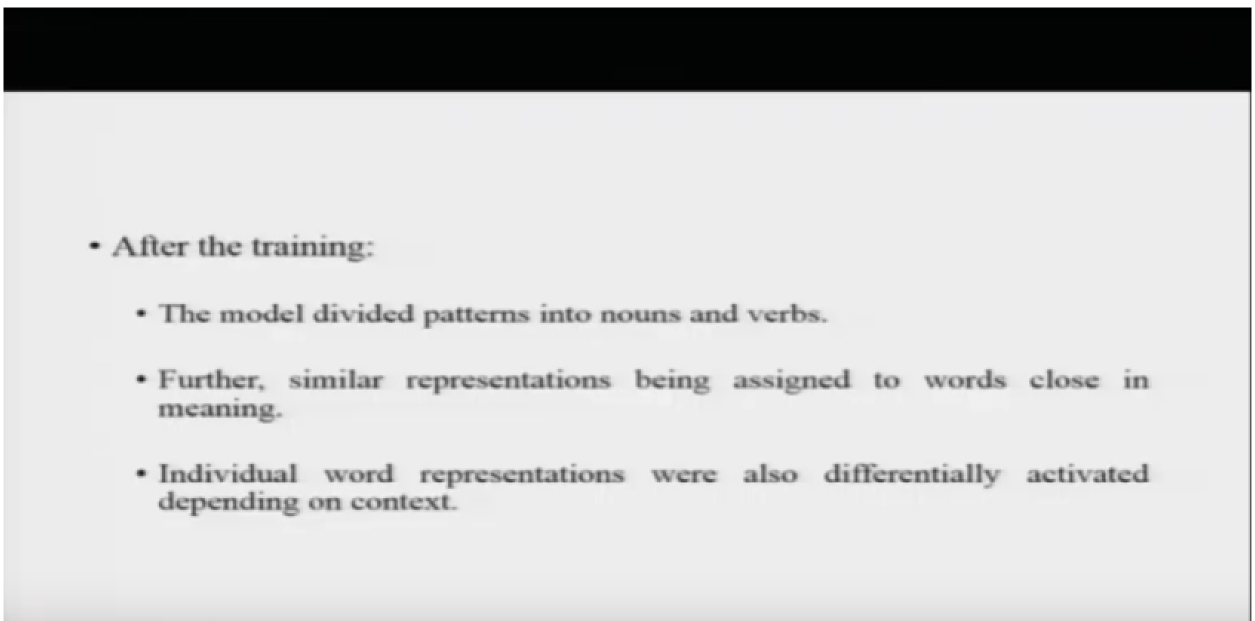

Now what happens after multiple rounds of training, the model kind of it divides the set of incoming words, into nouns and verbs, similar representations being assigned towards close in meaning. So, that also happens if you can kind of go back and see if you see lion, tiger, monster all will come together cat, dog, mouse, come together become. So, similar nouns kind of are grouped together versus you know as compare two dissimilar nose. Okay? Also individual word representations were also differentially activated depending upon context,

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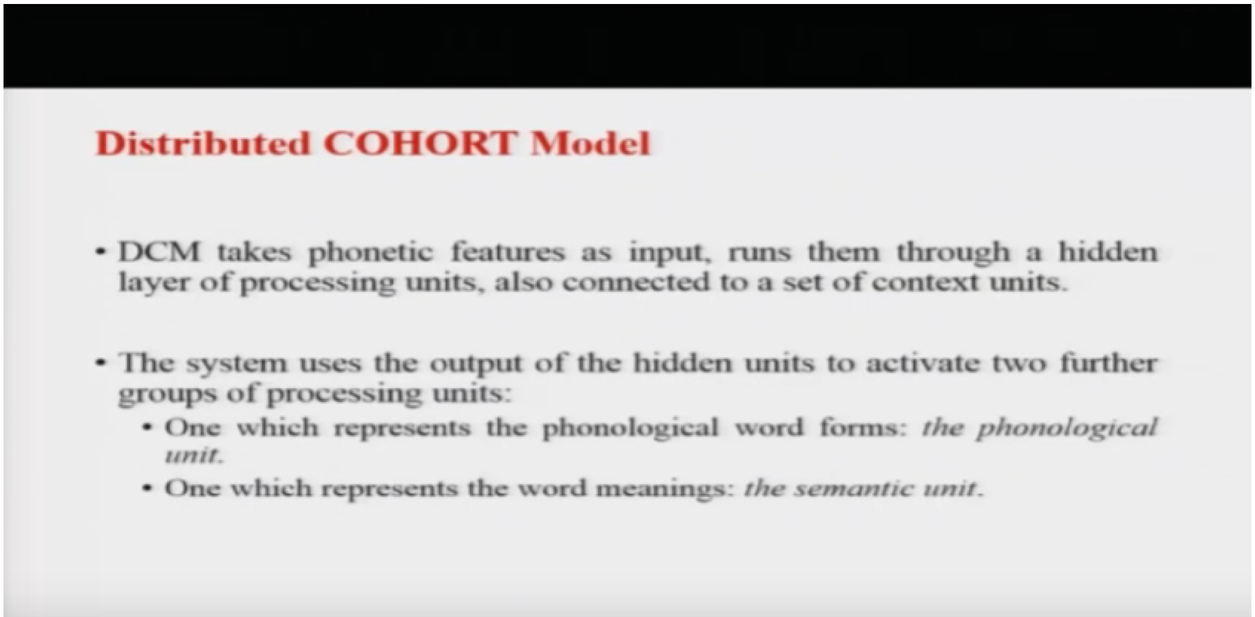

suppose the sentence context is something, then the words that will have the highest level of activation will be current those words that can fit into this context. Okay? So, context also site slightly plays a role here, now this is the simple recurrent model, let us move to the next model, the next model is the distributed COHORT model, this one is just an improvement on the COHORT model that we had talked about, in the earlier, section this just kind of on the basis of new and further results that came, in kind of adds in a few updates to the earlier model. So, it's precisely the same model, however this model is capable of taking phonetic features, as input and runs the through a hidden layer, of processing units, also a set of context change. So, now this has both a context unit and hidden layer of processing units, slightly unlike the COHORT model, because this is a PDP kind of model, the system uses the output of the hidden units to activate, to further groups of processing units. So, it kind of activates two other kinds of units, which the earlier model did not have, so, this has separate units for phonological word, forms which is the phonological unit and a separate unit for meaning which is the semantical. Now you have a differentiation between phonological processing and semantic processing, here that is an interesting upgrade that this model had.

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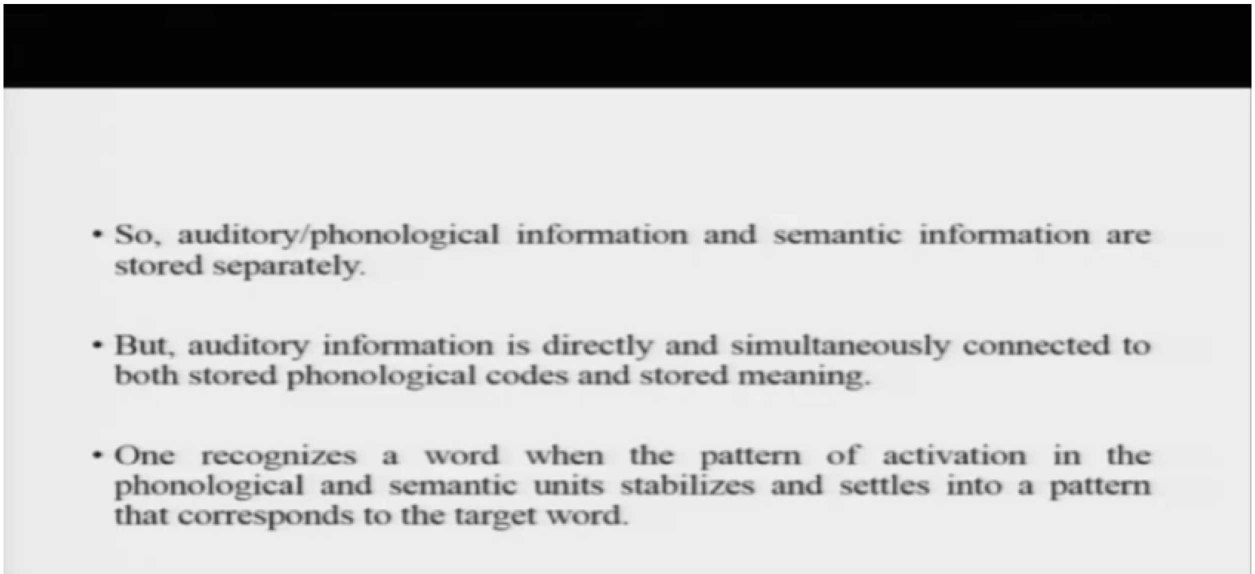

And what does this imply it implies that auditory phonological information and semantic information, are now stored separately in the earlier model, we do not see a lot of distinction between the two, further the auditory information is directly and simultaneously connected to both, stored phonological input and meaning. So, the input is basically, not coming through one set goal it is coming in a way that is reaching the semantics and the phonological units, at the same time. Now what happens in this model, is one would be able to recognize a word when the pattern of activation, in both these kind of units, stabilizes to a particular output and that is what will be the recognized word. So, there has to be some kind of integration or some kind of a converging evidence that seems to come, from both phonological and semantic units.

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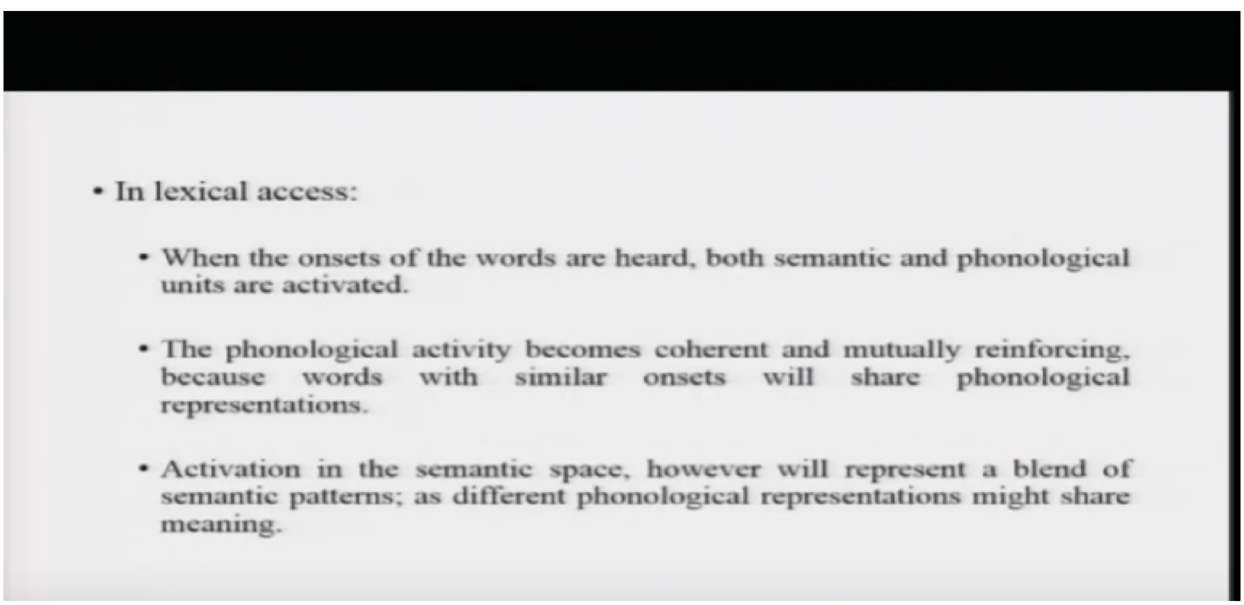

So, what happens in lexical access, moving slightly in more detail. Now when the onset of the words are heard both semantic and phonological units will get activated that is one the phonological activity, becomes coherent slightly, if it time and mutually re-enforcing because the word, with similar on, on sets will kind of facilitate each other and as soon as you are kind of moving in time, this will lead to stabilization of this activity, in a similar manner that I said the inverted pyramid is happening, you're selecting you're getting closer, to the target already, activation in the semantic space, however will represent a blend of semantic patterns. So, the context the local context the global context the, the setting the environment all of that. So, it basically the semantic space will represent a blend of semantic patterns, as different phonological representations might also share meaning, say for example cat and rat even though they are different phonological representation, but they share aspects of meaning, if you remember the semantic networks theories that we were talking about. So, this we probably you know should take a little bit more time to stabilize as compared to the phonological units.

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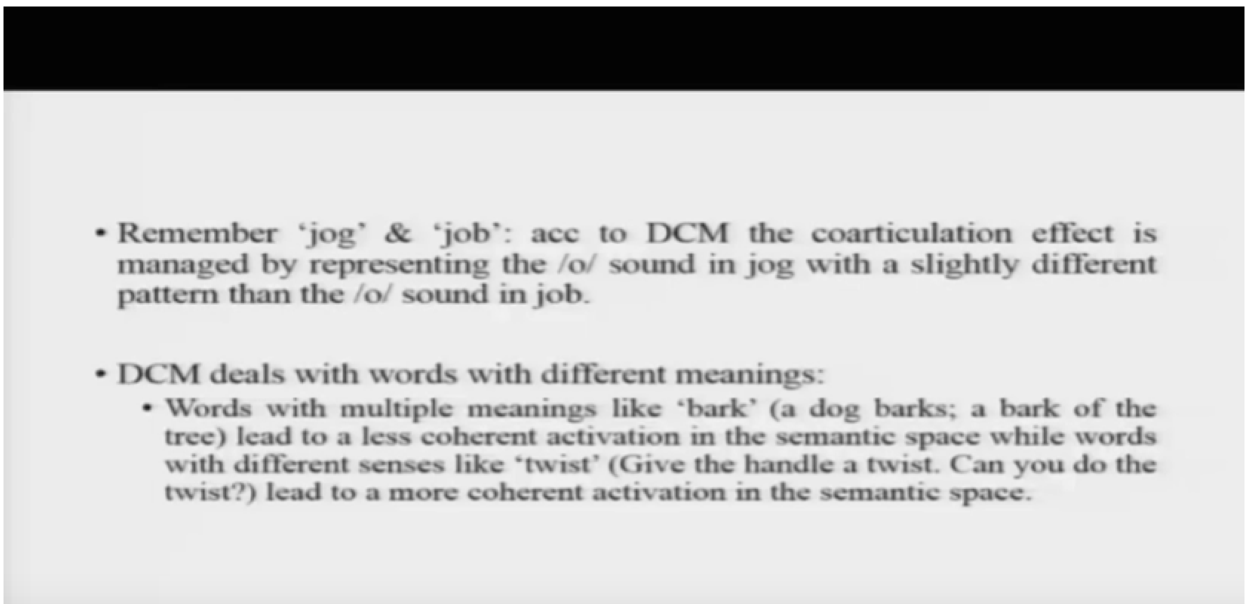

Let's take an example, you know take the example of two words, jog and job, according to DCM the coagulation effect is managed by representing the Oh sound in jog, with a slightly different pattern, as compared to the O sound in job. So, jog and job are slightly different the O's are slightly different here anyways. Now what will happen here is the DCM basically these how does this in deal with different meanings, now what will happen, is with words that could have multiple meanings like Bank or bark in this case, it will lead to a less coherent activation in the semantic space, while words with different senses like twist can basically lead to a more coherent activation, the semantics in this space. So, what happens is depending on whether they can be multiple meanings or whether it can be similar meanings and different senses, the stabilization pattern in the semantic space will be different. Okay? And this has to at some point converge with the stabilization pattern, of the phonological space and only then you will be able to finally select the target word.

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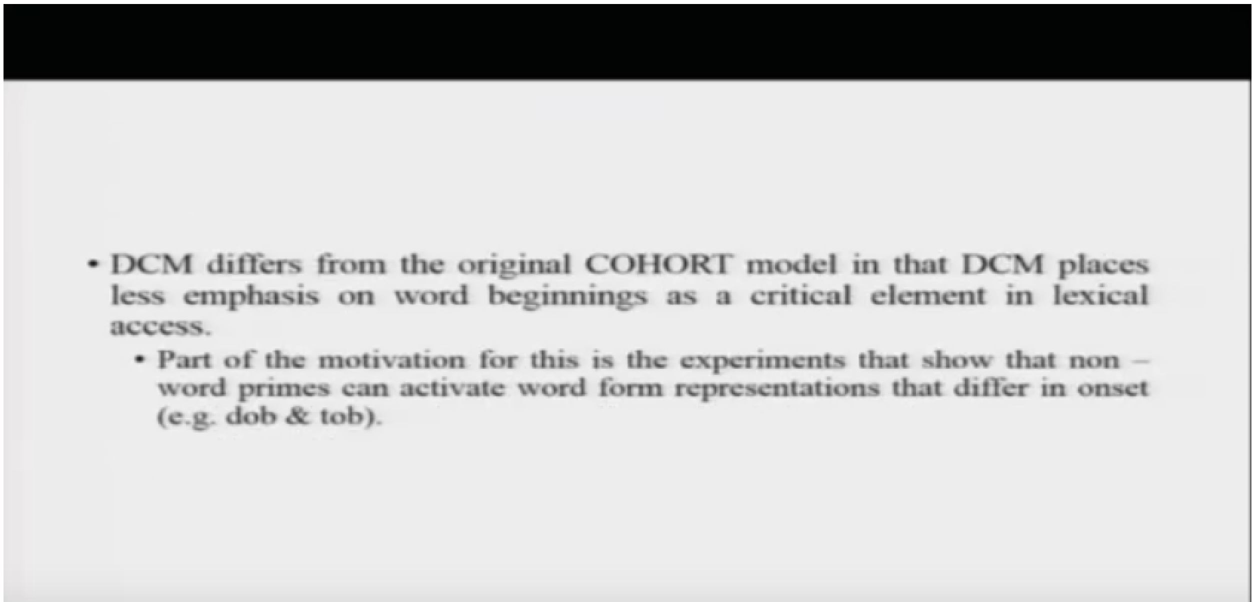

So, DCM basically differs from the original COHORT model, In a few ways in that the same place is less emphasis on word beginnings, as a critical element in lexical access, if you remember the COHORT model, heavily depended on the activation phase that is the activation, from a particular kind of onset, whereas basically, what happened in the latest studies, was they found that in some cases word middle or word endings, also play a sort of an important role. So, what happens is in this model, the emphasis on the onset is slightly reduced and distributed a little bit more, squarely across the onset middle and the offset. So, part of the motivation for this is that some experiments, show that non word Prime's can activate, word form representations, also that differ in ounces. So, this is basically some of the things that were taking into account.

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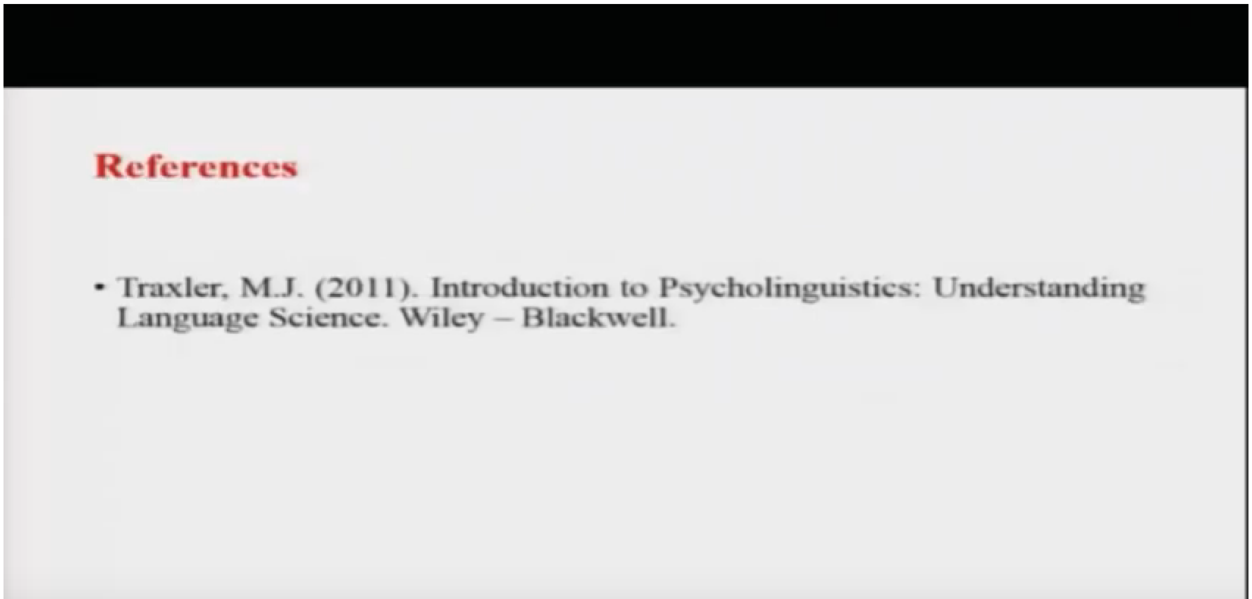

This was all from me about, the lexical access models we've talked about, three generations of model's of lexical access, first generation had Logan and Forbes, the second generation has trace and COHORT and that third generation has a simple recurrent Network and a distributed COHORT model. I hope these were different theories about, how do actually perform the electrical access. And none of them in any way complete, but they are different ways of looking at how this is happening in a more theoretical sort of a way. And that is basically what you have to take away, from this distance you know discussion about, how a lexical access really happens. Thank you for today, we'll talk to you more about, words in the next lecture. Thank you.