

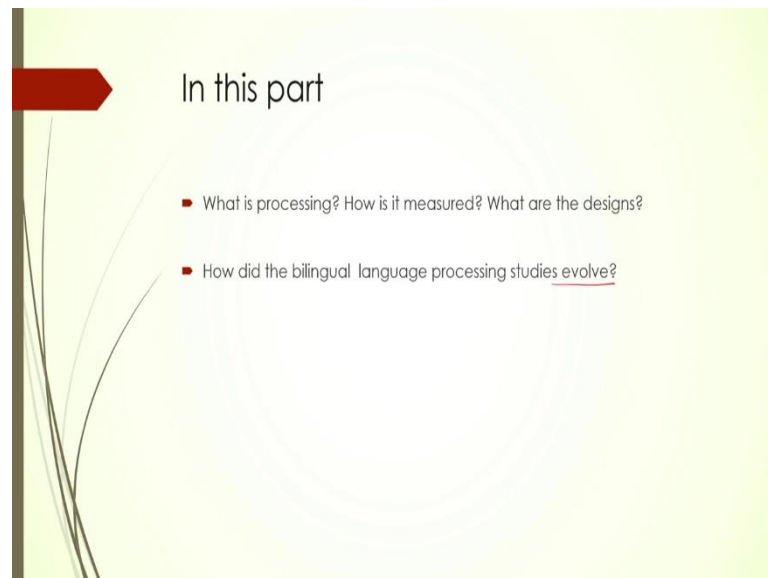
Bilingualism: A cognitive and psycholinguistic perspective
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Module - 06
Part - 01
Lecture - 13
Bilingual language processing

Hello and welcome back. Today, we will start with module 6 which primarily will deal with Bilingual Language Processing. This module will tell us about the various ways language processing is understood, how they are investigated, and what do we get out of it, what kind of results do we get, and how to interpret that output.

So, before we get into that because this is completely experimental chapter, we will talk about all the different types of experiments that are done in order within this domain.

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So, before that let us get the basic idea about this area. So, we will have some grounding work done first before we move on to the bilingual language processing in all its different shades. So, to start with, today we will discuss about what is processing, what do we, we keep using the word bilingual language processing or language processing in general, what do we mean by that. So, we will need to first understand that aspect before we move on to the more complicated parts.

So, what is processing, how is it measured, what are the designs, how are the output calculated and so on. So, these things we will discuss first. And then the second part within today's lecture, we will also try to cover how the bilingual language processing studies have evolved. Because anything that we see today is the result of many years, in fact, many decades of work put in together by the scientists.

So, what we understand today, if I just give you that much of information, you will not be able to understand the background of it. So, we will also discuss the background of the development of this particular domain.

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Psycholinguistic research on Language processing

- Psycholinguistics concerns itself with language processing
- How is the computing done in word, sentence and discourse meaning
- This is a mostly unconscious process
- How does the mental representation of these processes look like?
- Basically, what happens when we are busy 'doing language'

Handwritten notes: Compute, Production, y - Mole Eng, N - Tole Hindi

Now, when we talk about processing, we are automatically taken to the domain of psycholinguistics. What is psycholinguistics? Let me first give you a brief idea about what psycholinguistics is all about. Psycholinguistics is a sub discipline. You can call it a discipline within linguistics, but it is also slightly away from the typical linguistics domains because this deals with the psychology of language, as in how mental processes and language are connected.

What are the different mental states? What are the different mental processes? How are one group of humans different from another group of humans in terms of certain language related tasks? And all these kinds of fields are part of psycholinguistic research. So, in terms of language acquisition using experimental method, language processing using

experimental method, trying to understand the background cognition in terms of language processing, all of these are part of psycholinguistic research.

So, at the very base of it, psycholinguistics concerns itself with language processing. What does processing mean? Processing is slightly different from simply speaking or understanding. Processing takes us to the background mechanism, ok. So, background by background mechanism, we mean the computation.

Now, if I just ask you, one, I will just give you a series of words and ask you whether you understand those words or not. On the surface at a linguistic level, at the surface level, you might just say ok, this one word, first word was understandable, second word was ok, third word did not sound familiar and so on. So, this is the surface of it, the language part of it.

But psycholinguistics tries to find out why is it so that you took, let us say, you took longer to react to an object and a stimulus that was actually not a word. So, what are the mechanisms that makes you take more time, less time, what are the mechanisms at the back of it? That is the domain of psycholinguistics.

So, psycholinguistics takes us to the psychological aspect of language. That is why we call it a processing. It is not simply speaking or understanding because it also involves the different mental states and mental functions. The tricky part here is that when you speak or you understand that bit is visible or audible, as the case may be. But mental processes are largely invisible and also, they are unconscious.

The reason why, let us say that I give you a word like this, this is a word in English language. So, this refers to the tiny rodent type of animal. Now, let us say you are a bilingual, bilingual in Hindi and English, right. Now, this is a word in English, but this is not a word in Hindi. I give you another word like this. The question is, is this a word? To me it looks like a non-word. But let us say if this comes directly after this, so 'mole' followed by a word like 'tole'.

Now, if that is the case and you are a Hindi speaker, you will automatically immediately because 'tol-mol' is a word in Hindi, but if your task is to say whether it is a word in English or not, here you will take a little bit of more time. Because even if it is not a proper word in English language, but you are still going back to your Hindi and that interference

will take make you take longer to react. This aspect of processing is what we are interested in.

So, what we see is, this is yes and this is a no. This will get a 'yes' response, this will get a 'no' response. But the no response will take a little bit longer even though it is simply not a word in English. So, this is the aspect. This is the phase in language processing that psycholinguistics looks at, right. So, what happens on the surface and why it happens? So, how do you connect with the deeper aspect of it and the surface structure? So, that is where psycholinguistics comes in.

Now, this bit is unconscious because you are not really, if the subjects do not really sit down and think that this sounds like a Hindi word, let me you know understand and nothing like that. This is not a conscious process at all. We do not really think and decide. This is simply because it is there that Hindi word is somewhere there in your mental lexicon, so it takes care of that aspect. Hence it is unconscious.

Now, the question that there are many specific questions, this is the general level of what processing is all about, but in a specific level we need to have a proper question, research question. What exactly is it that we are looking at? Because as I said, this particular small problem, very simplistic problem in psycholinguistics research can be actually looked at from different perspectives.

So, one could be is what is the mental representation of both the languages? We have talked about memory in terms of bilingual language, lexical memory. So, what is it? So, this basically takes us to the shared memory hypothesis, if we recollect. So, there are these kind of different questions that could be asked.

So, how does the mental representation of these processes look like? So, for this example that I have just given you, what is the background mechanism? What is the mental representation? So, to put it very simply, to put it in the gist of it is what happens when we are busy doing language. Doing language means whether we are speaking or we are understanding.

So, when we say processing, processing has two parts, ok. So, processing is the overarching umbrella term for that we use for to include both comprehension and

production. So, basically this means both speaking and understanding, ok. So, this is what processing is all about.

So, how what are the different aspects, what are the different processes involved when we comprehend as well as what are the different processes involved when we speak. These are the two things that come under the broader term language processing.

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The slide is titled "Experimental technique" and features a red arrow pointing to the right. The text on the slide includes:

- online method: Online methods are important as they take us to the processing of language as it happens. This process is not accessible once the task is over.
- This means trying to understand the underlying mechanism as the participant is doing some 'tasks'.
- These tasks are designed in a way so as to help us understand the effect of one variable at a time or the interrelationship between more than one variable.
- For example, prime and the effect of masking condition can be combined to investigate bilingual language comprehension in L1 or L2.

Handwritten notes in red ink are present at the bottom right of the slide, showing "Male" and "Tote" with a bracket and arrows pointing to "monolingual" and "bilingual" respectively.

So, with that bit of a short intro, now let us move on to what are the methods that we apply. What are the methods the psycholinguistics applies? There are many, but we will be considering only online methods here. Online of course, does not mean doing things in terms of the way we are understanding online these days, not in a remote sense, but online as in as the things happen, in a dynamic way.

So, right now as I am speaking, what are the mental processes that are taking place in my mind right now, simultaneously, is what we mean by online in this domain. So, online methods are very important because they help us, they take to the processing of language as it happens, as it unfolds. As you are trying to figure out a simple word, non-word on the screen, what is happening in your mind then and there, that is what is online method.

So, the process is of course, not accessible once the task is over. That is why it is very crucial. So, you cannot make somebody see a display and then later on you sit down and

analyze that data. This is where a very important difference is difference exists between psycholinguistics and other descriptive linguistic processes.

In other linguistic descriptive processes, you take down the language data, you get the word list, you get the sentences, you get various kinds of grammatical structures, stories, narration so on and so forth and later on we can analyze them, we can annotate them and so on. But this is that is where the difference lies.

In this case, we will we typically make the participants take part in some kind of either comprehension or production task and it is judged then and there. The processing is investigated then and there, right. So, this means trying to understand the underlying mechanism as the participant is doing some tasks. So, there are various kinds of tasks which we will see now. These tasks are designed in a way so as to help us understand the effect of one variable.

Sometimes one variable, sometimes a combination of variables, sometimes you also want to see how one variable interacts with another. So, what do we mean by variable? Variable is a thing that changes and as a result of which the result also changes. So, for example, I can ask a bilingual versus a monolingual to do the same task that I mentioned just before. So, if we have the mole versus the same, let me give you the same example.

This is the task, and now I can have a monolingual subject, monolingual as well as bilingual subjects. So, this is the variable, this is one of the variables, ok. So, how many languages does the participant know? Is one variable. Variable as in a condition that varies across participants and as a function of which the result also will vary. So, these are variables. So, whether you are a participant is a monolingual versus a bilingual.

So, if it is a monolingual English speaker, the time gap, time lapse that we saw will not happen, but if it is a bilingual Hindi English bilingual, we can expect a time lapse in case of tole. That is the idea. So, this is how the designs are created. So, we already have a fixed, there are tasks that are that exist, but the task is designed in such a way that will take us to the research question and to understand them better. So, for example, prime and the effect of masking, this these are the things that we will discuss now.

So, there are priming tasks and then there are mask paradigm and so on. So, priming can be checked as one variable, but priming can also come along with masking. So, how what

is the interaction between these two and how are they jointly or individually impact the results? So, these are various things that we need to take into account when we talk about experimental technique.

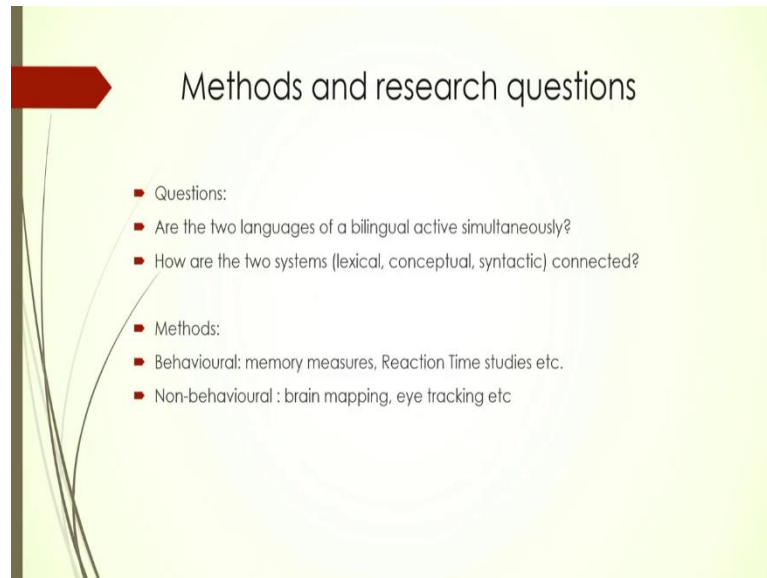
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So, when you say processing, we will talk about processing at two levels, lexical processing and syntactic processing. Lexical processing means processing at the word level. What happens when we deal with words at an individual level, single words, single individual words, just like we saw here. These are all single words. So, this is this will come under what we call lexical processing.

But when we talk about, when we use a full sentence as or more than one sentence as input, as stimulus, that is what we will be calling syntactic processing.

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The slide features a light green background with a dark vertical bar on the left side. A red arrow points to the right from the top of this bar. The title 'Methods and research questions' is centered at the top. Below the title, there are two sections: 'Questions:' and 'Methods:'. Each section contains two bullet points. The 'Questions' section asks about simultaneous language activity and the connection between systems. The 'Methods' section lists behavioural and non-behavioural techniques.

Methods and research questions

- Questions:
 - Are the two languages of a bilingual active simultaneously?
 - How are the two systems (lexical, conceptual, syntactic) connected?
- Methods:
 - Behavioural: memory measures, Reaction Time studies etc.
 - Non-behavioural : brain mapping, eye tracking etc

So, we will start with lexical processing that is processing at the word level. When we talk about bilingual language processing at lexical level, there are n number of questions that have been asked, n number of research agenda that have been investigated and with various methods and tasks and so on. So, there are a lot of lot of questions that are that needed to be answered.

But primarily the major questions, the broader questions that we have been asking for many decades now are typically these two, right. So, are the two languages of a bilingual active simultaneously? How are the two systems? Two systems as in one language, a language can be called a system because it has various layers, and within each layer there are multiple number of networks which we discussed in the introductory lecture.

So, this basically as a result of which each language is like an ant, ant hill. You know it has so many processes involved at so many level, layers, and each layer having so many levels and so on. So, these are the primary questions that have been investigated in lexical processing within bilingualism.

And for doing that, we will shortly see that these two questions cannot be answered by simply having one task. Each question has been you know tried to be investigated using a number of tasks and then making different permutations and combinations of those tasks using different kinds of methods and so on.

So, but basically at the root of it, these are the two questions that we are trying to understand. And we are still trying to understand, still time to get there. And in terms of methods there are primarily two kinds of method. One is the behavioural method and the other is non-behavioural method.

What is the behavioural method? Behavioural methods are those methods that depend on some kind of behavioural output from the participants. So, the participant has to do something, either he has to say something or he has to press a key to denote some answer, yes, no kind of an answer, and so on.

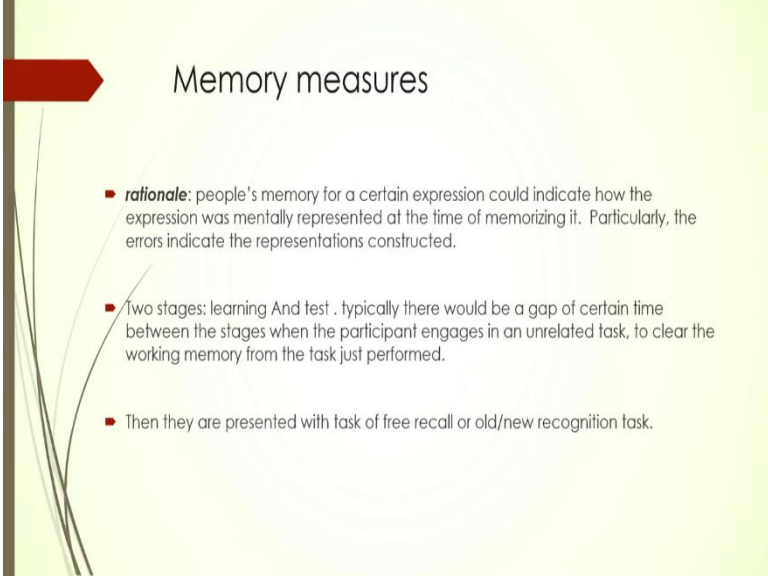
So, these are behavioural output which means the subject has to do something, right. So, there is a stimulus given and the subject has to react to it in some way. That is the behavioural, those are the behavioural methods. Within behavioural methods there are, we will discuss only a few here. So, memory measures and reaction time studies and so on.

In terms of non-behavioural, the significant difference between behavioural and non-behavioural tasks or methods is that in case of behavioural methods the subject has to do something. In case of non-behavioural tasks, the subject does not typically do anything as in there is no output in that sense. So, the person is let say is just simply watching a display, some words, some pictures or something and the tools that are used capture the underlying mechanism from that typically from his brain.

So, there are various kinds of imaging techniques and then typically brain imaging, brain mapping techniques and eye tracking and so on. So, there is a display or there is some kind of a task the person is busy doing that. And then, there are tools that collect the information from the either from the eye movement or from the brain waves and you know how the oxygen level in the blood increases in the brain and so on. So, there are these are the two kinds of methods.

The brain mapping methods we have already talked in the previous one of the previous sections. So, we will not get in there again. Today, we will discuss more about behavioural methods.

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Memory measures

- **rationale:** people's memory for a certain expression could indicate how the expression was mentally represented at the time of memorizing it. Particularly, the errors indicate the representations constructed.
- Two stages: learning And test . typically there would be a gap of certain time between the stages when the participant engages in an unrelated task, to clear the working memory from the task just performed.
- Then they are presented with task of free recall or old/new recognition task.

Now, in terms of behavioural methods there are one of them is memory measures. There are various kinds of tasks that can be utilized to understand how the human memory interacts with different kinds of language functions and what are the variables. Remember variable is that thing which changes.

So, high proficient bilingual versus low proficient bilingual, monolingual versus bilingual, you know early learner versus late learner. This can be these are some of the variables that can be utilized. So, depending on those variables there are certain kinds of tasks.

Now, the rationale behind this kind of studies is that people's memory for certain expressions can be awards or sentences whatever could indicate how that expression how that word or the concept was represented in the brain, how it was mentally represented and how that representation is retrieved or accessed, right. So, this is primarily the fundamental rationale for these.

So, typical memory measures will have this kind of tasks or designs will have two levels. First level is the memorizing stage and the second is the task stage. We have already seen some examples in the previous segments, but we will just go over this in very brief. So, in the first stage, remember if you remember, there are many types of this, but one type has been to give a list of words to the participants to read and to memorize and then there is a gap.

There are various designs what to do with respect to that gap. Sometimes there is simply a gap, sometimes there is a different completely different unrelated task that is incorporated in the middle, and then comes the task stage or stage 2 or stage B whatever you call it, where the person has to either recall free recall.

So, there are two kinds of things that can be done in the second stage. First stage is memorization, learning and the test stage can have two kinds of outputs. So, one could be free recall. Free recall as in how many words you can remember, how many of words you can freely remember.

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For example, this is a very simplistic example for free recall test. So, let say we have given this stage 1 memorizing or learning stage. So, here the participant will be ok. So, the participant is given a list like this and this they have to memorize it. And then there is a gap, here is the gap, where they let say they play chess for some time and then comes the stage 2 where they have been they will be told to simply recall as many words as they can, right, from the previously given list.

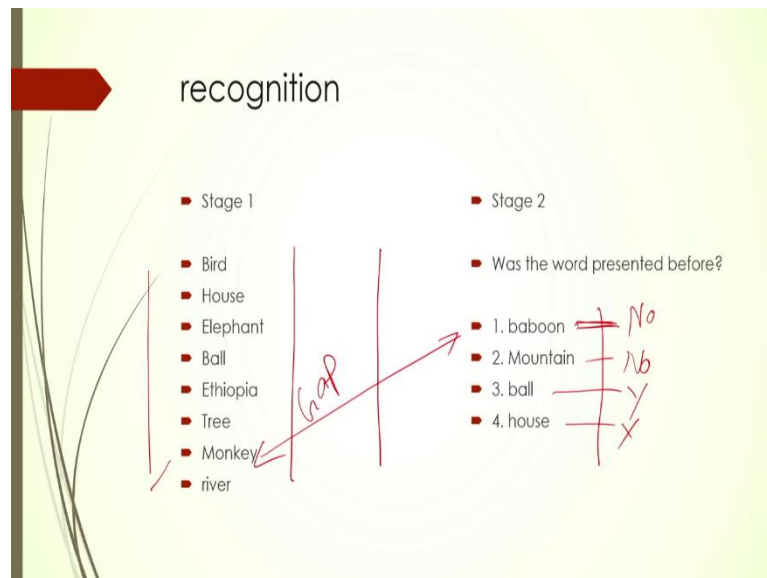
This is a free recall. As the name suggests this is there is no constraint, absolutely free. So, you simply remember try and recall as many words as you can. Now, here there can be many variables. So, you can you know give this can be a single word, single language list, it can be a mixed language list depending on what you are trying to look at. This list could

have, this is a monolingual list, right. So, we can also make it a bilingual list by mixed I mean bilingual.

So, it could be a let say Hindi English bilingual list. So, bird, and then house, and then this and then in between we can have a few Hindi words, and then another Hindi word here and so on. So, there are the; these are the manipulations that are possible. There are many other possibilities as well. But this is basically the primary task is this. Stage 1 will be learning. Stage 2 will be recalling, simple.

Now, depending on the research question which is what we are trying to probe, we can make various changes in the initial list, learning stage.

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Another kind of memory measure is recognition. Recognition is similar to the previous one. Again, we have a list of words and there could be a break where you can play you know you can play something or you can just simply have a gap or something. Let's just say there is a gap of sometime 10, 15 minutes or so. And then there is a there is stage 2.

In the stage 2, however, this is there is slight difference. Now, we can give them a list and ask how many of these words or which whether this word was be present before. So, this was presented as a list and this can be presented individually. So, one word at a time. So, you see baboon coming here, right. Because we had monkey here and baboon is coming

here even though they are not the same thing, if there will be a slight time, there is the possibility that there will be a slight time lapse here, to say no.

This is a no answer, right. This is a no question. This is also a no. This is a yes, this is also yes. See, so how we can change make changes. So, in this particular example, one of the variable could be if they are semantically connected, what will happen? So, we have a semantic connection between monkey and baboon. So, even if it did not occur before there will be some amount of disturbance that we can expect. So, these are the different kinds of variables we can build in, but primary level design is like this.

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Reaction time methods

- Reaction time, or RT, is used as a dependent variable in many experimental paradigms
- This is the output data of the experimental work
- This refers to the time taken to react after the onset of the stimuli
- The RT is the result that is calculated as a function of the type of stimulus and its relative processing difficulty
- This means, that the more complex the stimulus, more will be the RT.
- this variable is widely used

The diagram shows a staircase with a hand reaching for a step. A red arrow points to the step, and a label indicates a time of 3000 ms.

Then, comes what we call reaction time methods. Reaction time methods have been very useful and it has been really productive for quite many decades now and reaction time is basically the time that you take to react. Now, this is actually this is a very dependent variable. Dependent variable is which ultimately in the in an experimental paradigm this is what is our data.

So, if we change those independent variables like the way we choose our words, if they are semantically similar versus their phonologically similar and some their translation equivalents of each other, if we are using it in a mixed language context. All of these can be which we have which have been calling variables they are independent variables.

Now, because of those independent variables the reaction time may change. That is why reaction time is called a dependent variable. Whether the reaction time will change or not will depend on the those other variables that we have used that we have incorporated in the design. That is why this is the dependent variable.

So, basically this is the output. Finally, this is the output that we have as a data. And this is what we go by, this is what we analyze in the when we say we are analyzing the data. So, the time basically is the after the onset of the stimuli. So, that is the stages of the display that comes in the picture that comes in the screen. I will have some designs put there, we will see them shortly.

But there is this the typically in a typical experimental paradigm there will be a blank screen in the beginning; on the there is a computer screen that is there that is which is blank. And there will be a we call it fixation cross in the middle and the participants are supposed to look at it and that is how it is calibrated.

And then let say we have this recall task. So, there is this list of sorry; there is a lexical decision task, so there is a word here. And then that is a bit of a blank and then there is a target word here. So, this target word when target word comes let say this is on the screen for 300 milliseconds. We all measurements in the reaction time studies are done in milliseconds, 3000 millisecond.

So, this is that onset of the stimulus for us. We are trying to see a prime this is a prime target kind of a design. So, this is what the this is what needs a reaction, ok. This one does not need a reaction. This one needs a reaction now.

So, the moment the stimulus has come on the screen, from that moment till the reaction from the participant gets logged into the system is the reaction time. So, onset of the stimuli to the onset of the reaction is what we call reaction time, right. So, this is the result that is calculated as a function of the type of stimulus.

So, depending on what kind of stimulus you have given and how that results into difference in timing is what our data is. And the base line, the basic premise of this entire design is the longer you take the more difficult the task must have been which is almost common sense. So, if we if you are given a difficult task, you will take more time to do it. If we are given simple task, you take less time to do it.

So, the reverse idea is used here. So, if you are taking longer to process a word, to understand the word or to you know speak out in production studies. So, whatever the time duration the gap, the difference between time duration as a function of the stimulus is equivalent to the processing difficulty.

Simply put, higher the reaction time the more difficult the task has been. Lower the reaction time, the more easy it has been, right. So, this at a fundamental level, this is a very simplistic design.

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The slide features a title 'Reaction time method' with '(ms)' written in red below it. A red arrow points to the left from the title. Below the title, there is a bulleted list of tasks. The first bullet point is 'RT is a productive method, used for a range of processing studies. Some of them are:'. The subsequent bullet points are 'Lexical decision', 'Priming paradigm', 'Translation recognition', 'Self paced reading', 'Sentence processing', and 'Picture/digit naming etc.'. There are red checkmarks next to 'Lexical decision' and 'Priming paradigm'. The slide has a light green background with a dark vertical bar on the left side.

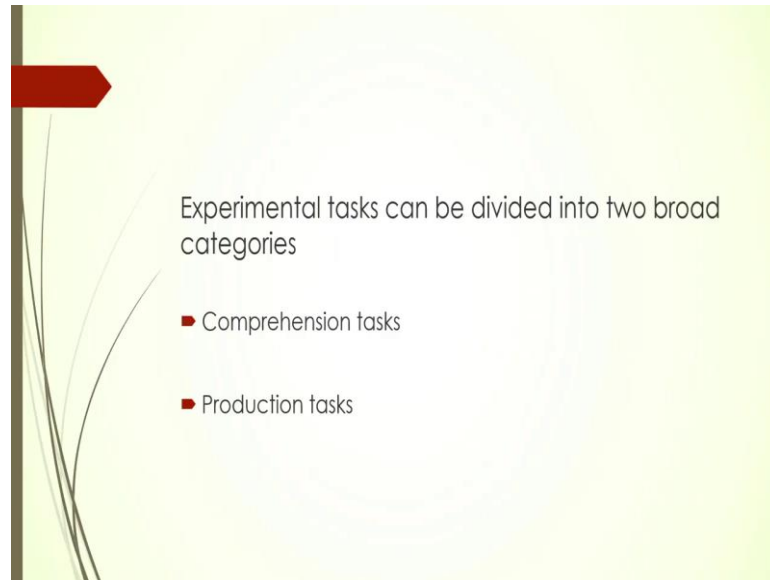
- RT is a productive method, used for a range of processing studies. Some of them are:
- Lexical decision ✓
- Priming paradigm ✓
- Translation recognition
- Self paced reading
- Sentence processing
- Picture/digit naming etc.

Now, there are various kinds of designs that can that are used with reaction time as the output, ok. So, reaction time is simply the output. Now, you can make the participants, the participate in different kinds of tasks all of which will ultimately give us a time in terms of milliseconds. So, reaction time is always millisecond, ok. This is something that you need to keep in mind.

So, there are different kinds of designs like lexical decision, priming paradigm, translation recognition, self-paced reading and so on. There are many kinds. We will discuss only a few. All of these I am discussing beforehand because as we go ahead as we talk about processing literature, we will be talking primarily about experimental evidence.

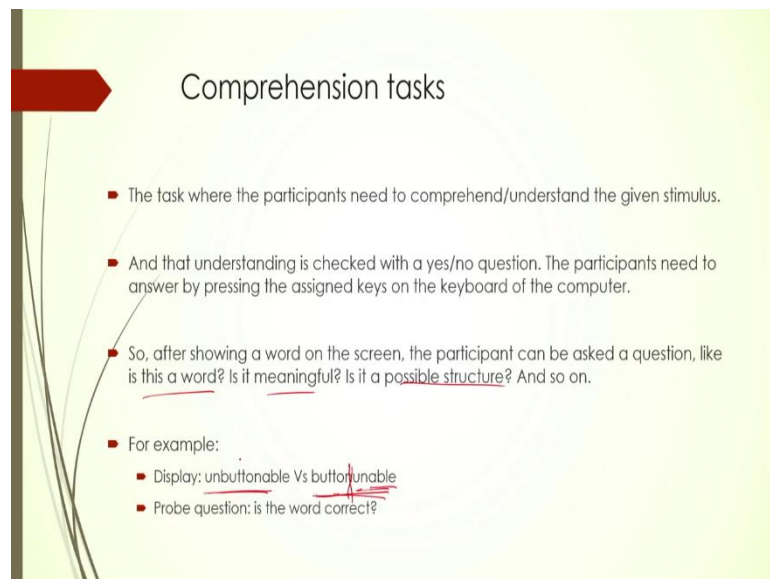
What kind of processing strategies have been found that bilinguals are typically found to use and how those strategies change with respect to different kinds of factors. So, before we get into that complexity, we need to understand these various designs one by one.

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So, we will go in a methodical way. So, we will first look at the comprehension tasks and then we will go to production tasks.

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As we said, that both comprehension and production are part of the larger domain of what we call processing, right. So, what is a comprehension task? As the name suggests, the

comprehension task is simply where the participants need to understand the given stimulus, understand or comprehend. That is why comprehension task. So, there is a stimulus on the screen and the participant needs to understand, right.

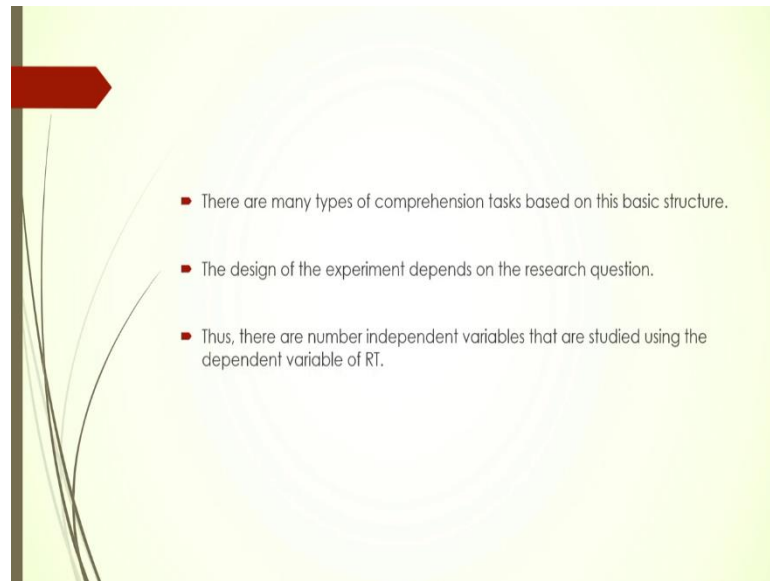
And now there are many ways to check whether the person is understood or not. Often there is an yes, no option. There is a question, is this a word, is this not a word? So, yes, no output, right. So, the participants needs to answer typically the answer is given by pressing a key. Those keys in the keyboard are always customized. So, one person may use for yes, no right or left key, some another person may use the y and n key.

It is customized depending on the each experimenter can have different kinds of customized keys for yes, no, but typically it will be a key press. So, that there is a display. The person has to look at the display. Task is to understand, and then press a key to react. And that time between the task and the reaction is our reaction time in millisecond, right. So, for example, after showing a word on the screen, the participant can be asked like is this a word like we have just talked about.

Now, let see there are words like this, ok is this meaningful, is it a possible structure and many kinds of questions you can ask. A simple example would be let say we have a display with the words like unbuttonable versus we have we jumble up the word and make it a word like buttonunable. This kind of thing can be used as a display; and the question can be is this a correct word.

Now, here it is individually you will be mentally basically dividing them. So, button comes here and then unable or especially un able all of these. So, this probably will take slightly more time than this. This is a simply a word. This is not a possible word in English, but the entire word is not; however, the component words are.

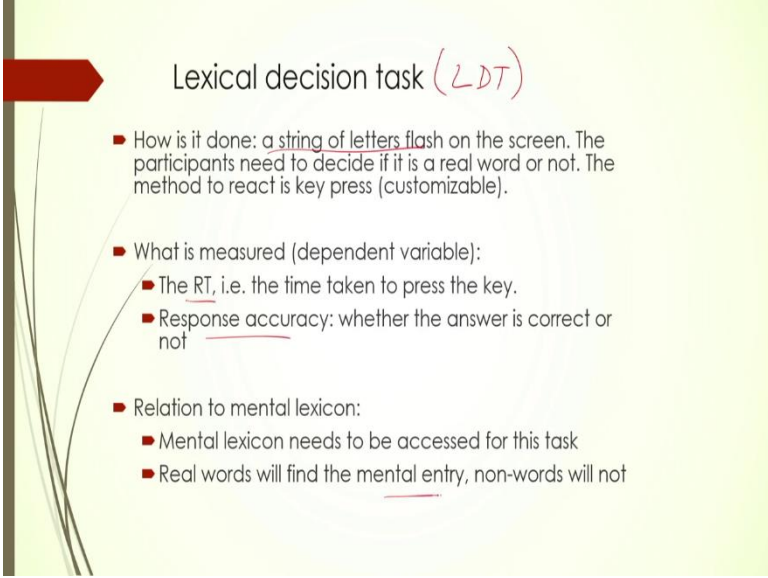
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So, there are these kinds of various kinds of complexities that one can build into the design. So, based, but fundamental is this is the idea. There will be something on the screen, the task will be to understand, and then react. So, depending on the research question you will have a different design, right. So, here I was let say we can think of if we create a different word using the same component words, will that help or will that hinder.

So, in this case this is not a possible word in English, but this is what is hindering hypothetically. Let say this person will take longer time here, because individual words within this construction are possible words, and they are correct words, like this. So, depending on the research question we can use different kinds of stimulus. But stimulus it is. They all will be coming under category of stimulus.

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Lexical decision task (LDT)

- How is it done: a string of letters flash on the screen. The participants need to decide if it is a real word or not. The method to react is key press (customizable).
- What is measured (dependent variable):
 - The RT, i.e. the time taken to press the key.
 - Response accuracy: whether the answer is correct or not
- Relation to mental lexicon:
 - Mental lexicon needs to be accessed for this task
 - Real words will find the mental entry, non-words will not

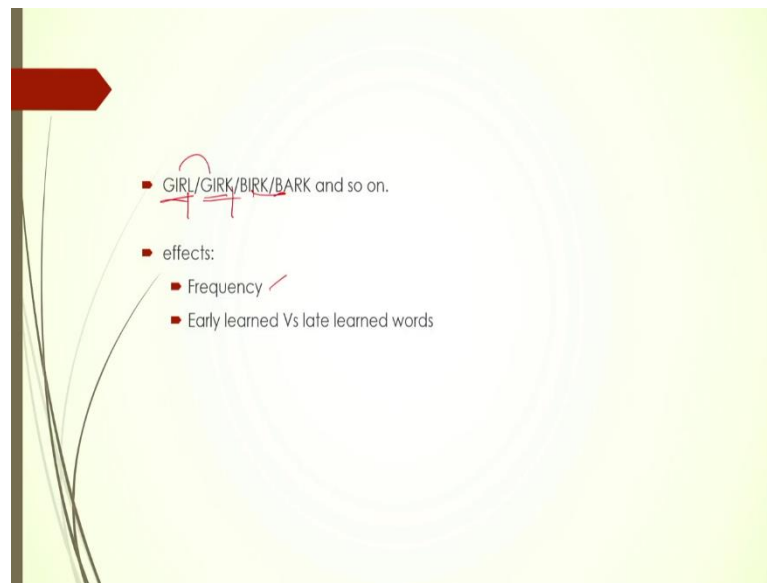
Now, lexical decision task, we have talked a lot about it. Basically, a string of letters because you cannot call them words. Since, we have non-words also and then they have to decide whether it is a word in the real world or not, in the either in one language or in two languages or there can be many variables put in.

So, what is measured is the reaction time and also the accuracy. So, though two outputs will be here, one is the time of course, that is something that we are talking about. But at the same time, we also note the accuracy, how many correct answers are there, how many errors are there, and then the errors are also analyzed like depending on the relationship between the errors and the kind of words and so on. So, this is accuracy is also another output.

Now, a relation this is also the reaction time studies in terms of LDT or lexical decision task. We often refer to them in short like LDT. So, they take us to the question of mental lexicon as to how do we access the mental lexicon. In case of bilinguals, there are lots of different types of studies using single language stimulus versus mixed language stimulus versus alternate language stimulus.

And trying to see how mental lexicon is accessed and what are the connections between the two languages, lexicon of the two languages. So, while real words are there in the mental entry, non-words do not. But non-words also create a lot of trouble.

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So, these are the kinds of non-words. So, there this is one word and this is there is this against this also, the way the non-words are created typically everything else will remain same except one phoneme. So, in this case everything is same except the last phoneme. So, in this case it is GIRL, here it is GIRK. This is how non-words are created. Non-words are maximally similar to existing word with the minute difference of one phoneme, either in the initial position or in the final position and so on.

So, this is how non-words are created, non-words are created, ok. And then we can check various parameters within this task. So, one could be the frequency. Frequency is a very important variable in terms of lexical decision task or various other kinds of task as well. Frequency means how commonly do you find that word in day to day communication.

So, there are some words which are always used, some words which are very rarely used, some words which are used only in certain domains and so on. So, table, chair cup, you know sky, mountain, tree, these are all high frequency words. There are they are used all the time, everybody from children to old age people everybody knows them.

However, on the other hand you have some word like response latency, that is what we are using in this course. Response latency is a word that is not only low frequency word, but it is also dependent on a particular domain. So, hence, as a result, frequency is a very important variable.

Similarly, you can have words that are learned early versus words that are learned late. And then we can combine all of it into this design, into this lexical decision design. And we can check whether early learned words are remembered or understood quick more quickly compared to late learned words and so on.

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Priming paradigm

- Process: the target word is preceded by another word, which is called the prime. Can be used in Lexical decision task
- Dependent variable: RT
- Priming effect:
 - related primes lead to faster recognition
 - This relation can be semantic, phonological, orthographical
 - Masked Vs non-masked prime (do the reading from reference list)

Handwritten diagram: Prime - Target
 A sequence of three boxes: a box labeled 'P', a box labeled '500 ms', and a box labeled 'T' with 'Panta' written below it. Arrows indicate the flow from P to 500 ms to T. The text 'Prime - Target' is written above the sequence.

Another important type of design is what we call priming paradigm. Now, priming is there are two words, there are two stimuli that appears on the screen, one comes first followed by the other. The one that comes first is called the prime, the one that comes later on which the subject has to react is called the target. So, the difference between there is a prime and there is a target, ok.

So, if the there is a relationship between the prime and the target, then there is depending on the kinds of relation that we have, there can be various kinds of reaction time. This is the pair, prime and target pair, ok. So, there is one display and then there is let say a bit of a gap, and then there is a target. So, this is the prime, there is a gap here of 500 millisecond, and there is a target word here.

The task is to understand this target word, right. Is this a word or is this; is this a simple, it can be a LDT, lexical decision task. So, we can have now depending on the relationship between the prime and target, we can have different kinds of results in this simple task. So, the why do we use prime? The fundamental logic here is that to see what kind of word level connections make it either easier or more difficult to process.

So, what are the kinds of parameters? For example, the prime and target could not be could be connected in terms of let's say semantics. So, I give a word like tiger here and then I give a word like leopard here, they are connected, tiger and leopard are connected in the sense that they are part of the same family of animals. So, they are connected.

But if I give tree here and then I give you let say pasta here, there is no connection whatsoever, right. So, depending on this difference, we can we will have different kinds of reaction time, ok. So, this is just one simple example of how prime is used. So, the connection between prime and the target, if there is a relationship of some kind, there will be faster recognition. If there is no relationship, there will it will not help.

So, the relationship can be semantic, it can be phonological, it can be orthographic and so on and so forth. Similarly, we also do there are lots of studies on masked versus unmasked paradigm. I have added a lot of reference because we cannot really discuss all of this.

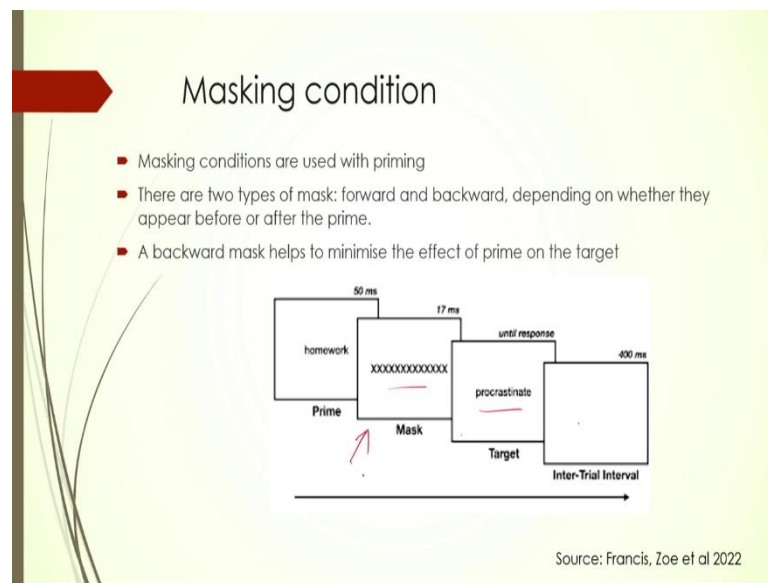
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- Example:
- 'Bread' followed by 'butter' Vs 'bread' followed by 'cycle'
- If the two words are related in any way, the recognition is faster.
- Because, reading 'bread' activates the related concepts, and when one candidate from those related concepts is the target word, recognition happens faster.

So, masked and unmasked paradigm is often incorporated with the priming paradigms, ok. So, and just before we go to mask, unmasked, for example, bread followed by butter is processed faster. So, if you have bread in the prime and butter in target, butter will be processed much faster as opposed to when it if the prime was different or let say bread is prime and butter is target, and then bread prime remains and we have cycle as a target. There will be no facilitation.

So, this will not help processing this. However, this will help processing this because the moment we say bread, we are already activating the related concepts. So, the in all probability bread is eaten not with sabji, but with butter. So, bread automatically activates the concept associated semantic concept of butter. So, that is why we see a facilitation. However, bread has nothing to do with cycle typically, so this will not help. So, this is how it is.

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So, now let us talk about masking condition, what we mean by mask. So, masking conditions are typically combined with priming paradigm. There are two kinds of masks: forward and backward depending on where it comes, before the prime or after the prime, ok. Now, the idea of masking is to see to minimize the impact of the prime on the target.

So, there is let say there is a prime like homework here. This is taken from a recent paper 2022. So, the prime is homework and then you have this mask. Mask is there can be anything there, there are hash marks or sometimes there are lots of cross on the screen. The idea is to make us forget what was before that.

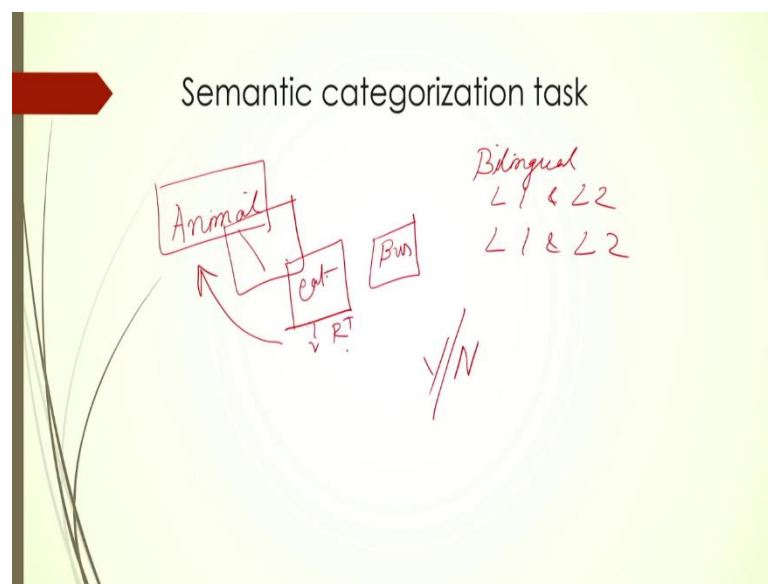
So, homework followed by mask and then there is the target word is procrastinate and then this is the target and then you have this target stays on the screen as long as there is typically a time given sometimes this 2000 millisecond or till the participant responds. And then there is a gap and then the next thing starts. So, this is basically what masking is all about.

what it is. So, road and rasta, is rasta a translation of road versus is ghar a translation of road.

Again, as I said there are many variables that can be built into this, but the task is like this. So, you can have variables like word frequency, translation direction. So, from in this case let say this is L2 to L1 direction, you can change the directions and make it let say rasta and then it becomes a road.

Now, you can easily check the difference between this direction and this direction. You can have a that itself could be a study. So, a from L1 to L2 direction versus L2 to L1 direction is there any difference in comprehension, that could be one study. This is how, this is how variables are built into the primary design.

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Now, there is another kind which is called semantic categorization task. Semantic categorization tasks have been used quite productively across various kinds of domains within the language processing. Basically, what semantic processing, semantic categorization task is all about; I guess I had mentioned this before in one of the previous modules.

Semantic categorization task is something like this. Let's say you have word like a simplistic type of semantic categorization task would be like this, ok. So, we have something like a word like animal and then there is a break. It is always like this. So, the

designs in the experimental outputs are always like this. So, this is called this is a box design.

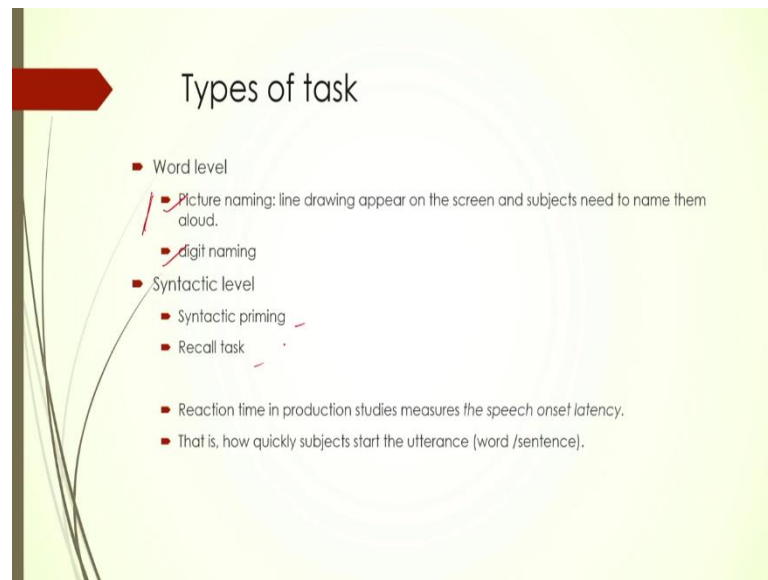
So, this is the first display, then there is a gap. You can have a gap, you may not have a gap, but let's just keep a gap here and then we say this is. So, is cat a part of the category animal? Is cat an animal? This is a very simple semantic categorization task. Again, similarly you can have; so, this is one option.

Similarly, you can also have another option like let's say bus. So, is bus a kind of an animal? Is it part of the category? This is a cate semantic categorization task at the root of it this is what it is.

Now, we can have many variables in case of a since it is a bilingual processing task, you can have various variables. So, you can make it the first input could be L1 or L2. Second also could be L1 or L2, like you can change the these two and then you can again you can also have frequency, word frequency you can have various other kinds of parameters built into this.

But semantic categorization task is simply this, the category name and the member name. Is this a member of the that category or is it not? Again, an yes, no question. This is also a key press and this is the reaction. So, depending on when is a when cat is presented and then till you answer is your reaction time, alright. You have to answer only in yes or no and that is the time.

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Now, let us go on to production studies. In production studies, typically the tasks that are used are picture naming and digit naming. Picture naming is widely used across different kinds of research questions and different kinds of probes, whether it is monolingual or bilingual studies and so on.

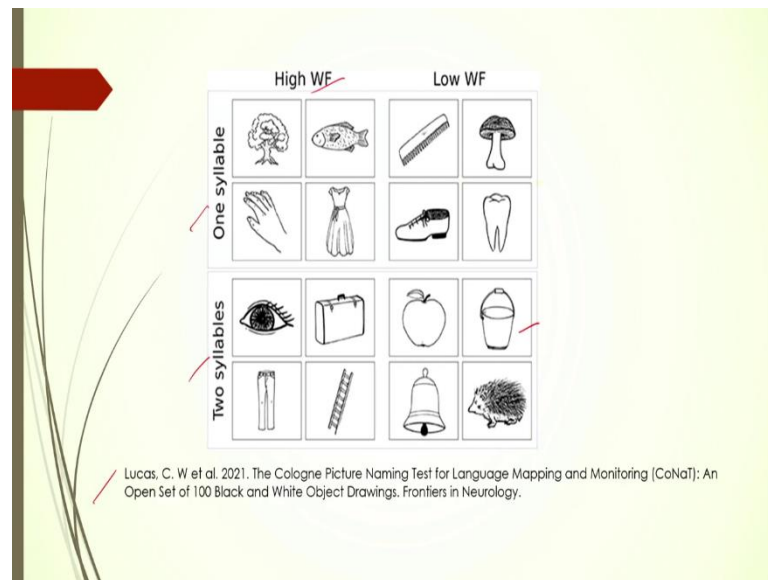
Typically, what will happen in picture naming is there will be a picture that will appear on the screen and the subject has to say. These are all production studies. So, we have there has to be a verbal output. The person has to name it. So, that is why picture naming.

One important thing to remember here is that these pictures are not like real life photographs, they are line drawings. We will see shortly and then there is digit naming also. Digit naming has been used in many kinds of; why picture and digit naming in certain cases picture for example, pictures take us to the conceptual level directly without any interference of the language.

So, whether I am a speaker of Swahili or a Zulu speaker versus a Maori speaker or a Hindi speaker, the picture of a house is irrespective of those language linguistic properties. It takes us directly. So, the picture is the direct replica of the concept /house/, right.

So, it is not dependent on the language. So, this is why picture naming has been utilized widely across different kinds of paradigms within this domain. So, similarly digit naming. In at syntactic level, of course, we have syntactic priming and recall tasks.

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So, this is an example of a picture naming task. In case of a picture naming, what kind of pictures do we use? So, this stands for word frequency. So, this is how you can see how the design, this is again from a recent paper. So, there are the differences are how the differences are in-built into the design.

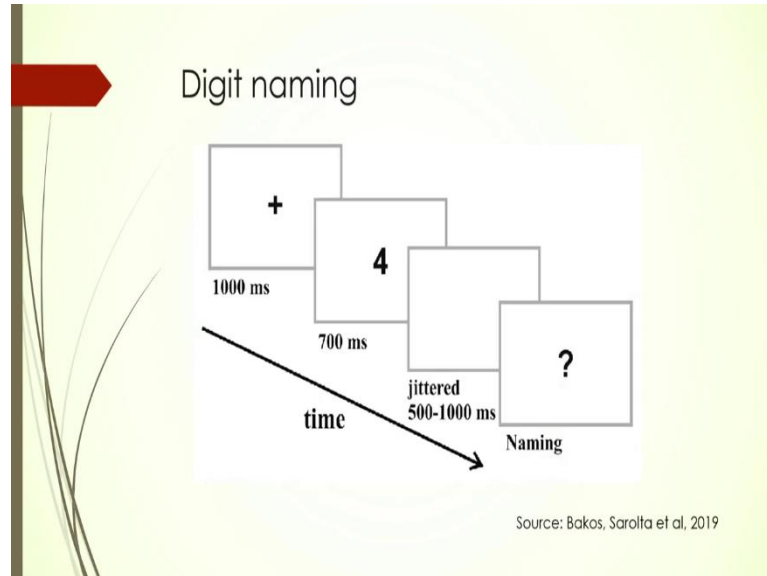
Only one picture appears on the screen at a time by the way. Here we are just showing you all the various kinds of the variables that if they have taken into account. So, one is high frequency word, another is low frequency word. So, these are all high frequency, tree fish, hand, dress and so on.

These are high frequency and within both high frequency and low frequency, they have differences of low to two syllable word versus one syllable word. So, we see the number of variables that can be built into a design is quite large depending on the research question. So, this is basically how picture naming tasks unfold. So, there is a picture, any individual picture like this and the participant has to answer.

Now, this answering can happen in one language or you know it can be in language 1 versus language 2, and then we can check how the reaction time changes depending on the language input. And within each language high frequency versus low frequency. Also, you can check in case of bilinguals, you can check whether early bilingual versus late bilingual difference is a factor in picture naming, so on and so forth.

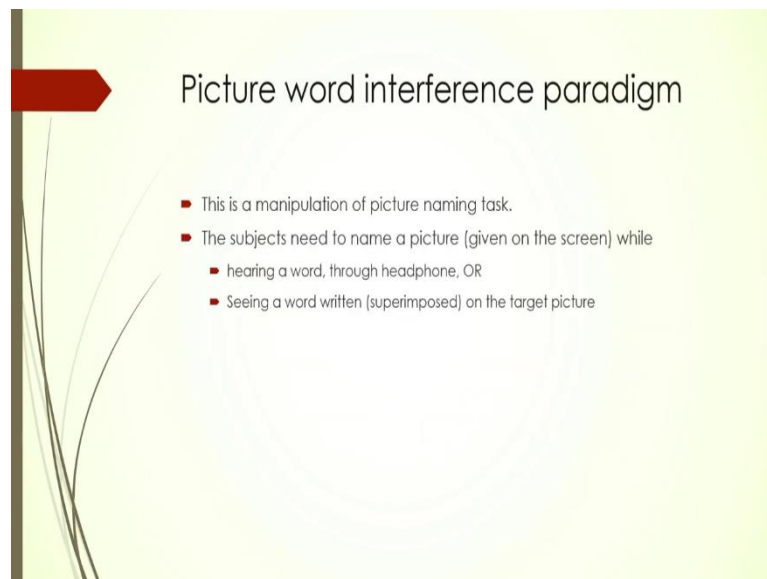
Various kinds of independent variables can be built into this. But the basic design is like this. There will be a picture like this and they have to name the picture.

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Similarly, digit naming looks like this somewhat. Again, a recent work, quite a recent work. So, there is this is what we call fixation cross in the middle, then there is a digit and then there is the naming. What is it? 4, like that.

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Similarly, there are some manipulations of these simple designs as well. One is what is called picture word interference paradigm. This is a basically a manipulation of picture

naming task with a with a with a incorporation of a different thing there. So, subjects name need to name a picture while sometimes hearing a word or sometimes seeing a word written on a picture.

So, there is a picture of a cow let us say and then on that picture the word bird is written, right. So, you have to depending on what kind of task it is, the you have to basically name the cow. So, we have to say cow, even though the word bird is interfering with your picture naming. This is what is a picture word interference paradigm, to see how different kinds of input stimulus interact with each other, ok.

And similarly, you can also hear a word while looking at a picture. So, how does the auditory input impact your visual in visual processing in this particular case? So, this is a visual and auditory interference, and this is both are visual; however, in two different modalities. Because when there is a word written our first its almost instinctive that we read the word, right.

So, hence, that kind of a design is created because that will be an automatic processing and this will try to interfere with the targeted the goal at that time which is naming the picture. And this has been utilized again in many different kinds of scenarios.

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Now, the tools, since, we have been talking about various kinds of designs that are utilized, various kinds of experimental scenarios. Now, how do it; we constantly keep saying that

it is presented on the screen, how is it presented. So, we need the help of various softwares that are available today. This there are software, there are many. I had just named a few the most commonly utilized ones.

That is a software called Eprime, then there is DMDX, then there is Presentation, they have all different sources, some of them are free, some of them are not, one has to purchase. But the primary job of these softwares is that once you have installed them in your system, they will and you have to give the stimulus and everything in you have to design the experiment on this.

And when the experiment is taken to the subjects, it takes care of the or on the presentation how to present the stimulus and how to log the data and give us an output. So, these are the tools that we typically use. DMDX is free, E-prime is not. Presentation is also not. Each of them they are different slightly different from each other depending on various parameters, but these are the most common software that are used.

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Now, let us move on to the actual studies that have taken place. Now, that the basic information is in place. We go ahead with the actual research. Now, before we get into what how the research stands as of today, what is what are the primary findings and where is the research going ahead. We will go a bit back in history when it all started.

So, 1950s to 70s saw a lot of work happening in the domain of bilingual language processing. Processing literature takes us back to that time. So, during this from 50s to 70s, the focus of the study were these are the focus at that time. So, primarily they started with classifying bilingualism, how different kinds of bilinguals are there, what kind of different mechanisms could be involved in each of these and so on. Bit of it we have already discussed.

And then, degree of bilingualism and language dominance, which language is dominant, what are the factors that decide and how do we know which language is dominant, these were another set of questions. Similarly, there was also lexical organization and taking us back to the memory measures to the bilingual memory and then of course, bilingual processing.

So, these are the primary areas of research interest that have been noted in during this time 1950s to 1970s. So, each of them we will now look at slowly.

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Classifying bilingualism

- All bilinguals are not same.
- Weinreich (1954) was the first to identify and classify bilinguals into three groups
 - Compound, coordinate and subordinate ✓
- Osgood (1954) also made a distinction but a two-way system
 - Compound and coordinate
- Among these two, Weinreich made a distinction between lexical and conceptual representation.
- This was also what De Groot (1993) incorporated in her model (RHM) many years later.

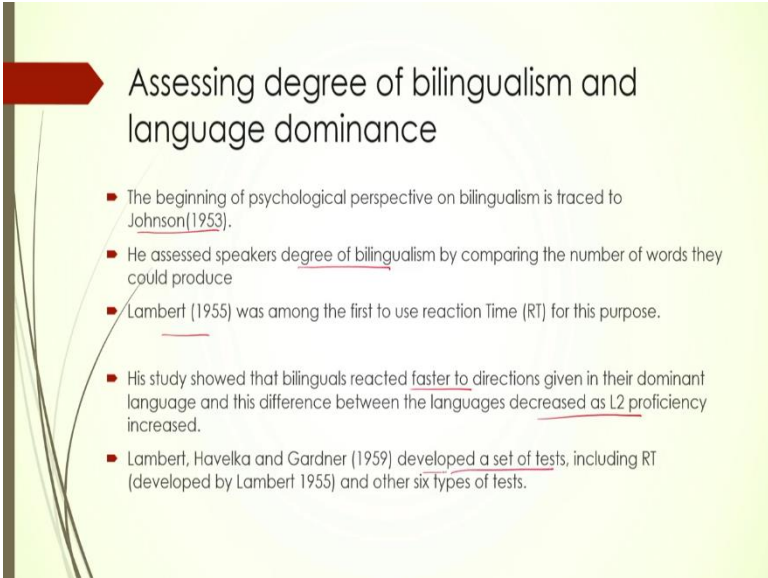
So, classifying bilingualism basically means that all bilinguals are not same. Remember our initial lectures that we have bilinguals have the different categories, sub ordinate, coordinates, you know all of that different types. So, this started at that time. Most notably with Uriel Weinreich. He was the first to identify that bilinguals can be classified into different types depending on the way the information is stored.

So, he had a three-way division which all of us still use: compound, coordinate and subordinate bilinguals. But he was not the only person who talked about it, we have also Osgood. It is in the same time, but Osgood made a two-way distinction as opposed to a three-way distinction by Weinreich.

Now, among these various researchers, Weinreich's ideas were basically hinged upon both lexical and conceptual level, which is not the case with Osgood. So, he made a distinction between lexical and conceptual representation and from there it takes off. We talked about this in the bilingual memory section that this is how the whole study started. As in how are the lexical information represented in the brain and how are the conceptual information represented in the brain and how do they interact.

So, starting with Weinreich and then later on we had Groot's revised hierarchical model that takes care of both the lexical representation and the conceptual representation and also the model shows how the relationship can change as a factor of proficiency. So, as the L2 proficiency goes higher, we build a stronger connection between L2 lexical representation and the conceptual representation.

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Assessing degree of bilingualism and language dominance

- The beginning of psychological perspective on bilingualism is traced to Johnson (1953).
- He assessed speakers degree of bilingualism by comparing the number of words they could produce
- Lambert (1955) was among the first to use reaction Time (RT) for this purpose.
- His study showed that bilinguals reacted faster to directions given in their dominant language and this difference between the languages decreased as L2 proficiency increased.
- Lambert, Havelka and Gardner (1959) developed a set of tests, including RT (developed by Lambert 1955) and other six types of tests.

So, this, so Weinreich's studies have remained relevant for quite a long time. Even today we do take them into account. Second was the domain of language dominance, which language is dominant? Is L1; are the people bilinguals L1 dominant or L2 dominant? The

primary idea has been that L1 is the dominant language, because that is the first language that you will learn and that is why you have a higher vocabulary.

So, the beginning of the study goes back to Johnson in 1953. He assessed speaker's degree of bilingualism by comparing the number of words they could produce, ok. So, as in the task will be ok, say within this time let us you produce as many words in 1 language or 2 language, in this language or that language as you can.

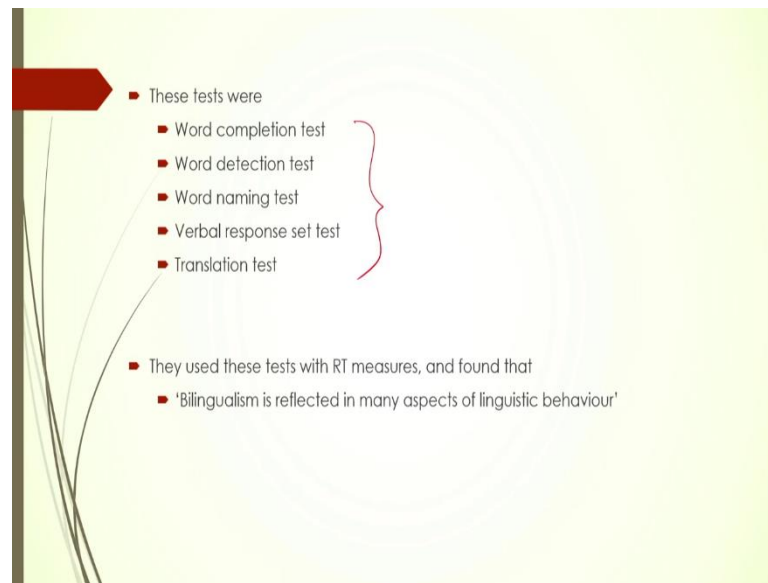
Depending on the number of words that you could produce, he will give you an assessment about the degree of bilingualism. So, they will say somebody can produce 50 words in the L1, but only 30 in L2. So, then that there is a difference that could be assessed. So, this is one of the first types.

Lambert was among the first to use reaction time for this study. So, you had there is a task and then depending on how long you take. So, reaction time was, reaction time started to get used even at that time 1955. So, his study showed that bilinguals reacted faster to direction given in their dominant language and this difference between the languages decreased as L2 proficiency increased.

So, the task was to give you know they there was directions given, so right left you know like this. So, there are the directions that are given and how quickly you respond to it, that there was a difference that he found; L1 was reacted to faster as opposed to L2. However, as L2 proficiency went higher, the people reacted the participants reacted quickly as well.

So, this was one of the first reaction time studies that Lambert did. And on the basis of these studies, they went on to actually create a set of tests, the then developed a set of tests including of course, RT to check this idea of dominance and how what kind of degree of bilingualism that existed.

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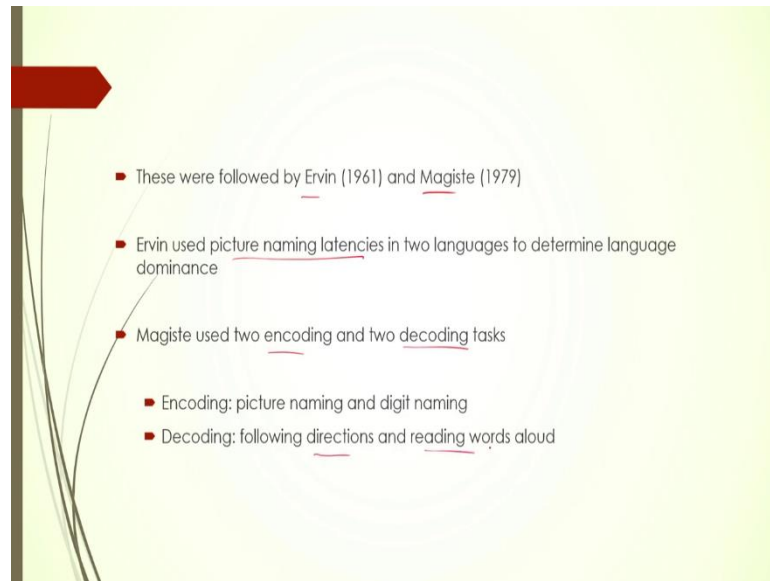


So, these are some of the tests that are still used word completion test, word detection test and so on. And very often RT was used as a dependent variable. Now, as a result of all of these remember this, we are talking about 1950s.

So, as a result of these, they declared that bilingualism is reflected in many aspect of linguistic behavior; that through processing, through giving them tasks, through experimental paradigm, we can check what are the different kinds of behavior that are impacted due to bilingualism is what the single most contribution of his, of Lambert is.

So, the not only he created with different kinds of sets of tasks, but also administered them and this is the these are the initial findings of bilingualism, processing research within bilingualism.

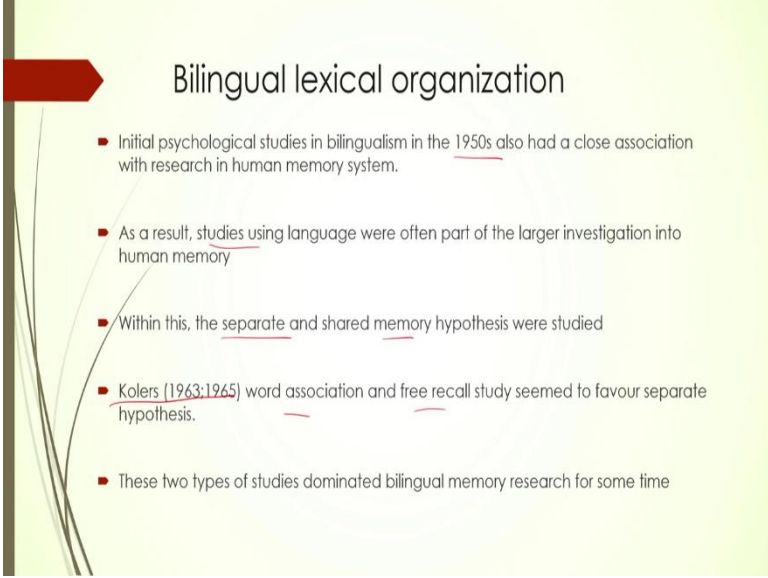
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Now, these were followed by Ervin and Magiste in 1961 and '79. Ervin used picture naming latencies, latency is a time, in two languages to determine language dominance. So, pictures as I said if various different kinds of independent variable can be built into, so Ervin built in the two languages. There are pictures, same pictures you name in L1 and you name them in L2. The time difference is what he took as a measure of language dominance. So, L1 if naturally will take less time in L1, so L1 is dominant.

Magiste used different kinds of tasks. He used both encoding and decoding tasks. So, encoding picture naming and digit naming are called encoding task and decoding is following direction and reading words aloud.

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Bilingual lexical organization

- Initial psychological studies in bilingualism in the 1950s also had a close association with research in human memory system.
- As a result, studies using language were often part of the larger investigation into human memory
- Within this, the separate and shared memory hypothesis were studied
- Kolers (1963:1965) word association and free recall study seemed to favour separate hypothesis.
- These two types of studies dominated bilingual memory research for some time

So, there are different kinds of tasks that they used and they found the for understanding language dominance which language is dominant depending on the reaction time, ok. Then, we move on to bilingual lexical organization. This is something that we have talked about. So, initial psychological studies within bilingualism in the 50s had a very close association with the research in human memory system within psychology. This was not happening in language; this was happening in psychology.

There was a lot of work going on, trying to understand how human memory really works, what are the different what are the functional parameters. So, that is where this connection also was built-in because language was used very often in these studies to understand human memory, words were used. So, that is why the connection became very strong.

So, studies using language because they were often part of the larger studies as a result of which this is also where bilingual lexical organization started. The studies in this domain started. And this is at the same time also, this is where we were talking about shared and separate memory hypothesis.

So, Kolers, again a very important name in this domain in the 60s. He used word association and free recall study, and they he tried to show that through this the this various kinds of studies, he showed that probably separate memory hypothesis is tenable.

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Free recall task

- List of words were presented in two conditions: single language and mixed language.
- Then the participants were asked to recall as many words as they could.
- The performance between the two conditions were checked to assess the organization of memories of the two languages.

So, free recall task of course, we have already seen what it is. So, what he did was list of words were given in single language versus mixed language. So, the one list sometimes the list was only one language, sometimes the list consisted words from both L 1 and L 2, and then participants were asked to recall as many words as they could. Now, the difference between the performance between single language versus mixed language group was taken as a measure to understand how much the organization, what is the organization.

So, if the mixed language if a mixed language does not give you a different result from single language group means there is a shared memory. If there are differences it will mean separate memory.

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Word association task

- Words in one language and their translation in another language were presented as stimulus.
- Participants were then asked to provide the first word that comes to their mind, in any one of the languages.
- For example, if the word pair is house-ghar (English Hindi) and participants answers are road-rasta Or road-khidki.
- The first is example of interlingual translation response and higher number of such responses were taken as evidence for shared hypothesis.
- Kolers (1963) found a low percentage of such responses and hence endorsed separate memory hypothesis.

Similarly, word association task also had words in one language and their translation in another language. These were used as stimulus. Now, the participants were then asked to provide the first word that comes to their mind. So, let say they had they use this kind of a thing. So, house and ghar, Hindi and English, and the participant tells us only road or sometimes they will use let say rasta that could be one possibility. Another possibility is they can give us road and khidki.

So, depending on what kind of word we get, we have we are talking about different kinds of representation. So, if we are if we get let say after hearing ghar we hear khidki; that means, this is intralingual processing that is happening. Within the same language that is happening. However, if you get house and ghar and after that you get road and rasta, this is an interlingual translation response.

If this is the case, then if this if there are higher number of such cases, then this is taken as an evidence for shared hypothesis because you can go across languages and because it is free, you could answer either in Hindi or in English or as the actual study was have taken Chinese and English participants. So, they were free to use either Chinese or English. But depending on the choice that you do and which kind of response are higher that will take us to either shared or separate memory hypothesis.

So, he found a low percentage of such responses, and hence, he endorsed separate memory hypothesis.

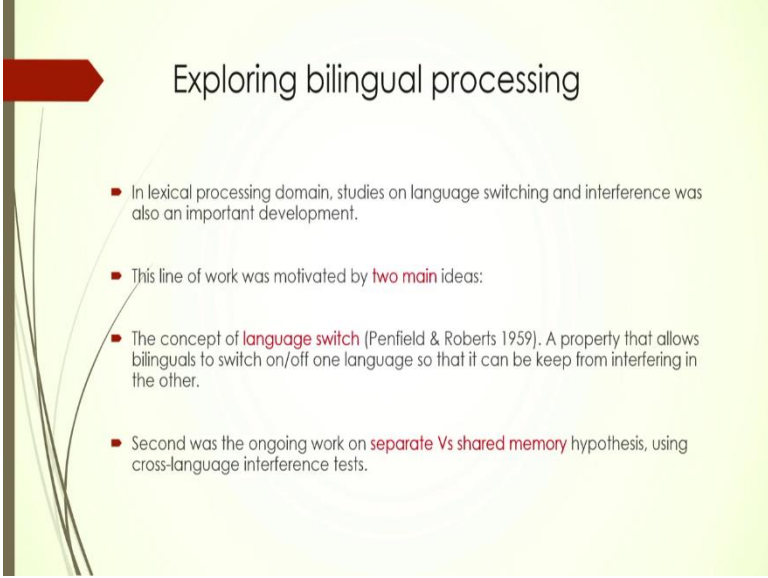
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Now, since both of these methods dependent depended on using individual words as stimulus, research on memory organization became almost similar synonymous with lexical organization. So, human memory organization and lexical organization became very closely tied together because of the stimulus that was given.

Now, gradually the difference that was brought in, separation between lexical and conceptual representation and studies started taking into account these factors again by Kolars himself. However, this study picked up pace only in the 70s. And there are some of these references that one can look up for the beginning of those studies.

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Exploring bilingual processing

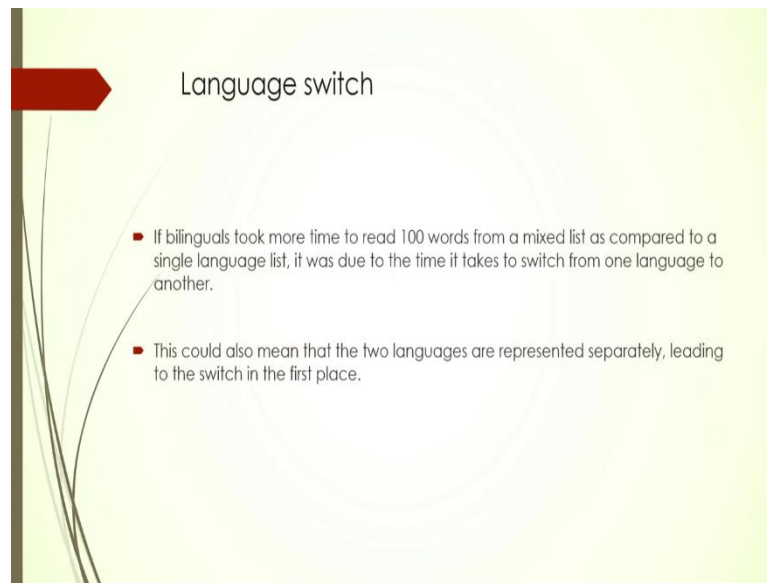
- In lexical processing domain, studies on language switching and interference was also an important development.
- This line of work was motivated by **two main** ideas:
- The concept of **language switch** (Penfield & Roberts 1959). A property that allows bilinguals to switch on/off one language so that it can be kept from interfering in the other.
- Second was the ongoing work on **separate Vs shared memory** hypothesis, using cross-language interference tests.

Similarly, there is bilingual exploring bilingual language processing. So, these are the 4 domains that were quite popular during 1950s to 70s. The reason why we have taken such a broad domain, broad time frame is because a lot of things happened within that time. However, it is not as the flood gate had not really opened, as it did after in the 90s.

So, at that time there was slow, but steady progress. There were lots of new findings. Those findings were getting solidified by more different kinds of studies and so on. So, in many sense, this was the beginning. This was the first few decades of bilingual language processing taking into account different aspects within that larger umbrella term and trying to figure out each of them separately. So, that is why this broad time frame.

So, within lexical processing domain, studies on language switching and interference was also a very important domain to study. Switching; and as you can imagine, this is switching and interference again takes us to it connects to the shared versus separate memory hypothesis. So, studies in these, there were two different types, concept of language switch and the separate and shared memory hypothesis.

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Language switch

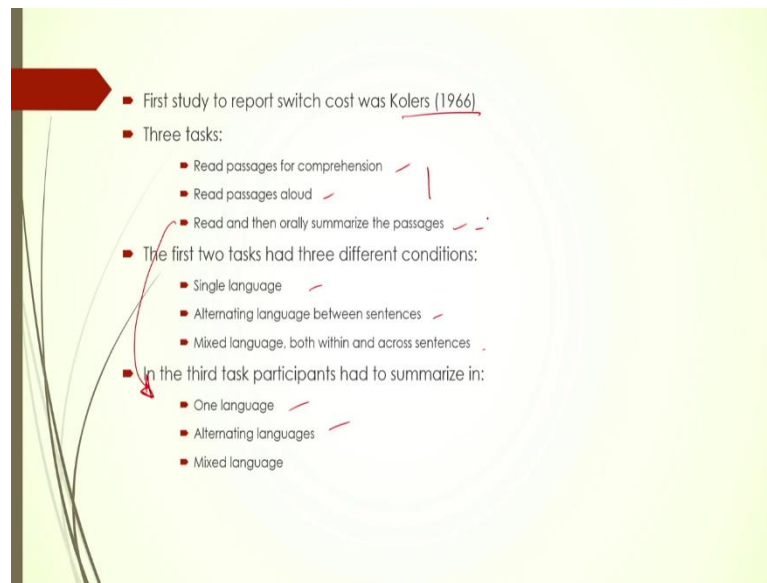
- If bilinguals took more time to read 100 words from a mixed list as compared to a single language list, it was due to the time it takes to switch from one language to another.
- This could also mean that the two languages are represented separately, leading to the switch in the first place.

The idea of language switch is very interesting one which we still study. Even today we study. So, the idea was that if bilinguals took more time to read 100 words from a mixed list as compared to a single language list, it was due to the time it took to switch, one language off. So, basically the idea was if it is a mixed language list, then reading them will make you go back and forth between language 1 and language 2.

So, when you were speaking in language 1, you have to switch off in some sense L2 or when you were speak when you are using L2, you have to switch off the L1. So, basically there has to be an on off switch sort of a thing and that is why it takes longer time. Mixed language reading takes longer time and the reason was that was given was this.

So, this could also mean that the two languages are represented separately. So, if there are two language, two lexical representations, so one when you are accessing one, you are shutting off the other and; that means, obviously, that there are two different storages. So, language switch, the idea of language switch was closely connected to separate memory hypothesis.

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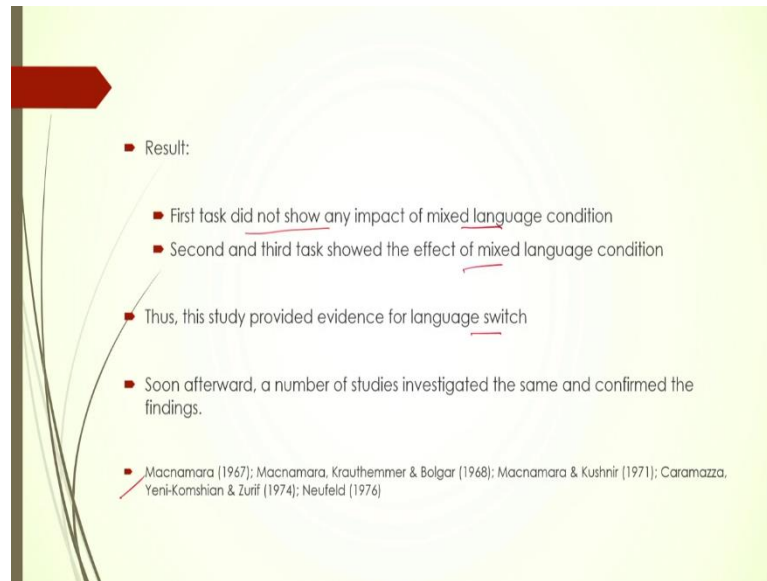


So, the first study to report switch cost was as I said Kolers, '66. They had 3 different tasks. One was read passages for comprehension, read passages aloud, read and then orally summarize the passages. So, 3 different kinds of tasks. And then the first two tasks had three different kinds of conditions. So, reading passage for comprehension in single language, in alternating language and then in mixed language.

Alternating language is a very interesting paradigm to use. So, different, one sentence in one language, second sentence in L2, third in L1, fourth in L2, like this. Alternating the language in each sentence that is one option. Another was single language, the entire passage in one language and then mixed. The mixing happened both within the sentence and across sentences.

The third task which was reading and summarizing, they had to summarize in either one language alternating or mixed language. So, these were the tasks. So, these were these two were comprehending. And this was a production study, right. So, this he did a complete set of studies here.

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- Result:
 - First task did not show any impact of mixed language condition
 - Second and third task showed the effect of mixed language condition
- Thus, this study provided evidence for language switch
- Soon afterward, a number of studies investigated the same and confirmed the findings.
- Macnamara (1967); Macnamara, Krauthammer & Bolgar (1968); Macnamara & Kushnir (1971); Caramazza, Yeni-Komshian & Zurif (1974); Neufeld (1976)

The result found that the first task did not show any impact of mixed language condition. However, the second and the third task did show some effect of mixed language condition. So, to him this provided evidence for language switch. Because mixed language is taking more time, hence the idea of switch was tenable.

So, a lot of studies followed and there are some examples here, and language switching in fact, has remained a very important domain of research within bilingual language processing. And today, we know a lot more about the processes involved which we will see later, but this is how it all began.

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Cross language interference

- In such studies the focus is to find out if performance in language A would affect the performance in language B.
- Penfield and Roberts (1959) suggested that this will not happen since the other language is 'switched off'.
- Thus, if interference is proved, it will question the idea of language switch.
- And, it will provide support for shared memory hypothesis.
- Studies in this domain usually use within language and between language tasks. (this has been discussed before. Hence not detailing here)

Another way of looking at the same question was cross language interference. In such studies, the focus is to find out if performance in language A would affect performance in language B. If there is a connection between these two, then there is of course; that means, there is an interference. And if there is an interference that will mean that there is some amount of shared memory between these two languages.

Again, a very important study in 1959, suggested that this will not happen since the other language is switched off. So, if the switching and the idea of language switch is tenable; that means, one language its possible to switch off your L1 while you are using L2 or the other way around, if that is the case then there will be no interference, right. However, if interference is proved; that means, switching is not tenable. So, that was the idea.

And so, what this they do is the studies in this domain usually use both within language and between language task which we have already seen in various kinds, various studies that have used this. And we already have seen the results.

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1980s

- From the beginning of this decade, hierarchical models of distinct lexical and conceptual representations were popular.
- an important symposium in 1981, focused on how the different types of surface form, like picture Vs words; L1 words Vs L2 words are connected to the underlying shared conceptual system
- Five studies were presented in this symposium and then they appeared in the 1984 issue of Journal of Verbal learning and verbal behaviour.
- Two of these went on to become torch-bearers of sort for future studies.
- These are:
 - Potter et al 1984 & Scarborough, Gerard & Cortese 1984.

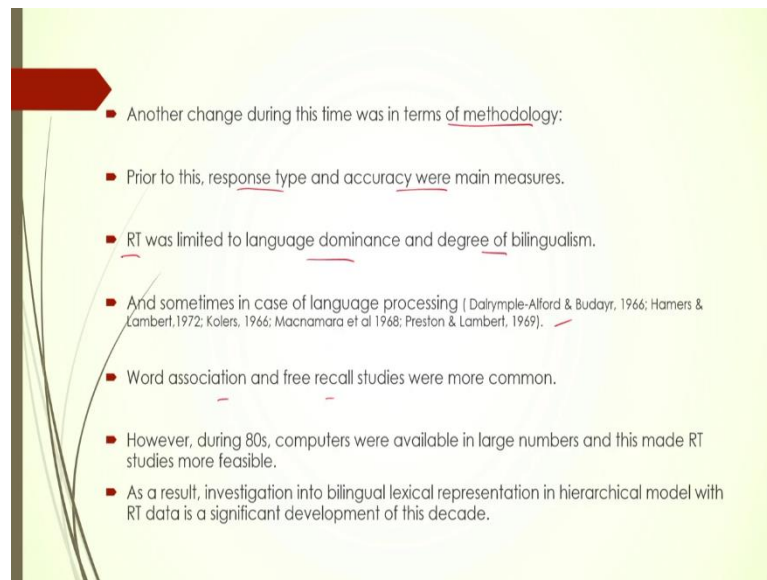
So, various, both shared and separate memory hypothesis were actually found to be tenable and that is how we came to know that there are two layers and two levels of representation in the brain, lexical and conceptual. And hence, there are the and that is how the hierarchical models came into being.

Then 1980s, we will talk about only this decade and then 90s also as one decade at a time. So, the beginning of this decade hierarchical models became popular as we have just said that depending on the finding from the previous decade new models came into existence with the starting with lexical various kinds of hierarchical models.

There was a very notable symposium that took place in 1981 in New York. So, they were trying to focus on how the different kinds of surface form like picture, word, L1-L2 difference and so on are connected to the underlying conceptual system. Just as we were mentioning. Are they tenable, are they accessing the separate kinds of representation, or are they accessing same or representation at the conceptual level and so on.

And these studies were published in 1984 issue of verbal learning and verbal behavior. And these two studies as we have seen before are the landmark studies by one is Potter et al and 1984 and Scarborough et al, 1984.

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So, this is how this basically opened a Pandora's box in this domain of understanding shared versus separate memory hypothesis. Another change that happened during this time was in terms of methodology. Now, prior to this time, response type and latency, and accuracy were the main measures. However, the response time was limited in terms of only language dominance and degree of bilingualism as we have seen before, because it was not very widely used across different kinds of research questions or designs.

So, only few cases this was used as I consider the references. So, more important was word association and free recall studies at that time, before 1980s. However, 1980s something changed which is computers became largely available, it became quite common to use computers for experimental work.

And as a result, reaction time studies became more feasible which is understandable. Because today we have different kinds of softwares available, so we can actually create very different kinds of quite nuanced and complex designs. Similarly, the major change that happened in 1980s was the use of computers or let's say widespread use of computers, and hence reaction time studies became quite popular.

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1990s

- This decade saw a rapid growth of research on lexical representation and processing in bilinguals.
- A number of state of the art reviews came out highlighting the progress made thus far and providing in depth analysis of various issues at hand. (de Groot & Kroll 1997; Harris 1992; Schreuder & Weltens 1993).
- Two main journals of the field started during this decade. These are: Bilingualism: language and cognition (1998) and International Journal of Bilingualism (1997).
- These are journals dedicated to psycholinguistic studies on bilingualism

So, in the next segment, we will talk about the changes that happened in 1990s and then move on to the 2000s and the kind of changes and more sophistication that was built into these studies and where we are today.