Lecture 27
Theories of Reading

Hello and welcome to the course, introduction the psychology of language. I am Ark Verma from IIT Kanpur. And we are running in the sixth week of the course. We are talking about reading, in today's lecture I will talk to you about, particular theories of reading, mostly from the perspective of how do you move eyes, across the page, what are the processes that intervene, while you're moving eyes and getting the maximum information, out of the given text. There are two I mean so, basically the theories, of reading kind of try to explain, reading behavior, by answering two, interesting questions. First is when should eyes move, say for example, when and how the eyes should move across the page, in order to get you,

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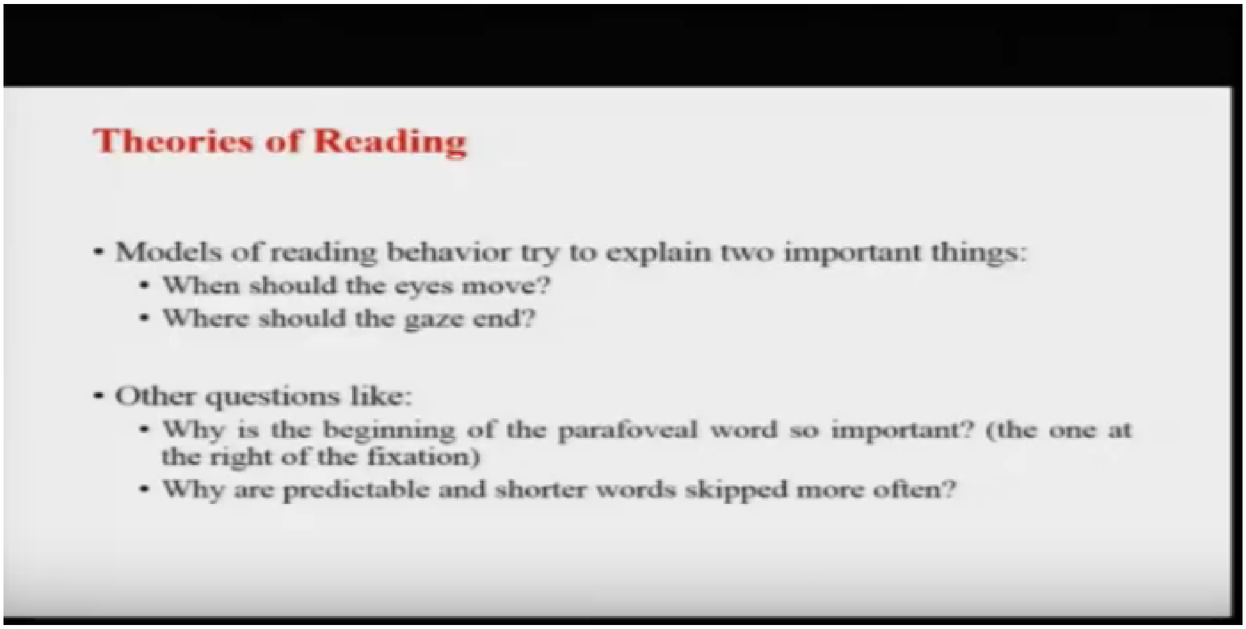

the best meaning, say for example in order to get you the best, chance at getting maximum information. And making meaning and moving further and also when should the gaze and when have you got enough, information that you can move to the next point. So, both things, when should eyes move, from there which portion to, which portion, how exactly and when should the gaze at a particular place end and before you move to the next point. So, these are some of the questions, other questions also very important, say for example why is the beginning of the Parafoveal word important. Now if you remember, in the last lecture I was talking to you about, this aspect that there is also, something there's something called,' Parafoveal Preview', which is basically the information that is accessible outside the foveal region. Okay? Say for example the 1 to 2 degrees is the fovea where you're getting the maximum information. And after this 2 degrees, there is this region between 2 to 5 degrees in the spatial area, which also kind of you're getting some information even though the activity, is not that you know high, why is this pair of who will preview important. So, it has been shown, in a number of studies across the literature that peripheral, preview is very, very important for you know getting the maximum equity and so, on and so, forth. So, that part is also very, very important. Also there are you know the reading theories could try and explain, why particular kinds of words are, skipped more after then others, you know via some words more predictable, why do we often choose, to say for example, skip the grammatical function words. And move only from content word, to contain words, in various degrees. So, some of these things, we will try and answer, in today's lecture. Now before we kind of go to the theories, lately there is some, you know, important facts some trivial information that we would like to share,

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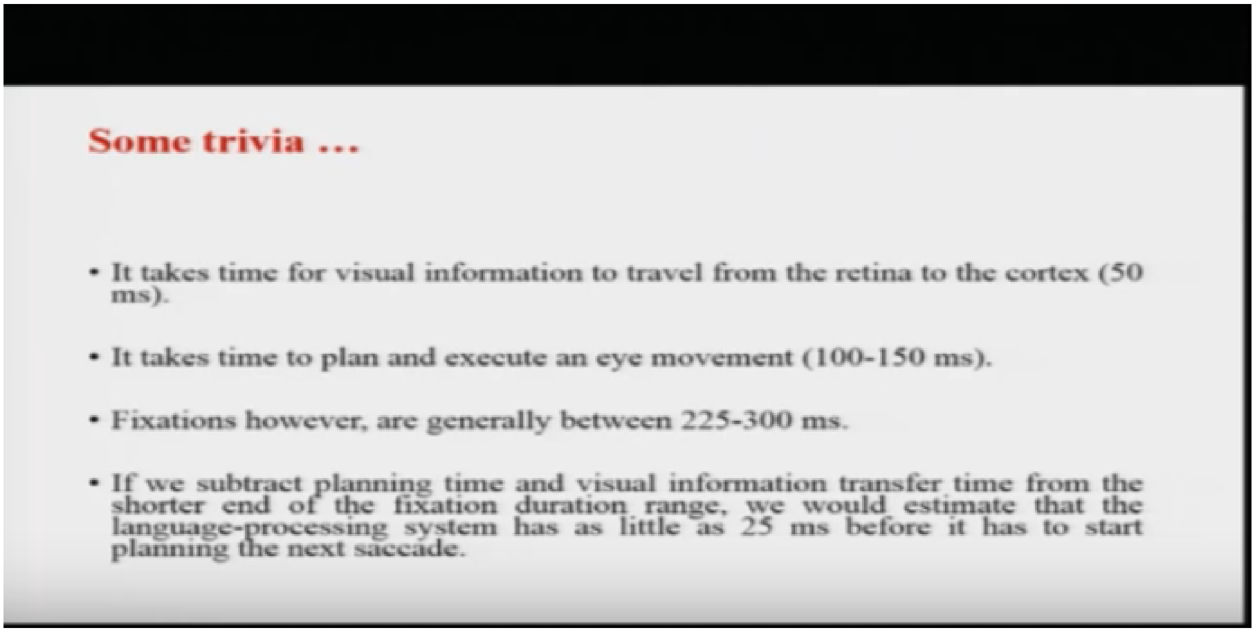

say for example that, as we said, as we kind of did in the last lecture that we talked about the eye brain lag, which is the time it takes, for visual information from the retina to, to reach to the cortex. So, that is 50 milliseconds, it takes around a hundred 250 milliseconds, to plan and execute a saccade. So, that is some time and fixations generally, at one place are between, 225 to 300 milliseconds. So, if you kind, of now you know you know try and subtract, the 50 milliseconds with the 100, 150 milliseconds in planning and executing a saccade, basically what you will be left, is you'll be left, with anywhere between 25 to 50 milliseconds, which is basically the language processing time. So, from the first 50 milliseconds, the information was just going from the retina, to the visual cortex you're not really processing anything, as soon as those 15 milliseconds ended, you started processing information, in the next 100 250 milliseconds you started, to plan the second and execute, the second. The entire time that you were anyways going to spend, spend at this particular fixation, is anywhere between 225 to 300 milliseconds. So, if you kind of subtract from this 225, the hundred and the 50 you're anywhere getting between 50 to 75 or 25 to 75 milliseconds, for actually, doing the linguistic processing of this stuff. Okay? That is a very, very short amount of time that you're spending, on actually you know the, the reading part. So, that is there is something very interesting, there are two kinds of models, you know that we can talk about, when you are talking about, models of reading. And the first kind of models, are effort as the oculomotor, control models. The oculomotor control models are basically, as the name suggests our models about, how the eyes are moving and they majorly talk about, movements of eyes and mechanisms that govern the movements of the eyes. Typically the belief in the oculomotor models, is the fact that language related information, does not really play a part,
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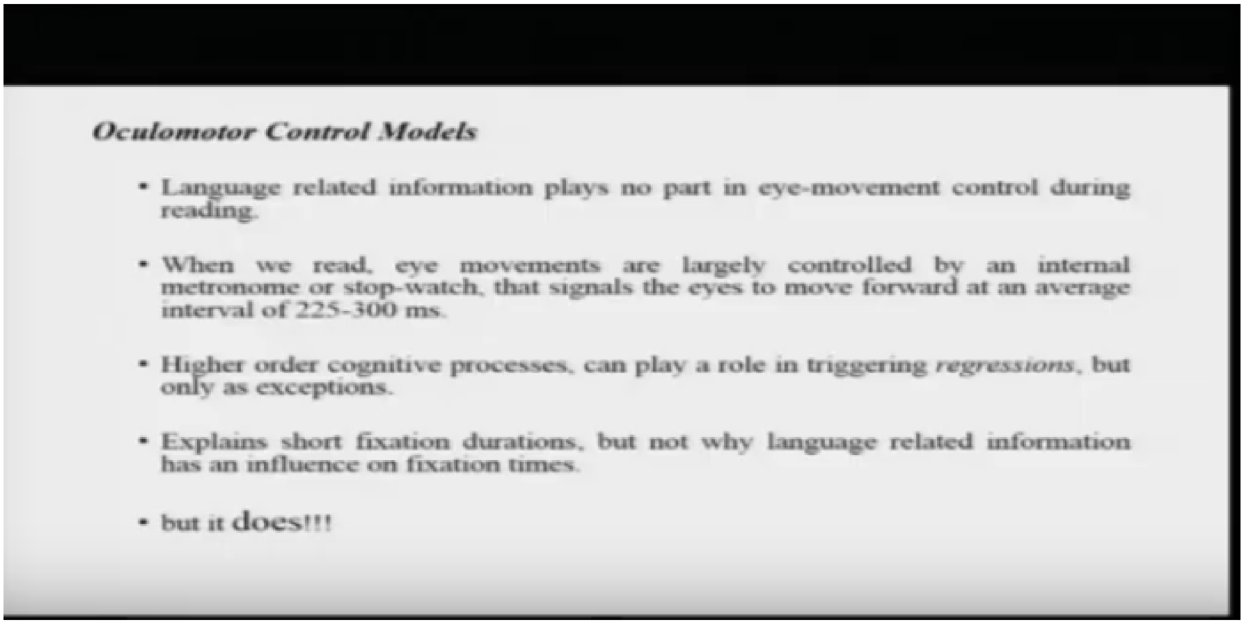

in eye movement planning. So, they sing eye movement control in planning, does not really take a lot of input from language, related variables basically it is more about the motor part. So, that is why these models don't really talk about, you know language related processes. And the belief is that when you reach, the eye movements are largely controlled by an internal metronome, basically a sort of a timer that or a stopwatch that kind of signals the eye, to move forward at an average interval of around, 225 to 300 milliseconds. So, even if you have gotten visual information or a linguistic information on the text, your eyes will automatically move, from 225 to 3 and milliseconds from one point. And then another to 25 to 3 in relation to another point and so, on and so, forth. So, it's almost like a, set pattern that eyes are following and eyes are basically just keeping information, during that - 25 to 3 in machines that they are resting on a particular place. This is the belief of the ocular motor, this is basically you know something that comes out of these ocular motor control models. As far as the higher cognitive processes, meaning-making integrating, inferencing is concerned, basically the higher it is it is kind of relieved at a higher order cognitive processes, usually play a role in triggering regressions, but also only as exceptions. So, for example the regressions might, happen through these higher order cognitive processes, if suppose you've messed up something, if not being able to understand, something around the text and only then the language, related information, will influence a moment's but that is only going to happen as exceptions. Okay? Another, another aspect that the ocular motor control models, say is that it that the ocular motor control models can explain, short fixation Eurasians, but it is not really explained by language related information, may or may not have an influence on the reading times or fixation times, if you look. So, this these are set of assumptions, you know that, the oculomotor control models usually go, by and some of them, we actually if you look at the literature, will find out that they are not really true, for instance the fact that language, related information, does not affect I move in planning that is the basic tenet of these models. And that is something that has been called into question many a time. So, let us so, in, in something we can say that there is enough evidence, to suggest that language related information does influence a moment and eye movement control in planning.

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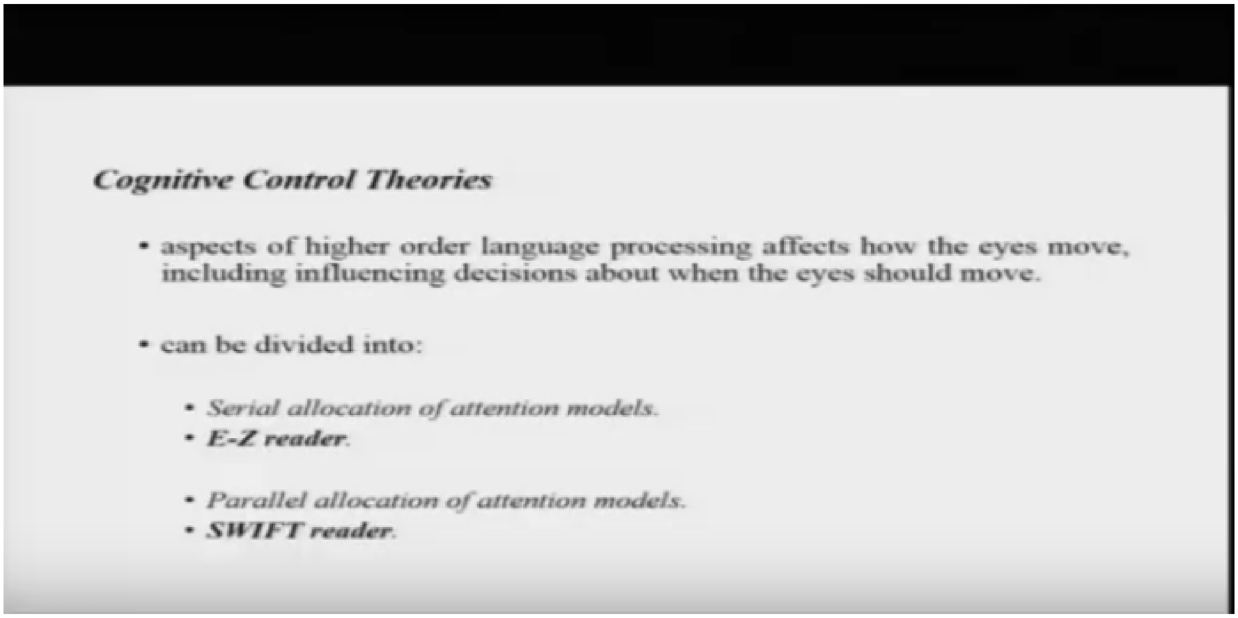

Why that happens? To address such an assumption, we have another class of theories, called,' Cognitive Control Theories', of feeling, which are the theories which we will be talking about, today and assumption in these theories, is basically that the aspects of higher or higher order language processing, not only affect how long how the eyes would move, but it also influences decisions about when, the I should move, while you're scanning for reading. Okay? And these cognitive control, theories basically we going to talk about, two kinds of theories or basically two instances of these theories, one will be the cereal allocation of attention models that you know you're processing everything in a very serial systematic fashion. Now the example from that end will be the E-Z reader and then there is a parallel allocation of a tension model, which is the SWIFT reader. So, an instance of that kind of theory is a Swift reader. So, we basically talk about, two models the E-Z reader and the Swift reader. Let's talk about the E-Z reader the E-Z reader basically is a mathematical model.

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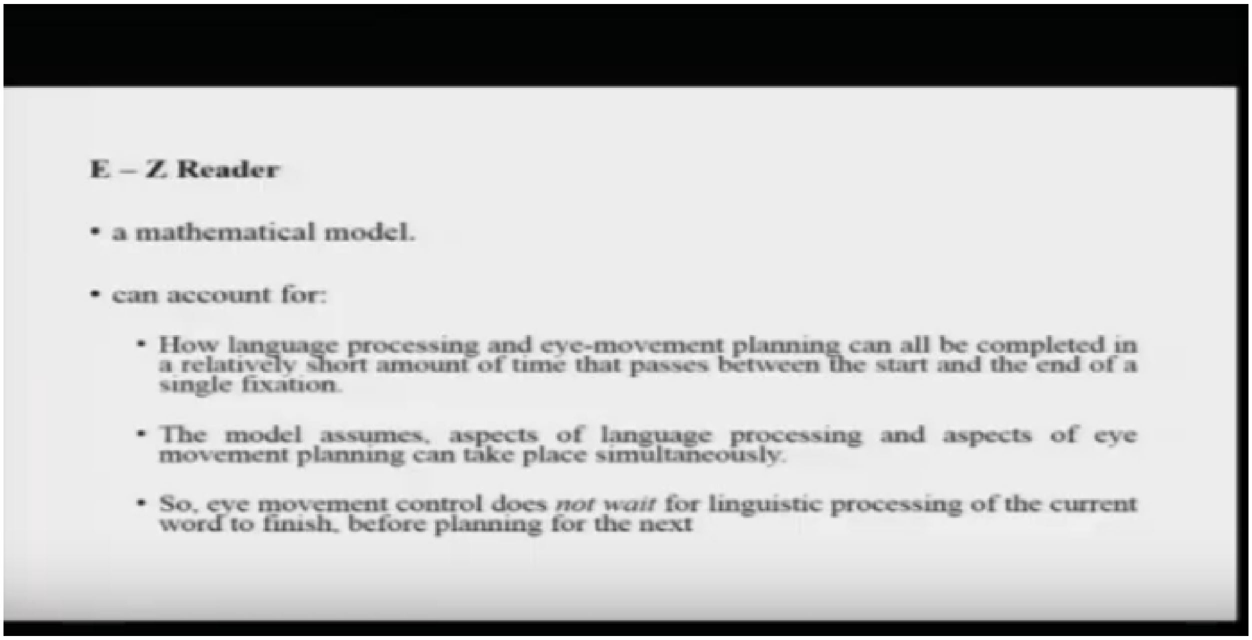

And it can account for the following things, it basically can account for how language processing. And eye movement planning, can all be completed in a relatively short amount of time that passes between, the start and the end of a single fixation, remember a single fixation is anywhere between 225 to 300 milliseconds. So, the idea that this model tries, to explain is that within this 225 to 3 in milliseconds, there is enough information for language, related processing to happen the model, assumes that Lang aspects of language processing. And aspects of eye movement planning can happen simultaneously that is why this much time should be enough. Okay? Also it basically says that I move in planning or I move in control, there's not really wait for the linguistic processing to finish, you know or say for example, it is not it does not really happen that the linguistic processing of the current, word finishes before planning, for the movement of the next, you know has to be planned. So, these are some of the assumptions, let us see how does this really take place in, the first million 50 milliseconds, I'm talking about what happens during a fixation that is within the 225 to 300 milliseconds. In the first 50 milliseconds of this time, this is referred to as the visual uptake phase and what really happens is that in this visual uptick phase, visual information travels from the retina, to the visual processing areas that is at the back of the head the occipital cortex or the primary visual cortex. First 50 milliseconds gone, in the next 75 to 100 milliseconds. So, that is 50 plus 20 125 200 150 milliseconds cumulatively.

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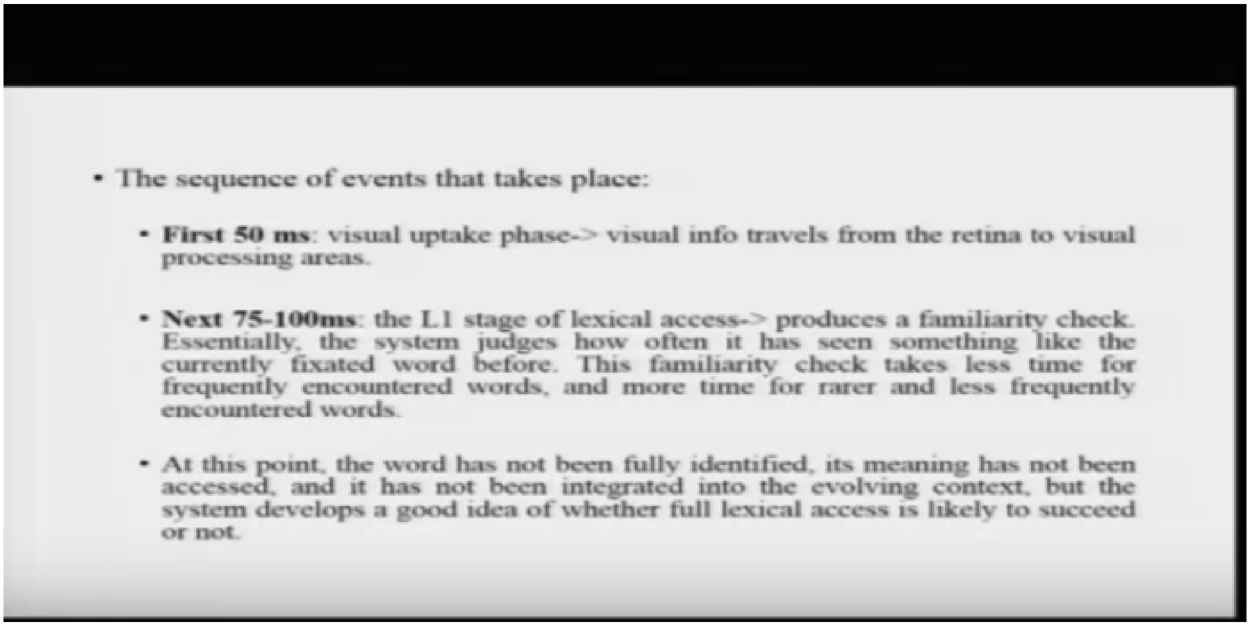

this is the L 1stage of lexical access, this is the first stage of lexical access, what happens here? It kind of this phase the system produces a sort of a familiarity check. So, essentially the system is judging and so, how often it has seen something like the current word, the currently fixated word that is and this familiarity check, you know it's a swift process, it takes less time, for frequently encountered words takes, a little bit more time for words that you've not read or seen before. Okay? So, it is kind of on that continuum, at this point basically in the L 1 you know stage of lexical access, the word is not really been fully identified and its meaning has not really been access. And has also not been integrated into the evolving context, only what happens is the system kind of develops a good idea of whether, I have seen this word or not what is the probability that I know this word and so on. So, you kind of reach from the 50 to around 150 milliseconds, this is what has happened? The visual first visual uptake phase and the l1 stage of lexical access. The next two steps basically from 150 to 300 milliseconds, 125 to 300 milliseconds, is two things happening in parallel. The first thing is the saccadic planning that where do I move next, which word what particular site in that word.

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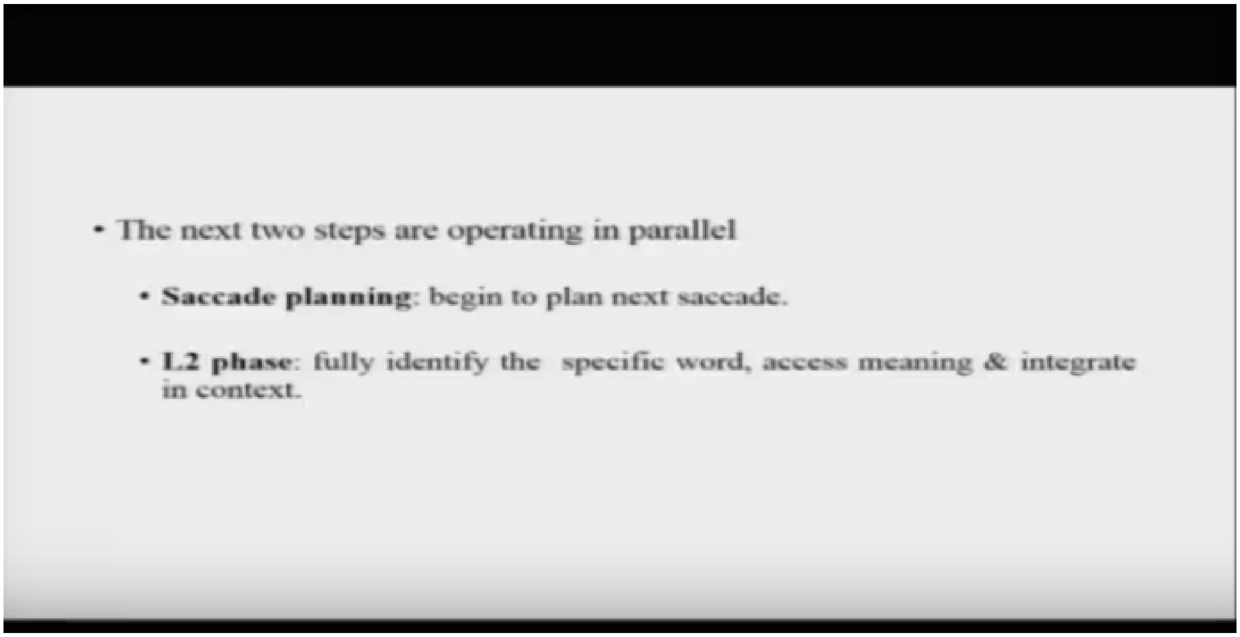

Now the second is the l2 phase which is fully identifying, the specific word. Accessing its meaning and integrating the meaning, into the whole sentential context. So, here the saccadic planning and the L2 phase are both happening in parallel. Now after this l2 phase basically, what happens is the reader shifts our attention to the word, immediately to the right of the originally fixated word and then again begins with the visual uptick phase and the l1 phase and so on. Okay? Now the easy reader,

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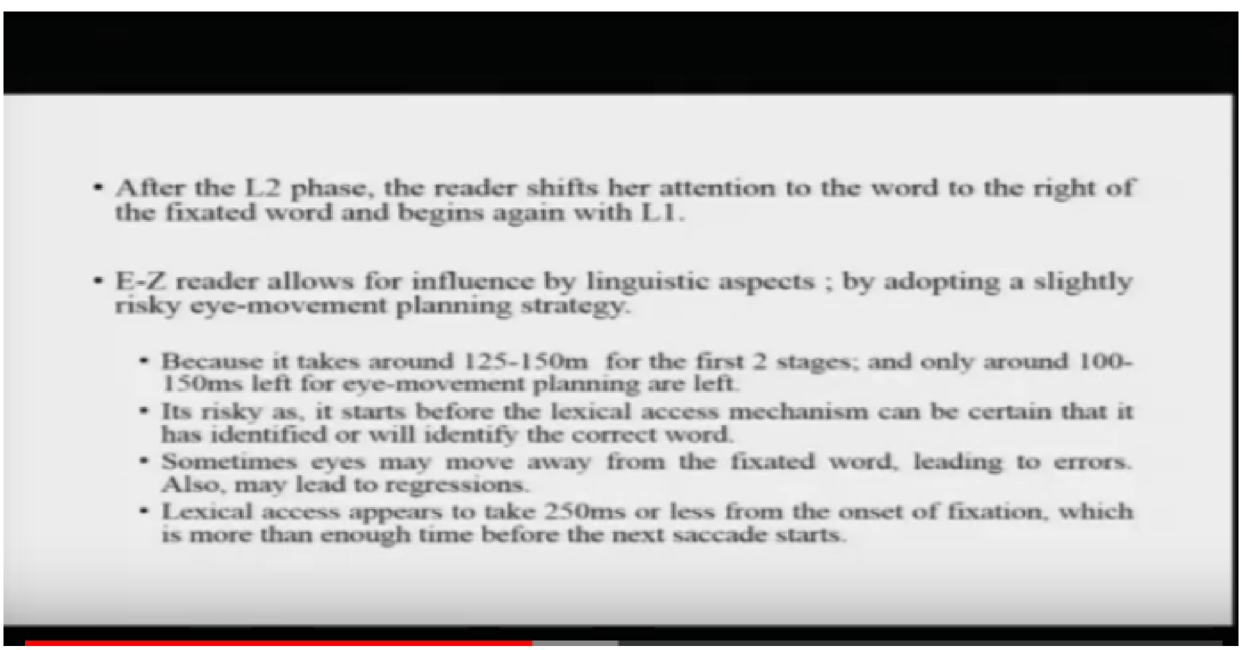

basically allows for enough allows the model to be influenced, by linguistic aspects. And it adopts a very slightly risky, I move in planning strategy, basically what it does is that because, it takes around 125 250 milliseconds for the first two stages. And only around 100, 250 milliseconds is left for I'm on planning and linguistic processing. So, basically it's leaving a very little time, for you know that's a risky, strategy you might, because if not completely understand understood this word and you're not, completed processing of this word, you might kind of you know make a mistake. So, it is risky and I mooned plan is also, in the in that sense risky because even before the lexical access mechanism, can be certain that it has identified, the word correctly or it will be able to identify the word correctly in the next few milliseconds. The I move in planning study, has already initiated, the eyes will eventually move to the next word, even before they are very sure of what is being read in this instance, sometimes that is why it is may move away, from the fixated words leading to errors. And then come back again to reread this word again. So, that is what integrations basically, you know account for. Now lexical access around takes around two hundred to two and five 50 milliseconds, from the onset of fixation, which therefore there because again this is happening in, in Perry which is more than enough time before the next saccadic ,could start. So, that is basically what is happening in the E-Z reader, I'm not really going to a lot of detail for this because that's kind of outside the scope. We can have a discussion about this in a later part, but the E-Z reader can account for some of the effects in reading for example, it can account for frequency effects, basically it says is that,

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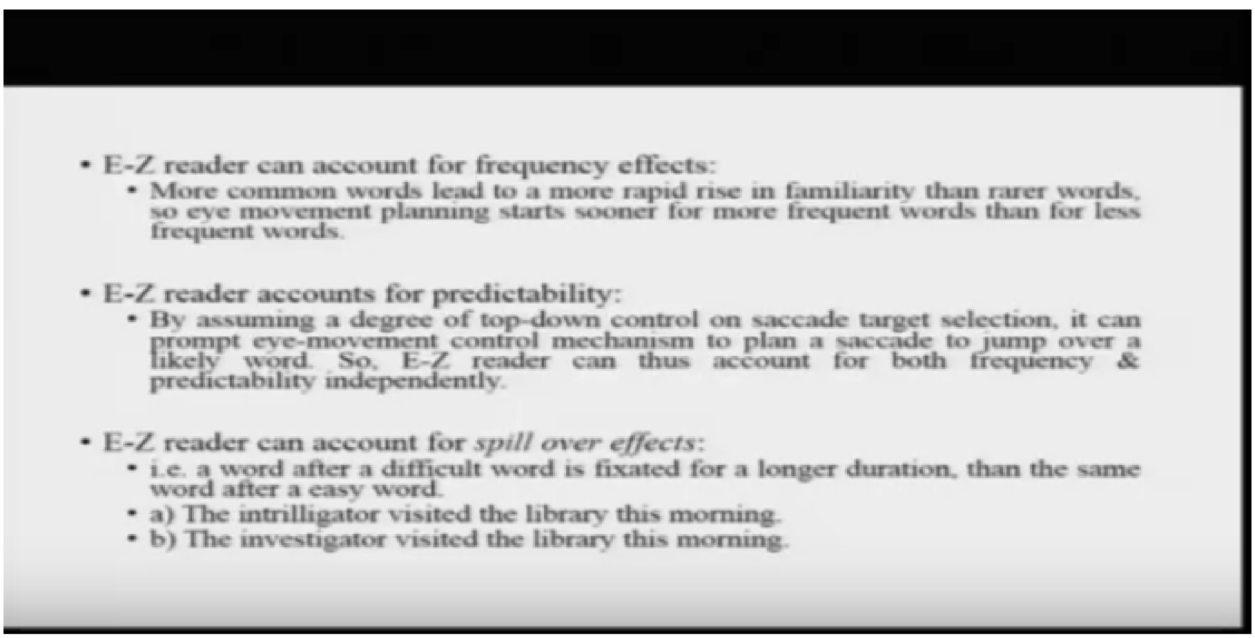

more common words lead to a more rapid rise in the familiarity check, in the L1 phase then rarer words. So, I mooned planning starts sooner for frequent words, than for less frequent words that basically keeps you at top speed, when you're processing high frequency words, one after the other. Okay? The E-Z reader also kind of accounts, for predictability in a sense that it basically assumes a degree of top-down control, on saccade target selection, it can prompt I move in control mechanism, to plan a sack ad or to jump over a likely word. In order to say for example, you know in order to for example, ease the process of reading or keep it as fast as possible. So, the E-Z reader can therefore account, for both frequency effects and predictability in an independent and non interactive sort of fashion, predictability basically, because you know in the top-down fashion as soon as you kind of get a sense that. Okay? You might know this word or you're you know fairly familiar with this word, you can decide to skip, the word and that's why the predictable words, will be more often skipped. Also the E-Z reader can account for what has been referred to as spillover effects? What are the spillover effects? A spillover effect is basically that if you're reading, it more difficult word, in the correct in the current fixation, you're reading time for the next word will, also become slower or if you're reading a very easy word, in the current fixation you're reading time, for the next word will also become, much faster. And it's, it's very easy to figure out in the sense, if you kind of take this word, they for example the investigator, visited the library this morning, investigated as an easy word but it's kind of longish, you spend more time here. So, you're reading for the next one become a slightly slower, but if it is a pseudo word, say for example the intially gator visited, the library this morning ,you kind of not be able to understand, it and you'll kind of read it reread, it spend a lot of time here and this one we considerably slowed down your reading of the next words. So, this is basically what is referred to as the spillover effect. Okay? And why spillover effect happening, obviously because the L1phase will spend, more time as on a difficult word as compared to an easy word, if L1 phase you know kind of you know it's slower it's not really very sure, you will spend need to spend more time, double fixations and so on. And that's why the entire process will get slow, if it is very easy highly predictable, you might kind of very quickly, move on to the next word. Now yeah that's what I already tell, you told you and then the next thing that the E-Z reader kind of predicts is it predicts, skipping you know. So, as attention to the so, how does that how does the E-Z reader explained that, it says that as attention shifts to a word.

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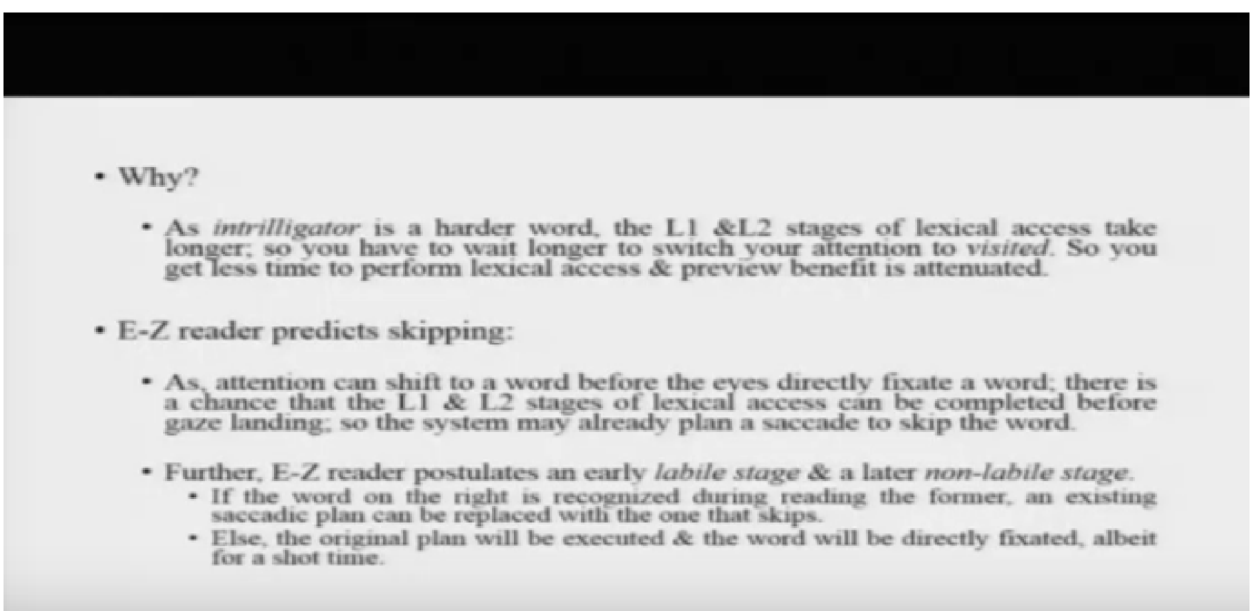

Next you know before the eyes directly fixated. So, the next word in line the para fovea word. There is a chance that the l1 and l2 stages of lexical access, can be completed before even the gaze lands, on, on that word. So, the system might already, say for example if this one is an easy word, I'm doing the l1 phase here and in the next 150 milliseconds, I'm not only planning the second, I'm kind of doing the linguistic processing here. So, what happens is in this next word, by the time my eyes actually shift to, it if this one is an easy word, say for example a function word, a and preposition kind of thing, I might already be sure that I know this word and I can kind of move, to the next word. Okay? So, that basically kind of helps explain the skipping, behavior. Okay? Further, one of the other things that easy data kind of helps us do is that it postulates an allele a by stage. And later non by stage, syllabi basically meaning and from a flexible stage, value in getting most information from. So, if the woerden on the right, is recognized during reading the former word, the currently fixated word and existing saccadic plan, can be replaced with the one that skips. So, initially your plan was to you'd you read this word, you read this word, you read this word, when you're reading this word, here and you're you know getting the Parafoveal preview of this word. In the next in the last 100 250 milliseconds, you can change the saccadic, plan and you can decide to skip this word. And move directly from this word to the third word here. That is basically, you know a flexible and an inflexible arrangement of how eyes can kind of move. So, in, in this sense the E-Z reader model can also predict, what or explain the benefits of the Parafoveal preview, as the majority of the fixations include time,

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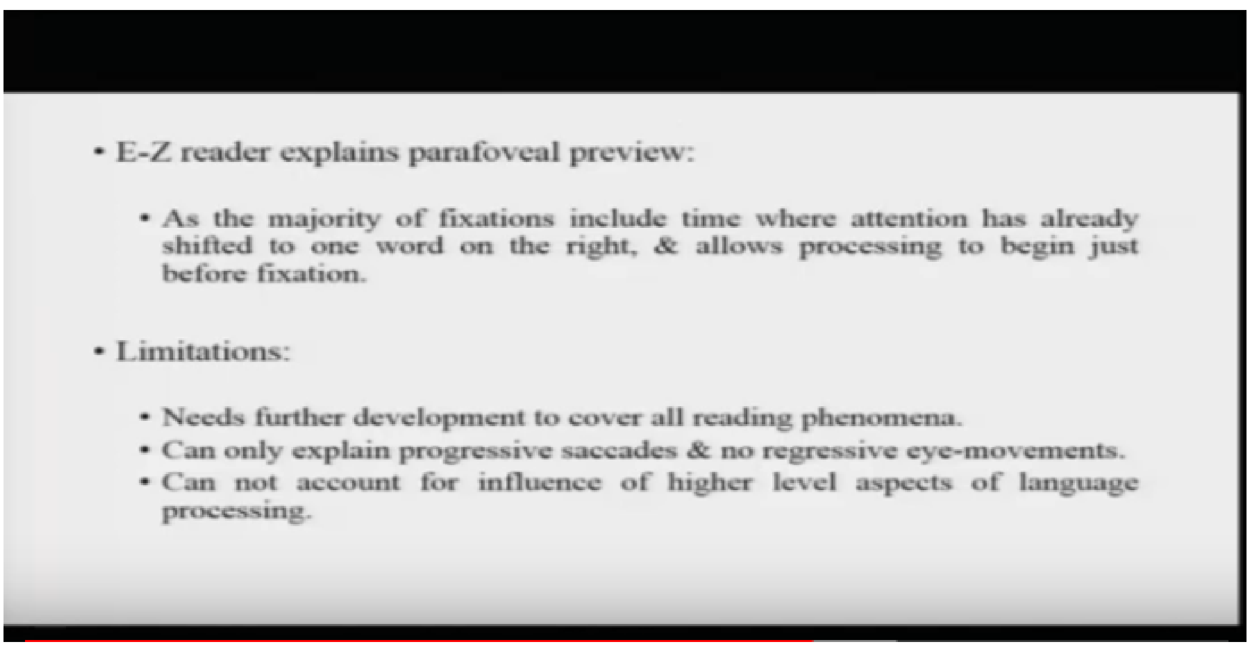

where attention has already shifted to one word on the right, it allows processing to begin, just before the fixation and in that sense Parafoveal preview is very, very important. If so, for example if in the you know moving window paradigm or the boundary change paradigm, you kind of you know take away the benefit of the Parafoveal preview. That is how you will see that you know the reading speeds kind of become, much slower in, in those instances. Now the E-Z reader is a fairly good model, it kind of explains quite a few phenomenon related to reading, but it also has a few limitations of its own which are for example, it does not really cover all kinds of reading, phenomena it's a very simplistic, sort of a basic model of reading it can, also only explain, progressive circuits, but not really and cannot, really tell, how or why the regressive eye movements really happen or that aggressive circuits really happened, finally the E-Z reader model can also not really account, for influencing of by the higher-level processes, of you know long higher-level aspects of language processing, say for example reading metaphors. And you know making abstract connections and so on. None of those things really find, you know sort of a entry into how the easy leader kind of explains, world reading. So, that is basically there was about, the E-Z reader model and here is you can see the schematic borrowed from Trax last book,

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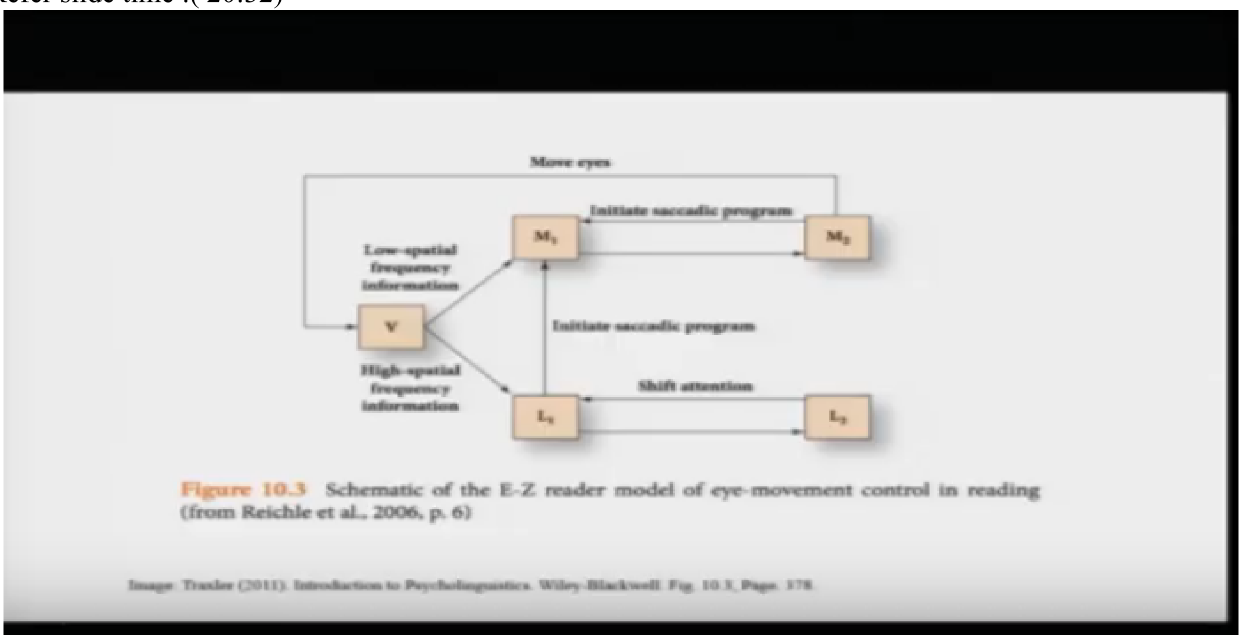

Figure 10.3 Schematic of the E-Z reader model of eye-movement control in reading (from Reichle et al., 2006, p. 6)

Image: Traxler (2011): Introduction to Psycholinguistics. Wiley-Blackwell. Fig. 10.3, Page. 178.

how does that really look like. So, this is basically the schematic of the E-Z reader model of eye movement control in reading, you can see that there are these particular you know movements, movement one, movement two and then there's this l1 and l2 phase, which are happening and you have lows so, initially you're basically doing the visual processing information. Okay?

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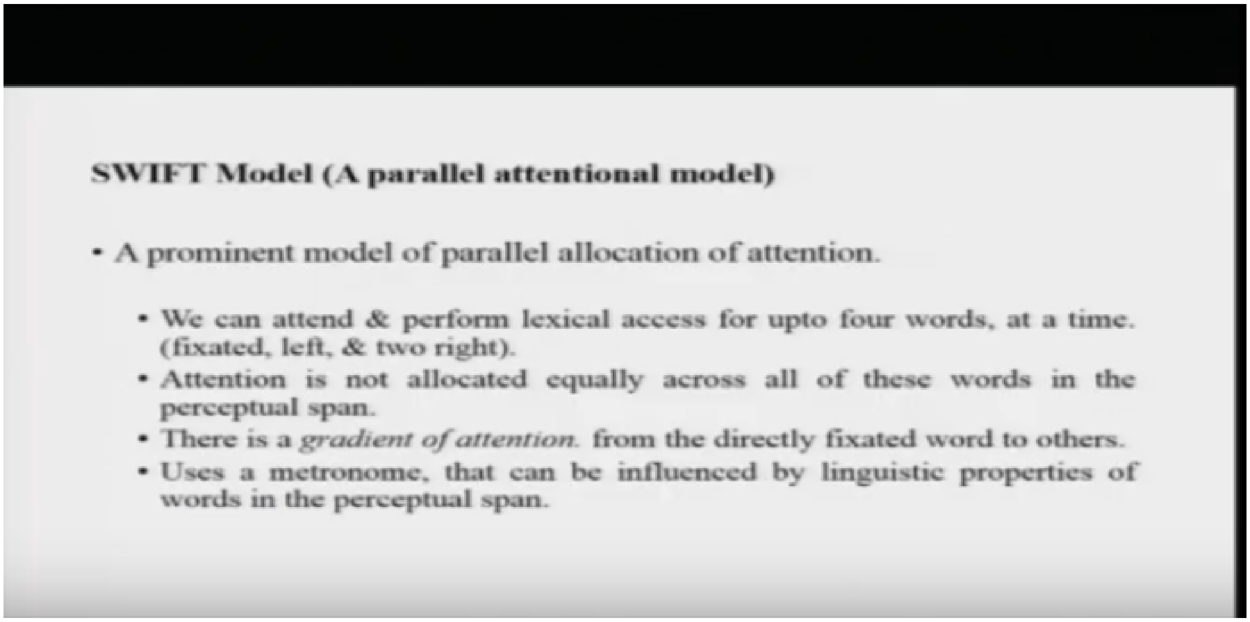

Now let's move our attention to the swift reader or a swift model, which is a parallel attention model, as opposed to the sequential attentional model that was implementing the E-Z reader. Now this is a very prominent, a very important model, of parallel model of allocation of attention, basically says that we can attend and perform lexical access for up to four words at a time. Okay? So, basically the one that is fixated, one at the left and two on the right. So, in the entire perceptual Spaniel kind, of gain information from this entire visual perceptual span, at once and it says that attention is not really allocated equally, across all these words, the highest amount of attention will probably be, in this in the fixated point and then kind of you know going degrading, slowly on the either side. So, this is basically referred to as a gradient of attention, from the directly fixated words to the other words, on the right and the left. Basically it predicts using a metronome and the metronome can basically, a metronome or in it in an internal stopwatch. And this metronome basically can be influenced by the linguistic properties ,of the word that fall within the perceptual span. So, let us look at this a little bit in a little bit more detail. Now when the perceptual processing is difficult the execution, of the next,

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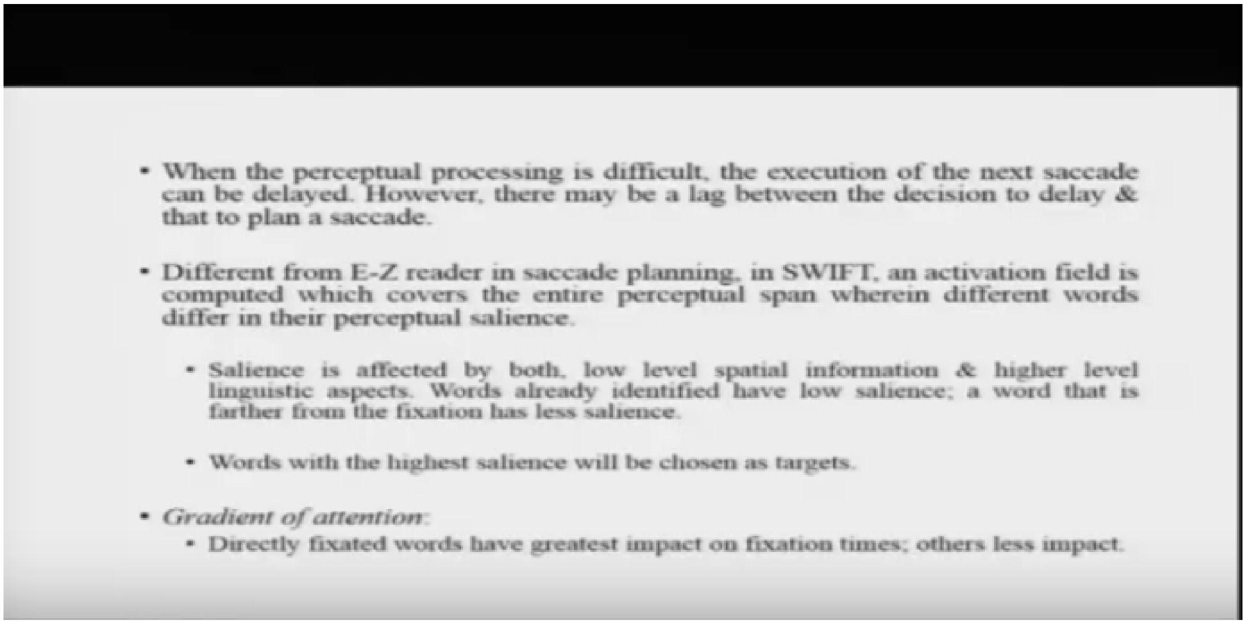

saccadic can be delayed however, there may be a lag between the decision to delay the you know and plan, next card now the Swift model is different from the E-Z reader model, in terms of saccadic planning, say for example in swift and activation field is computed. So, basically you are actually looking at the entire perceptual span and you're kind of looking at an activation field. So, the highest activation is coming from the regions falling on the fovea. And then gradually going and decreasing towards the left and towards the right. So, basically what is happening is that this activation field, is computed over the entire perceptual span, where in these words are differing in different in their perceptual salience. And salience in their senses basically being affected by both, lower level spatial information and Highland's linguistic aspects. So, basically depending on the, visual acuity that's the low level salience information and also the higher level linguistic aspects, if it is a you know is a difficult word, like entry Lee investigator or it's an easy word, say for example or is it a function word or a grammatical word, a function word or a Content word, those kind of things will also affect or impact the salience of the word, within the perceptual span. Again words with the highest salience, will therefore be chosen as targets. So, basically the movements will of the eye movement, the eye movements will basically, be according to highest salience. So, you're perceptive span is there is this and this is the highest salience and then the next field, will again kind of them. I moment will be from the highest salience word here, to the highest salience word, in here. So, this gradient of attention basically works, like this directly fixated words, have the greatest impact on fixation, times and the others will have slightly less impact on how much time you spent there.

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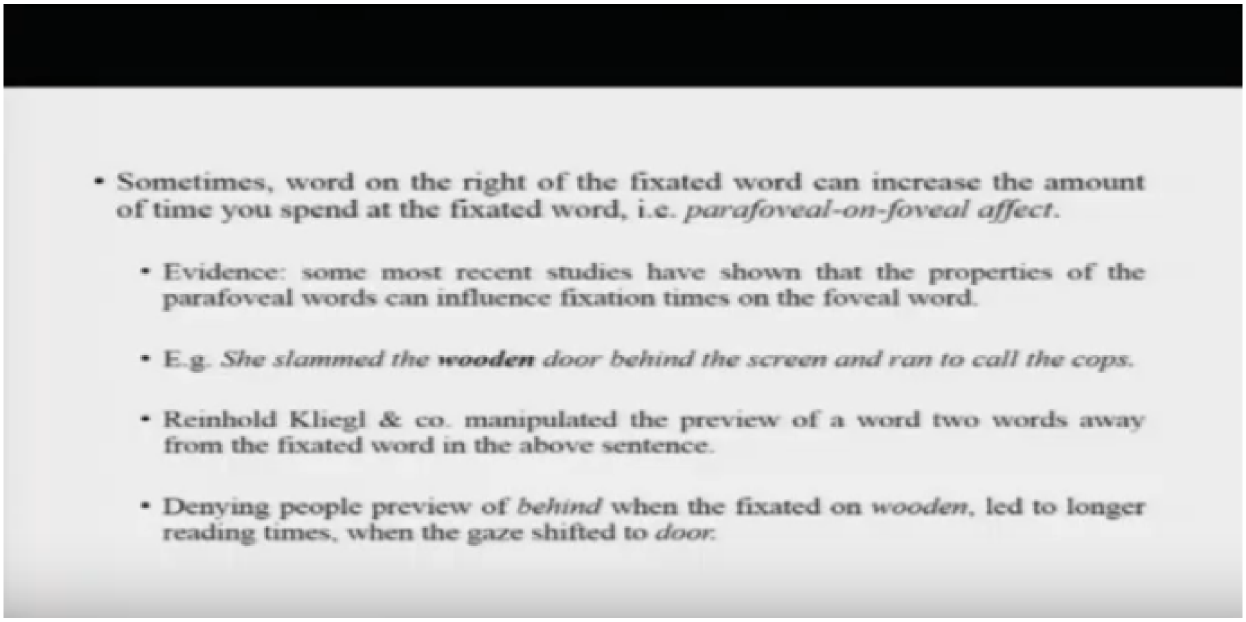

Sometimes what could happen, according to this particular model is that words on the right of the fixated word, can increase the amount of time you spend on the fixated word, say for example this is called,' Parafoveal on foveal effect, in some of them you know some of the studies there is some evidence about, this as well say for example. So, the most recent studies, have shown that the properties of Parafoveal words, can actually influence the fixation times, on the foveal word. Let us look at this sentence, she slammed a wooden door behind the screen and ran to call the cops. Now Reinhold Kliegl and colleagues manipulated the preview, of a word to words away from the fixated word in above sentence, say for example the fixated word is wooden and they would basically manipulate the preview of the word behind. Okay? One word ahead and basically, when they you know manipulated the preview suppose, they converted that to XS it led to longer reading times, when the gaze shifted to door. So, because the preview was not there, it kind of you spend more time on no because you're trying to get that preview apparently. Okay? Also it has been shown that manipulation, of linguistic properties of the Parafoveal words, also influences the fixation times as has also been predicted, by the surf model, because all of that is being processed at the same time, if there is any difficulty in terms of visual or linguistic processing, of the words in that perceptual span that is going to have some impact on the you know highest salience target or the fixated word also. Now are there any evidence is there a lot of evidence for these kind of Parafoveal effects, which the Swift model is you know postulating so, to speak.

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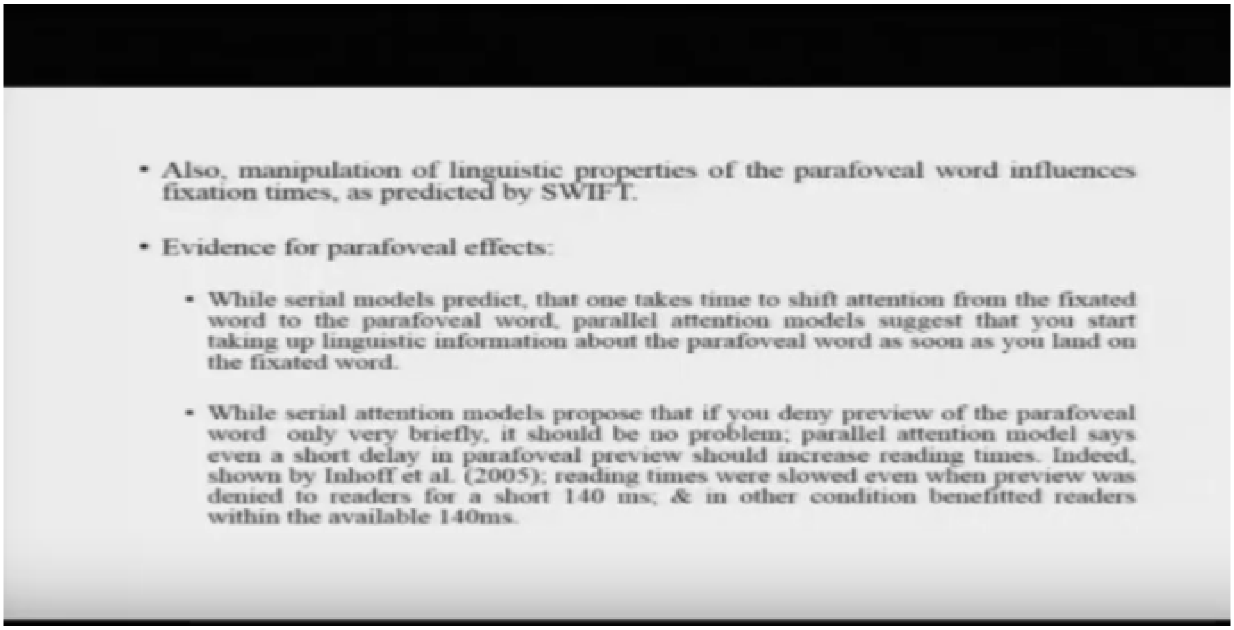

Now while serial models like the E-Z reader, predict that one takes time to shift attention from the fixated word to the Parafoveal word, in a serial sort of a way. Parallel attention models like swift suggest that you start taking, up linguistic information from the entire perceptual span, which includes the peripheral word as well, as soon as you land on the fixated words. So, basically two words on the right one word on the left, all of that and this current fixated all four of the words are being processed both, visually and linguistically at the same time. while serial attention models, proposed that if you deny, the you know preview of the Parafoveal word, only even if only very briefly, it should be no problem, parallel attention models basically, say that even a short delay in the Parafoveal preview of the words to the right and the left of the fixated word, should increase the reading times. Indeed it has been shown say for example in study by Inhoff in colleagues they're reading names were slowed, even when preview was denied to readers for a for a short duration of about hundred and forty milliseconds. And in other conditions, if when preview was made available it benefited the readers, within the available 140 milliseconds. But then again this evidence, on of Parafoveal on foveal words is not really very you know it's not really very clear and very definite say for example, Robin modest and colleagues, basically found,

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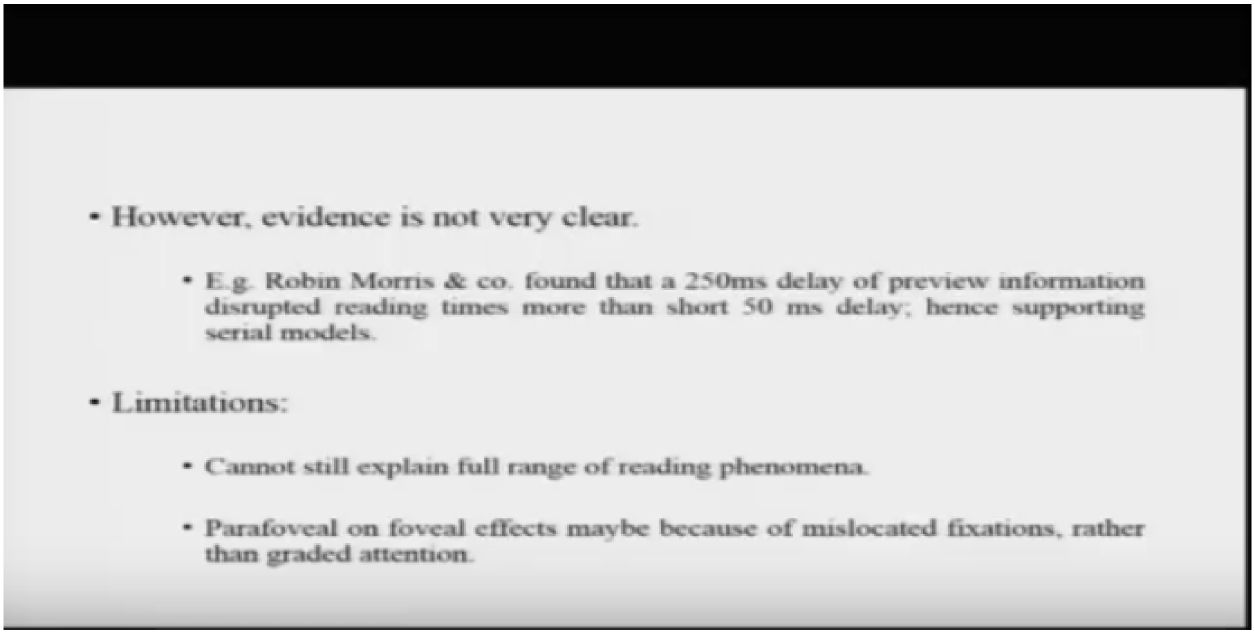

at a 250 milliseconds delay of preview information, disrupted reading times, more than a short 50 milliseconds, delay hence kind of supporting the serial models more. Now while it kind of sounds very interesting, the Swift model also has some of its you know, limitations, say for example, it can also like the earlier model not explain a full range of reading phenomenon, also Parafoveal foveal effects might sometimes, basically be attributed to miss located fixations, rather than the gradient of attention that this model is kind of predictable.

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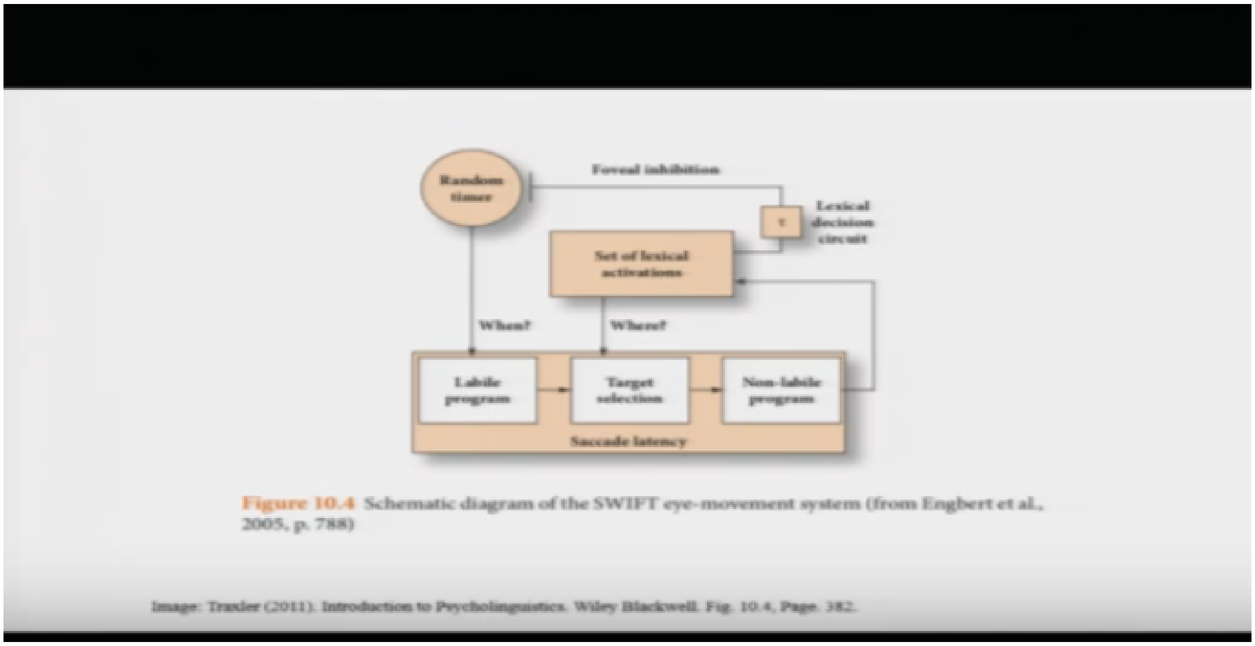

This is the schematic of diagram of the Swift model and you can see here. That you know there's this random timer, which is deciding how the eyes will have to move and kind of decide about saccadic latency in terms of when and where and so, on and so, forth.

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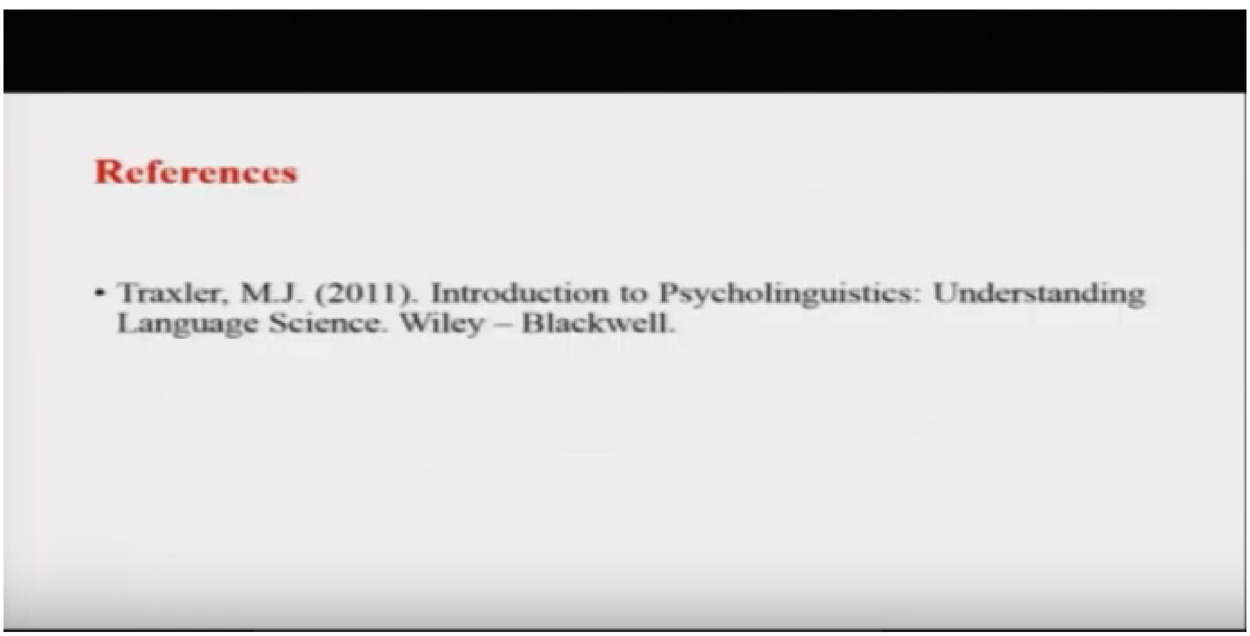

This is all from me about, the two models of reading that we are supposed to discuss today. I'll talk to you about other aspects of reading in the next lecture. Thank you.