

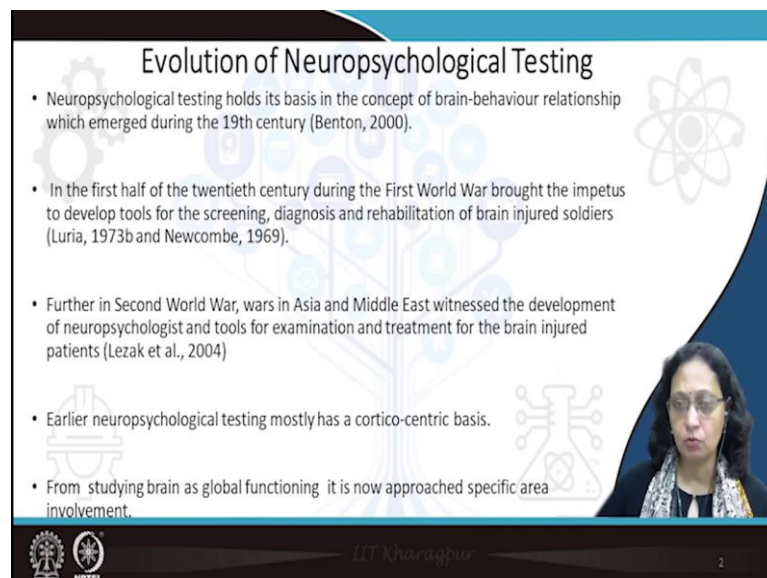
Cognition and its Computation
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Lecture - 06
Neuropsychological Testing

Hello and welcome. Today, we are going to talk about Neuropsychological Testing and Cognitive Testing. Are they different? Are they the same? So, we are going to divide this into two parts. First we are going to talk about standard neuropsychological tests, what they do, what how do they help in understanding certain aspects of the individual, how what do we do in research with neuropsychological tools.

And, then we will talk a little about a few neuropsychological tests, name a few neuropsychological tests and then we will move into some cognitive tests specific cognitive test. We will try and see how they are related to different parts of the how they can be localized to different areas of the brain and thereafter we will discuss one or two particular cognitive tests.

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Evolution of Neuropsychological Testing

- Neuropsychological testing holds its basis in the concept of brain-behaviour relationship which emerged during the 19th century (Benton, 2000).
- In the first half of the twentieth century during the First World War brought the impetus to develop tools for the screening, diagnosis and rehabilitation of brain injured soldiers (Luria, 1973b and Newcombe, 1969).
- Further in Second World War, wars in Asia and Middle East witnessed the development of neuropsychologist and tools for examination and treatment for the brain injured patients (Lezak et al., 2004)
- Earlier neuropsychological testing mostly has a cortico-centric basis.
- From studying brain as global functioning it is now approached specific area involvement.

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So, first and foremost, so, what is neuropsychological testing? So, neuropsychological and testing is primarily derived from the term neurology and psychology. So, actually these were earlier known as brain based testing. So, what does that mean? So, we are

trying to identify the functioning areas, the anatomical areas that are related to certain cognitive functions.

So, neuropsychological test started with you know earlier as early as 19th century during World War I when the screening test became very important for selecting individuals for World War I. And, the primary focus of the screening tests was for the to assess information processing ability these were at that you know point of time known more as intelligence tests.

And, in the Second World War from then on we actually see that the it also brought in the neuropsychological tests emerged because of brain injuries due to the war. And, neuropsychological or neurocognitive test battery is developed for screening and diagnosis and rehabilitation of brain injured patients.

So, Luria Alexander Luria from Russia had a vast number of patients and experiences that helped him to develop to work in this area and he is still credited for many of the tests that have you know that have emerged in the neuropsychological test battery of Luria Nebraska.

So, in during the Second World War especially in wars with wars in Asia and the Middle East we witnessed the development of the neuropsychologist and more tools of examination and treatment for brain injury patients. So, with also the advancements in brain imaging techniques and neurophysiology, we got to understand the brain areas better. And, so, definitely the test became more the neuropsychological testing also became more refined.

Earlier neuropsychological testing had a cortico-centric basis. This is because earlier lesser information was available about our brain and about the brain mechanisms, and our knowledge was restricted to inferences about brain behavior relationships from cortical damage of patients. So, patients with brain pathology were tested on cognitive tasks and the test results were correlated with the site of the cortical lesion.

So, patients with sub-cortical pathology many times demonstrated disturbances in movement. When these movement problems emerged and was also accompanied by cognitive deficits it was assumed that the cognitive impairment was a manifestation of the cortical deafferentation.

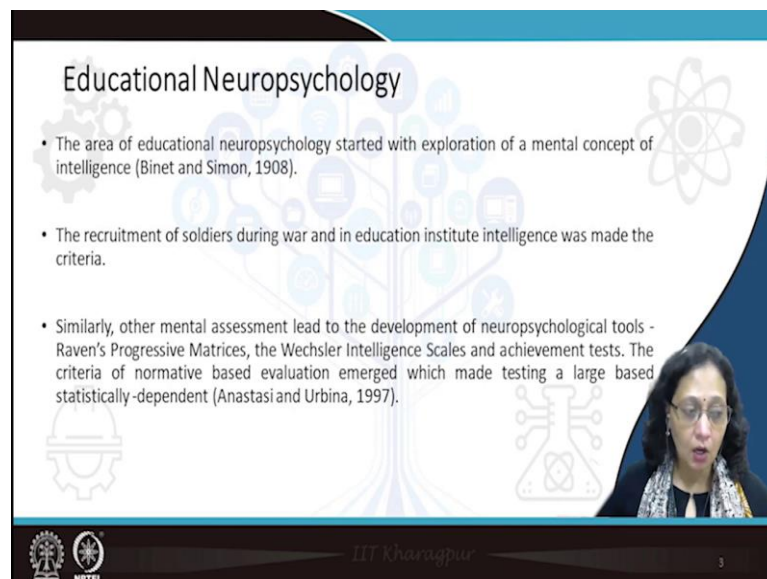
Now, definitely we have come a long way from that and now, again as I said you know with the advancement of the brain imaging techniques we have a better understanding of the neuro-anatomical areas and we do not the, we know more about the localized areas that are responsible for functioning for a certain function.

But, I must say that the despite the criticisms of anatomists and neuroanatomists specifically regarding about these neuropsychological tests, the earlier neuropsychological tests definitely had a value. The it told us it the global functional approach told us or informed let us know further about the areas that might be involved in a kind of in a particular neuropsychological, right in a psychological functioning or in a cognitive function.

So, it is all the work done in earlier in your psychology earlier has not gone to waste. But, now as I said we are fine tuning it and we have also understood that when we are trying to understand a cognitive function if you are trying to anatomically route it to a specific area it is not so. So the there are multiple areas within the brain behavior system that are integrated for a cognitive function.

This is a very important piece of information for all of us to remember and I shall revisit this statement as we progressed through this session.

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Educational Neuropsychology

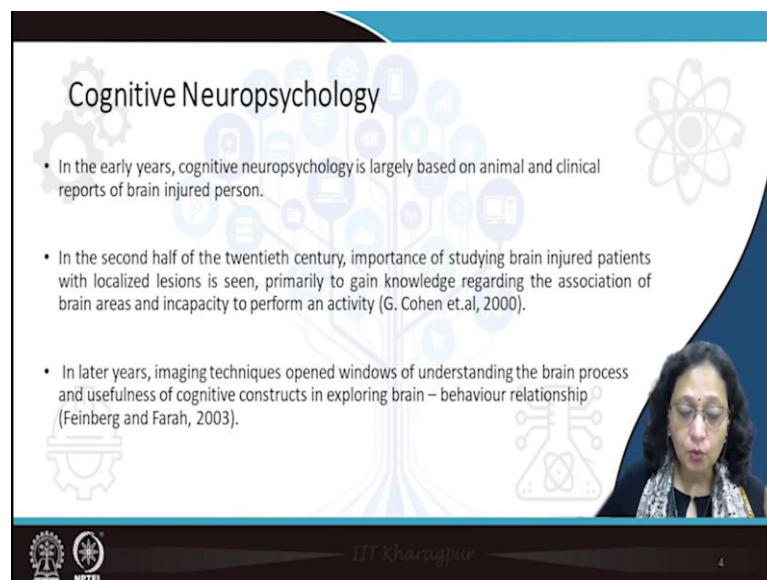
- The area of educational neuropsychology started with exploration of a mental concept of intelligence (Binet and Simon, 1908).
- The recruitment of soldiers during war and in education institute intelligence was made the criteria.
- Similarly, other mental assessment lead to the development of neuropsychological tools - Raven's Progressive Matrices, the Wechsler Intelligence Scales and achievement tests. The criteria of normative based evaluation emerged which made testing a large based statistically -dependent (Anastasi and Urbina, 1997).

The slide features a background with faint icons of a gear, a brain, and a tree. A video inset in the bottom right corner shows a woman with glasses speaking. The footer includes the IIT Kharagpur logo and the text 'IIT Kharagpur'.

So, before we move on further about neuropsychological testing let us understand the different branches of neuropsychology. So, it starts with educational neuropsychology which developed with an exploration of mental concepts of intelligence with Binet-Simon's test of intelligence and screening of intelligence was made and especially when screening of intelligence was made in essential practice in for the recruitment of soldiers as I mentioned during wars and in educational institutes.

So, from group test of intelligence, psychology shifted to individual test of intelligence. For both screening people who had lower information capacity information processing ability as well as move to the higher end of the curve so, for people with to assess people with higher intelligence or superior intelligence.

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The slide is titled "Cognitive Neuropsychology" and features a background with various icons related to psychology and neuroscience, such as gears, a brain, and a tree. The text on the slide is as follows:

- In the early years, cognitive neuropsychology is largely based on animal and clinical reports of brain injured person.
- In the second half of the twentieth century, importance of studying brain injured patients with localized lesions is seen, primarily to gain knowledge regarding the association of brain areas and incapacity to perform an activity (G. Cohen et.al, 2000).
- In later years, imaging techniques opened windows of understanding the brain process and usefulness of cognitive constructs in exploring brain – behaviour relationship (Feinberg and Farah, 2003).

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Cognitive and clinical neuropsychology's focus was primarily on understanding the brain mechanisms of lower animals and clinical reports of brain injured patients. In the second half of the twentieth century, again with advanced techniques of understanding the brain, the focus of cognitive and clinical neuropsychology has been on it is localized lesions that is to gain knowledge regarding the association of brain areas and incapacity to perform an activity.

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Child Neuropsychology

- Child neuropsychology has been developing which focuses on understanding mental retardation, learning disabilities and child's behavior problem.
- The importance of child neuropsychology is also in understanding the behavioral and cognitive deficits in adults.

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In relationship to this is the next branch of psychology in neuropsychology that is child neuropsychology which deals with pathologies in brain behavior mechanisms in children. And, primarily focuses on retardation, specific learning disabilities, attention deficit and other childhood behavior problems.

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Forensic Neuropsychology

- In legal proceeding neuropsychological assessment is required to give judgment regarding whether the claimant has undergone brain injury. Due to brain injury the type and amount of behavioural impairment sustained. The claimant's rehabilitation potential and future requirements are to be specified by the neuropsychologist.
- In criminal cases, the defendant is to be assessed neuropsychologically to validate the latter was not in the mental capacity to stand a trial or his/her's brain damage is the cause of his misconduct.
- The murderer of President Kennedy was judged by psychologist as having impaired self-control and judgement (J.Kaplan and Waltz, 1965).
- Limitations – Use of neuropsychological assessments in court of law have been criticized for malingering of symptoms and exaggerations. In addressing the issue many tests have been devised to combat these limitations.

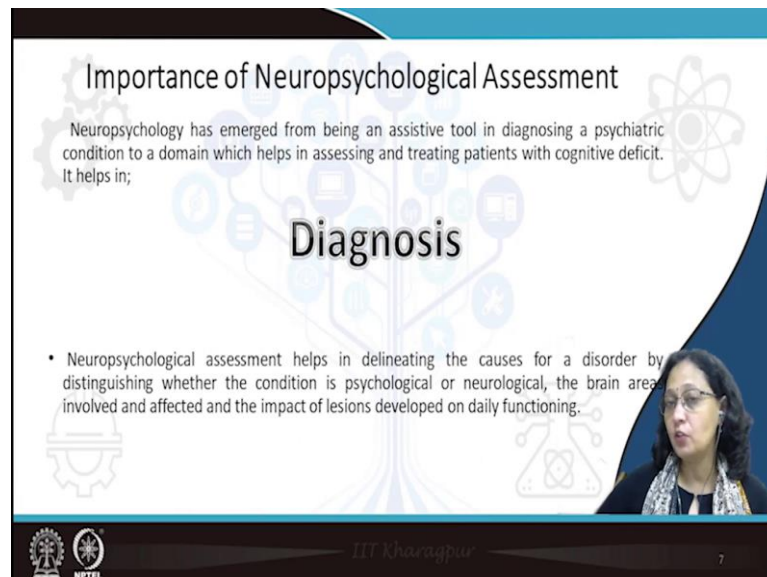
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Forensic neuropsychology is another branch of neuropsychology that is more from a legal perspective and the approach is to especially using neuropsychologists in cases to

identify in the court to identify whether the defendant is capable of or has the mental capacity to stand a trial.

Sometimes the profiling the neuropsychological profiling of murderers of addictions are also done and in fact, the murderer of President Kennedy was judged by a psychologist to have impaired self control and judgment. At that time it was not known as a branch of forensic neuropsychology per se, but again you know this branch of neuropsychology has gained maximum criticism because it has also shown that there is a lot of malingering of symptoms and exaggerations to bypass the law.

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Importance of Neuropsychological Assessment

Neuropsychology has emerged from being an assistive tool in diagnosing a psychiatric condition to a domain which helps in assessing and treating patients with cognitive deficit. It helps in;

Diagnosis

- Neuropsychological assessment helps in delineating the causes for a disorder by distinguishing whether the condition is psychological or neurological, the brain areas involved and affected and the impact of lesions developed on daily functioning.

The slide features a background with a stylized tree of icons representing various cognitive and psychological functions. A small inset video shows a woman speaking. Logos for IIT Kharagpur and NPTEL are visible at the bottom.

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Slide 8 features a blue and white background with a central graphic of a tree-like structure composed of various icons representing cognitive functions. The slide contains three bullet points:

- It helps in understanding whether the disorder is a manifestation (Ingraham and Aiken, 1996) or the consequence of brain impairment (Gorp, Baerwald, Ferrando et.al., 1996)
- Screening to elucidate the brain injury and to find out person in risk for a disorder
- Limitations - In disorders like toxic encephalopathy, Alzheimer's disease and other dementia related like disorders the organic deficits are not clearly or could be demarcated as inability to perform is not necessarily related to lesions because even organic deficit occurs an individual carries on an activity.

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So, role of neuropsychological tests; the primary role is diagnosis. So, it does not specifically diagnose an individual with a brain issue, a brain issue be it a lesion or a some kind of other pathology.

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Slide 9 features a blue and white background with a central graphic of a tree-like structure composed of various icons representing cognitive functions. The slide has a title "Patient care and Planning" and three bullet points:

Patient care and Planning

- Patients are referred for neuropsychological assessment to gain information about their cognitive status, behavioural alterations, and personality characteristics to adjust to their present condition.
- Precise understanding of a person's debilitating condition can help in careful management of many neurological disorders. This helps in rational planning with capabilities and limitations of the person undergoing treatment
- Repeated neuropsychological examinations at regular intervals provides reliable indicator of whether the underlying condition is alleviating or aggravating and at what rate (Salmon, Heindel, and Lange, 1999). This is evident in situation of cognitive training (Parente and Anderson, 1984), deficits in attention (Freides, 1985).

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Treatment planning and remediation

- Rehabilitation programs are tailored according to patients's neuropsychological assessment that should be sensitive, broad-gauges and accurate (Allain et al., 1985)
- Rehabilitation of neuropsychological condition involves multi-disciplinary approach to treat the same problem from different specialties.

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But, it also assists the clinician in this case a medical professional to guide his patient care and treatment planning for medication programs.

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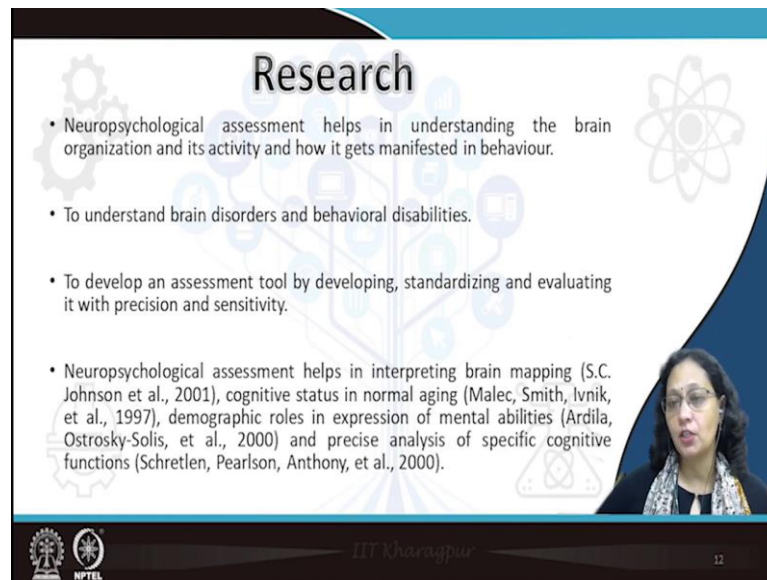
Treatment evaluation

It helps in evaluating surgical procedures (B.D. Bell and Davies , 1998), brain stimulation (Moretti et al., 2002a), drug efficacy in (Meador, Loring, Hulihan, et al., 2003) HIV (Llorente, van Gorp, et al., 2001), seizure control (Kelland and Lewis, 1996), attentional deficit disorder (Riordan, Flasham, Saykin et al., 1999), multiple sclerosis (Fischer, Priore, et al., 2000) and psychiatric disorders.

The slide features a background with a stylized tree of icons representing various fields like engineering, medicine, and psychology. At the bottom, there are logos for IIT Kharagpur and NPTEL, and a small video inset of a woman speaking.

So, this it another major part of neuropsychological testing is treatment evaluation. So, after many brain operations surgical interventions it is seen that neuropsychological tests are done or given to see if cognitive functionality is lost due to the surgical intervention.

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Research

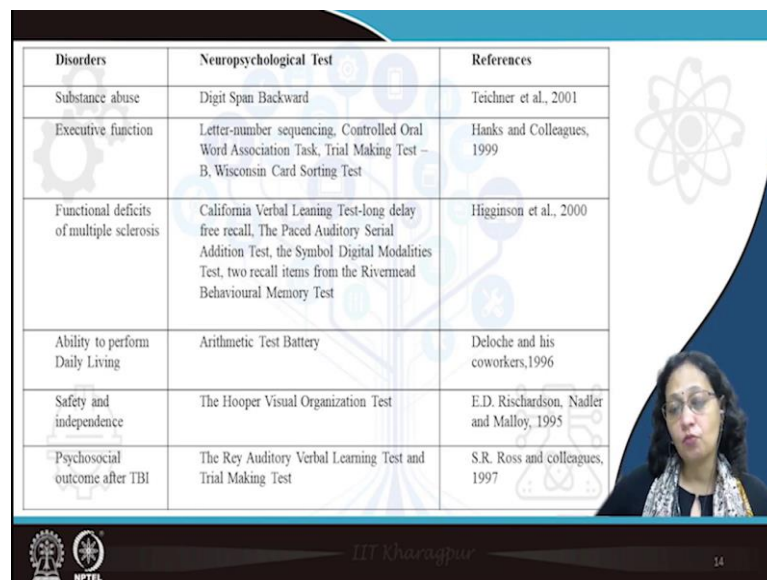
- Neuropsychological assessment helps in understanding the brain organization and its activity and how it gets manifested in behaviour.
- To understand brain disorders and behavioral disabilities.
- To develop an assessment tool by developing, standardizing and evaluating it with precision and sensitivity.
- Neuropsychological assessment helps in interpreting brain mapping (S.C. Johnson et al., 2001), cognitive status in normal aging (Malec, Smith, Ivnik, et al., 1997), demographic roles in expression of mental abilities (Ardila, Ostrosky-Solis, et al., 2000) and precise analysis of specific cognitive functions (Schretlen, Pearlson, Anthony, et al., 2000).

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Looking at research in neuropsychology, the primary focus is on understanding the brain organization and its activity. And, and how it gets manifested in behavior.

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Disorders	Neuropsychological Test	References
Substance abuse	Digit Span Backward	Teichner et al., 2001
Executive function	Letter-number sequencing, Controlled Oral Word Association Task, Trial Making Test – B, Wisconsin Card Sorting Test	Hanks and Colleagues, 1999
Functional deficits of multiple sclerosis	California Verbal Learning Test-long delay free recall, The Paced Auditory Serial Addition Test, the Symbol Digital Modalities Test, two recall items from the Rivermead Behavioural Memory Test	Higginson et al., 2000
Ability to perform Daily Living	Arithmetic Test Battery	Deloche and his coworkers, 1996
Safety and independence	The Hooper Visual Organization Test	E.D. Rischardson, Nadler and Malloy, 1995
Psychosocial outcome after TBI	The Rey Auditory Verbal Learning Test and Trial Making Test	S.R. Ross and colleagues, 1997

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And to understand the brain disorders behind behavioral disabilities and map as I have mentioned earlier map anatomical areas to different cognitive function. So, to talk about some of the common neuropsychological tests, if we look at when we talk of neuropsychological tests the first thing we talk of is executive functioning.

And some of the tests that are used to screen or to identify to assess executive functioning would be letter number sequencing, controlled oral word association task, trial making etcetera. We will talk about 3 such tests later. So, I am not getting into the details.

So, ability to perform daily living, and safety and independence, then substance abuse – so, many times digits span forward is a technique that is used specifically for checking out the processing ability in substance abuse. It is not mind you, there are several other tests that could be used as a you know to see if an individual is suffering from substance abuse, but this what we are trying to see is the information processing ability.

Now, the for TBI or Traumatic Brain Injury for an aftermath of traumatic brain injury, some neuropsychological tests that are used are RAVLT or Rays Auditory Verbal Learning Tests and trail making test.

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How is Cognitive testing different from neuropsychological testing? Or is it different at all?

- Cognitive testing is the primary way to establish severity of cognitive impairment and is therefore a necessary component in a neuropsychological assessment
- Clinical interviews alone are not sufficient to establish the severity of cognitive impairments, for two reasons:
 - patients are known to be poor reporters of their own cognitive functioning (Edmonds et al., 2014; Farias et al., 2005; Moritz et al., 2004; Schacter, 1990), and
 - clinicians relying solely on clinical interviews in the absence of neuropsychological test results are known to be poor judges of patients' cognitive functioning (Moritz et al., 2004).

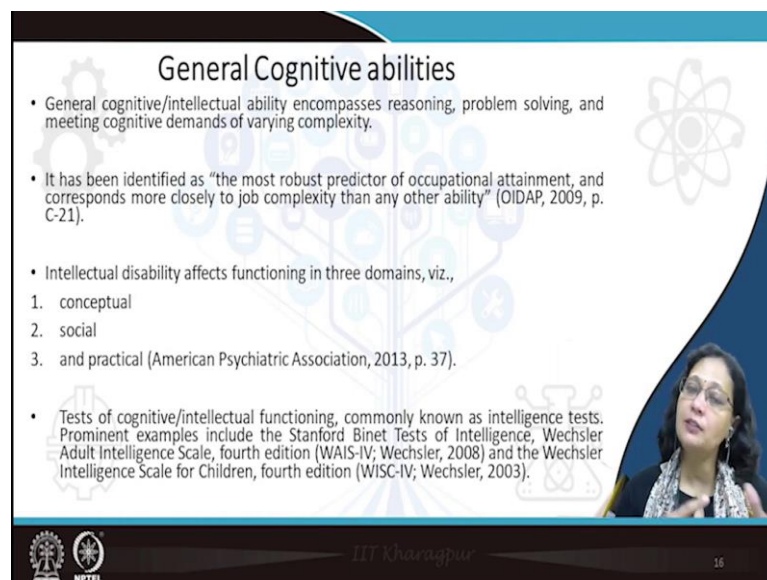
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So, here many of you as I am talking about these tests you might be wondering that well I have heard about these as cognitive tests and now here she is speaking about them as neuropsychological tests, what is the difference? Now, are cognitive tests different from neuropsychological testing or are they the same? So, cognitive testing is the primary way to establish severity of cognitive impairment and is therefore, a necessary component in a neuropsychological assessment.

Neuropsychological assessment would also involve clinical interviews, but along with some cognitive tests. So, one of the reasons why we have these cognitive tests in a neuropsychological assessment tool is because patients are known more often than not to be poor reporters of their own cognitive functioning.

And, if we rely specifically on clinical interviews we are not able to quantitatively mark you know individuals on a long term based on a longitudinal basis. So, that is why there are several neuropsychological tests that I use. MMSC is mostly neuropsychological testing is also used I should say frequently used for the geriatric population especially when we are looking at dementia and MCI as well as Mild Cognitive Impairment or Alzheimer's disease.

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General Cognitive abilities

- General cognitive/intellectual ability encompasses reasoning, problem solving, and meeting cognitive demands of varying complexity.
- It has been identified as “the most robust predictor of occupational attainment, and corresponds more closely to job complexity than any other ability” (OIDAP, 2009, p. C-21).
- Intellectual disability affects functioning in three domains, viz.,
 1. conceptual
 2. social
 3. and practical (American Psychiatric Association, 2013, p. 37).
- Tests of cognitive/intellectual functioning, commonly known as intelligence tests. Prominent examples include the Stanford Binet Tests of Intelligence, Wechsler Adult Intelligence Scale, fourth edition (WAIS-IV; Wechsler, 2008) and the Wechsler Intelligence Scale for Children, fourth edition (WISC-IV; Wechsler, 2003).

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And, here some of the primary tests that I used are MMSC – Mini Mental Status Examination along with that one of the tests that are used independently are the clock drawing test and I have already spoken about the trail making test. Now, when we now when we are talking of cognitive testing, I will be mentioning a couple of tests here and we will start with general cognitive abilities.

So, a general cognitive or intellectual ability encompasses reasoning, problem solving and meeting cognitive demands of various complexity. And, these have been identified as the most robust predictor of occupational attainment and keeping a job than any other

ability. Now, intellectual when we talk of intellectual disability it affects functioning in 3 domains.

So, one is a conceptual domain. So, a conceptual domain would include memory, language, reading, writing, maths and majorly knowledge acquisition. So, these this is more of the learning paradigm. The social domain, so, that is in interactions and interpersonal skills, empathy, social judgment, friendship abilities and practical judgment or the practical domain. So, that is more of self management in areas of personal care, job responsibilities so, in the occupational setup and in the individual setup.

Now, if you just think about this a little this is this seems very very close to Sternberg's theory of intelligence and actually you know tests of cognitive and intellectual functioning are you know trying to earlier it would try and only look at the conceptual aspects.

But, now it is trying to see whether the individual is able to relate to others, able to adapt himself or herself to a new environment and adopt the environment as well and how practical, how pragmatic the individual is in daily living. So, as you will if you look through the intelligence tests over time, you will see these changes. So, theoretical changes have been accompanied by changes also in the tools so, assessment tools.

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The slide features a white background with a blue header and footer. The title 'Wechsler Adult Intelligence Scale (WAIS)' is centered at the top. Below the title, there are two bullet points. The first bullet point defines intelligence as 'The global capacity of a person to act purposefully, to think rationally, and to deal effectively with his/her environment.' The second bullet point states that the original WAIS (Form I) was published in February 1955 by David Wechsler, as a revision of the Wechsler-Bellevue Intelligence Scale, and that the fourth edition (WAIS-IV) was released in 2008 by Pearson. The slide is decorated with faint icons of a gear, a tree, a lightbulb, and a circuit board. In the bottom right corner, there is a small video inset showing a woman with glasses speaking. The footer contains the IIT Kharagpur logo and the NPTEL logo on the left, and the text 'IIT Kharagpur' and the number '17' on the right.

Wechsler Adult Intelligence Scale (WAIS)

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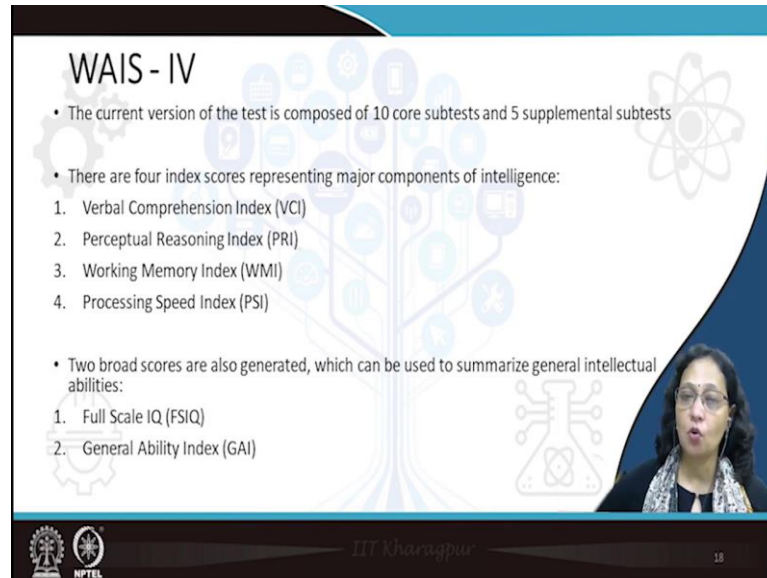
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So, the prominent or I should say the classical intelligence tests as we all know are Stanford – Binet test of intelligence, the Wechsler Adult Intelligence Scale and we can also talk about the Wechsler Intelligence Scale for children.

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WAIS - IV

- The current version of the test is composed of 10 core subtests and 5 supplemental subtests
- There are four index scores representing major components of intelligence:
 1. Verbal Comprehension Index (VCI)
 2. Perceptual Reasoning Index (PRI)
 3. Working Memory Index (WMI)
 4. Processing Speed Index (PSI)
- Two broad scores are also generated, which can be used to summarize general intellectual abilities:
 1. Full Scale IQ (FSIQ)
 2. General Ability Index (GAI)

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So, the WAIS or the Wechsler Adult Intelligence Scale was published first in 1955 by David Wechsler and this and the current version of WAIS-IV was released in 2008. The WAIS-IV just to talk a little very briefly about WAIS-IV WAIS-IV which was released in 2008 composed of was composed of 10 subtests, 10 core subtests and 5 supplementary sub tests and, the with the 10 core sub tests comprising the Full Scale IQ.

So, the so what are these indices and scales? So, the 4 index scores representing the major components of intelligence are in WAIS are WAIS-IV are verbal comprehension index or VCI, Perceptual Reasoning Index, Working Memory Index, Processing Speed Index. And, along with these two broad scores are also generated, which can be used to summarize general intellectual abilities.

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Verbal Comprehension Index	Perceptual Reasoning Index
Similarities	Block Design
Vocabulary	Matrix Reasoning
Information	Visual Puzzles
Comprehension [Supplemental]	Picture Completion [Supplemental]
	Figure Weights [Supplemental]

Working Memory Index	Processing Speed Index
Digit span	Symbol Search
Arithmetic	Coding
Letter-Number Sequencing [Supplemental]	Cancellation [Supplemental]

WAIS gives a full scale IQ based on the total combined performance of the verbal comprehension index, the perceptual reasoning index, the working memory index and the processing speed index. It also has something called the general ability index based on the 6 sub tests that comprise the verbal comprehension index and the perceptual reasoning index.

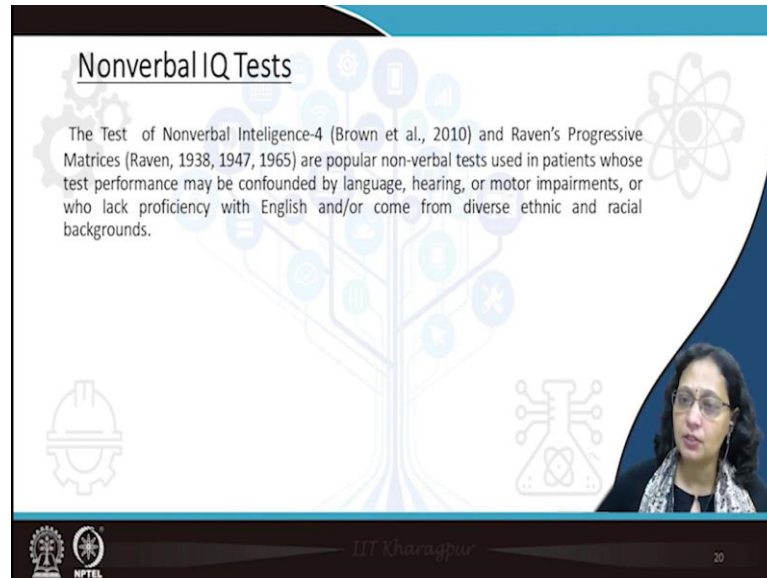
So, what are these sub tests? In the verbal comprehension index the 4 subtests are similarities, vocabulary, information and comprehension. The perceptual reasoning index comprises of 5 sub tests. They are block design, matrix reasoning, visual puzzles, picture completion, figure weights. As you can see that there is no verbal association in these tests, so, it is more of non verbal performance and the working memory index is obtained from 3 tests.

So, they are digit span, arithmetic problems and letter number sequencing. So, when I was talking about neuropsychological tests and assessment tools these are so some of these tests have been incorporated into neuropsychological test batteries to make it more comprehensive, to understand specific brain areas that may be damaged or may be dysfunctional due to some lesion or you know some other pathology.

So, coming back to this again, the processing speed index includes 3 tests that is symbol search, coding and cancellation. Again these are more related to the visual modality and it does not have any language usage. So, some neuropsychologists use specific sub tests

as I was mentioning right now in order to get an idea of the extent of brain damage. So, digit span we saw can be used for attentional difficulties as well as if you are trying to look at the substance abuse.

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Nonverbal IQ Tests

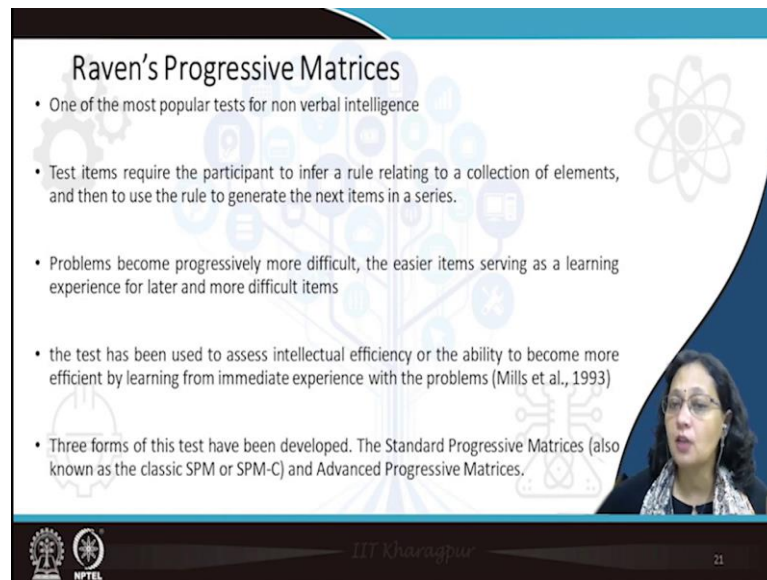
The Test of Nonverbal Intelligence-4 (Brown et al., 2010) and Raven's Progressive Matrices (Raven, 1938, 1947, 1965) are popular non-verbal tests used in patients whose test performance may be confounded by language, hearing, or motor impairments, or who lack proficiency with English and/or come from diverse ethnic and racial backgrounds.

The slide features a background with a stylized tree of icons representing various cognitive functions. A video inset in the bottom right corner shows a woman speaking. The bottom of the slide includes the IIT Kharagpur logo and the NPTEL logo, along with the text 'IIT Kharagpur' and the number '20'.

So, it what we are trying to get that is a an information processing ability based on a the performance as well as the processing speed. We can come back to this a little later. So, as WAIS is developed for the average non-injured individual separate norms were also developed for appropriate comparison with similar functioning individuals.

Now, there are some other nonverbal IQ tests that are majorly of use and one of them is the test of nonverbal intelligence which is as of now the fourth version is being used. This was given by Brown et al., in 2010.

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Raven's Progressive Matrices

- One of the most popular tests for non verbal intelligence
- Test items require the participant to infer a rule relating to a collection of elements, and then to use the rule to generate the next items in a series.
- Problems become progressively more difficult, the easier items serving as a learning experience for later and more difficult items
- the test has been used to assess intellectual efficiency or the ability to become more efficient by learning from immediate experience with the problems (Mills et al., 1993)
- Three forms of this test have been developed. The Standard Progressive Matrices (also known as the classic SPM or SPM-C) and Advanced Progressive Matrices.

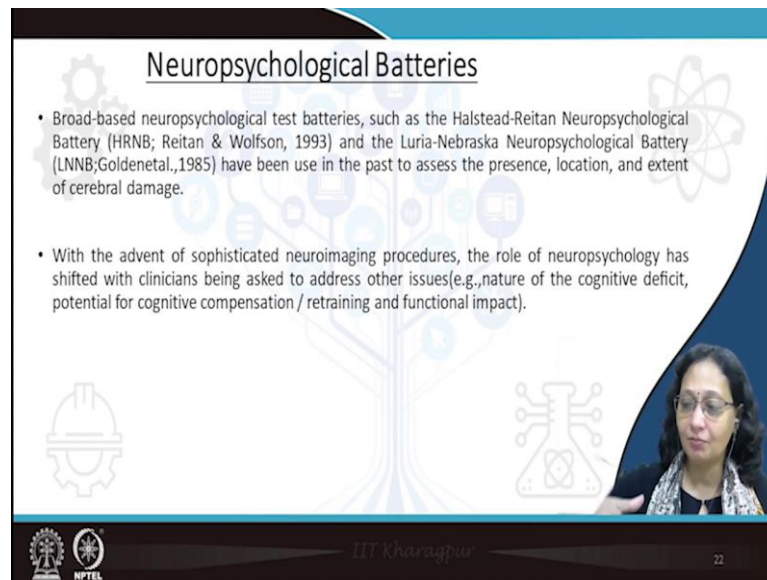
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And, again a very popular intelligence test which is actually a test of inductive reasoning is Raven's progressive matrices and these, these 2 tests are culture free. There are along with this there are multiple other culture free or culture fair tests that are in use where language is not a barrier to you know or is not seen as a limitation in intellectual functioning because this was one of the criticisms of most of the verbal test of intelligence.

The RPM is has test items that would require the participant to infer a rule relating to a collection of elements. So, it is like matching and so, matching a reasoning sequence and identifying which would be the next one in the sequence in the series. So, the problems become progressively difficult and the easier items of the test serve as a learning experience for the difficult items.

So, what it tries to check is how efficient the learning is from immediate experience with similar problems. The test is a popular measure of conceptual ability because responses require neither verbalization nor any skilled manipulative ability nor any subtle differentiation between visual spatial information.

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Neuropsychological Batteries

- Broad-based neuropsychological test batteries, such as the Halstead-Reitan Neuropsychological Battery (HRNB; Reitan & Wolfson, 1993) and the Luria-Nebraska Neuropsychological Battery (LNNB; Golden et al., 1985) have been used in the past to assess the presence, location, and extent of cerebral damage.
- With the advent of sophisticated neuroimaging procedures, the role of neuropsychology has shifted with clinicians being asked to address other issues (e.g., nature of the cognitive deficit, potential for cognitive compensation / retraining and functional impact).

The slide features a blue and white color scheme with decorative icons of gears, a brain, and a tree. A small video inset in the bottom right corner shows a woman with glasses speaking. The footer includes the IIT Kharagpur logo and the NPTEL logo.

So, if somebody has a deficit in any of these areas he would still be able to function without any limitation without any restriction in RPM. The verbal instruction is also kept at a minimum. There are 3 forms of this test. The first is the standard progressive matrices or SPM it is also known as SPMC and the advanced progressive matrices.

I spoke about neuropsychological batteries earlier and there are broad based neuropsychological batteries such as the Halstead-Reitan neuropsychological battery or it is also known as HRNB by Reitan and Wolfson in 1993 and the Luria Nebraska neuropsychological battery, you can look it up.

And, these have been used to assess the presence, location and extent of cerebral damage. And, with the advance this was more used earlier and with the advent of an advancement of the neuroimaging procedures the role of neuropsychologic has shifted now where clinicians are being asked to address other issues that is not what the deficit is, but the nature of the cognitive deficit.

Potential of the deficit and the cognitive compensation that is required or that is present and retraining what so what would help for you know with training what would improve with training. And, the one of here you know the flavor of interdisciplinary sciences is visible where you know computational techniques are very very relevant in identifying you know hierarchical designation of your psychological tests which would be relevant.

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The Cognitive Assessment System (CAS)

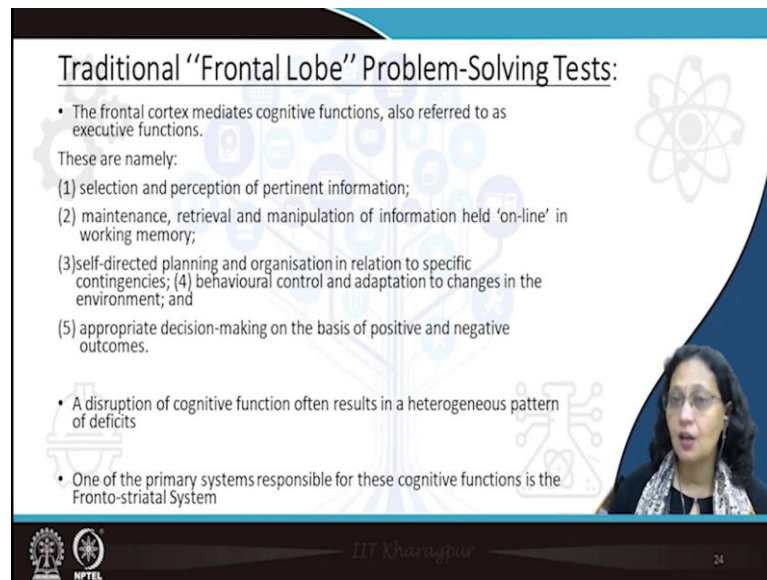
- Designed to assess cognitive processes in children and adolescents (Naglieri & Das, 1997).
- The CAS is based on the PASS theory of cognitive processing (i.e., Planning, Attention, Simultaneous, and Successive)

The slide features a background with a stylized tree of icons representing cognitive functions. In the bottom right corner, there is a small video inset of a woman speaking. The footer includes the IIT Kharagpur logo and the NPTEL logo, along with the text 'IIT Kharagpur' and the number '23'.

There is something called the ablation method through which we can understand that which test is more relevant for a particular or which sense test is more sensitive in for a particular stage of say dementia. The cognitive talking about neuropsychological test batteries we have multiple neuropsychological test batteries. In India, we have the NIMHANS cognitive battery, we have the PGI this battery.

And, one of the prominent ones is the cognitive assessment system or the CAS. It was designed to assess cognitive processes in children and adolescents. This was done by Das and Naglieri in 1997 and the CAS is or the cognitive assessment system is based on the PASS theory of cognitive processing.

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Traditional “Frontal Lobe” Problem-Solving Tests:

- The frontal cortex mediates cognitive functions, also referred to as executive functions.

These are namely:

- (1) selection and perception of pertinent information;
- (2) maintenance, retrieval and manipulation of information held ‘on-line’ in working memory;
- (3) self-directed planning and organisation in relation to specific contingencies; (4) behavioural control and adaptation to changes in the environment; and
- (5) appropriate decision-making on the basis of positive and negative outcomes.

- A disruption of cognitive function often results in a heterogeneous pattern of deficits
- One of the primary systems responsible for these cognitive functions is the Fronto-striatal System

The slide features a blue and white color scheme with a background of faint icons related to cognitive science. A small video inset in the bottom right corner shows a woman speaking. Logos for IIT Kharagpur and NPTEL are visible at the bottom left, and the number 24 is at the bottom right.

So, it posits that cognition depends upon 4 interrelated functions, that is – planning, attention, simultaneous and successive. And, they interact with the individual's knowledge base and skills. You can look up the cognitive assessment system. It is primarily based on cognitive of on brain functioning and it is very well in use.

Now, talking about some traditional frontal lobe problem solving. So, now we get to specific cognitive tests for frontal lobe for problem solving. Now, here in this part of the session we are going to talk about specific brain areas that our brain systems that may be involved in a cognitive function.

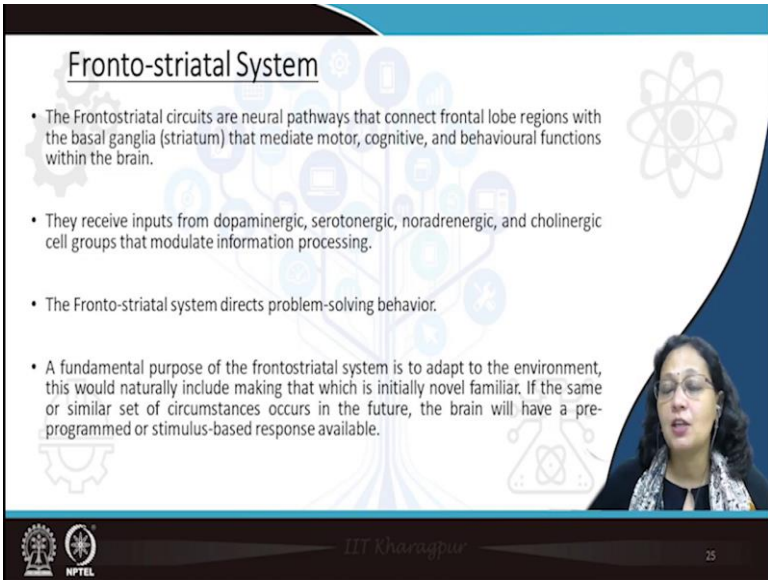
As I told you earlier that, earlier it was spoken about or earlier it was thought that there are specific areas that may be mapped to specific cognitive functions. Today we have realized that it is not one cognitive function may be due to an integration of functioning in different areas and different systems may be at work. So, we will just discuss one or two such tests; cognitive tests where we will talk about the brain areas and the brain systems involved.

So, we already know that the frontal cortex mediates cognitive functions and which we also pretty often refer to as executive functioning. I have often spoken about the executive functions so far. And, what are these executive functions? They are namely selection and perception of pertinent information, maintenance, retrieval and manipulation of information, held currently for in working memory for some given task.

Self-directed planning and organization in relating to specific contingencies. Behavioral control and adaptation to changes in the environment and appropriate decision making on the basis of positive and negative outcomes. So, all these are functions of the frontal lobe.

Now, a disruption of a cognitive function often results as I was mentioning right now to in a heterogeneous pattern of deficits. So, it is a mixed pattern including distractibility, perseveration, social irresponsibility, lack of initiative impulsivity and profound disintegration.

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Fronto-striatal System

- The Fronto-striatal circuits are neural pathways that connect frontal lobe regions with the basal ganglia (striatum) that mediate motor, cognitive, and behavioural functions within the brain.
- They receive inputs from dopaminergic, serotonergic, noradrenergic, and cholinergic cell groups that modulate information processing.
- The Fronto-striatal system directs problem-solving behavior.
- A fundamental purpose of the frontostriatal system is to adapt to the environment, this would naturally include making that which is initially novel familiar. If the same or similar set of circumstances occurs in the future, the brain will have a pre-programmed or stimulus-based response available.

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When we were talking about just recall our discussion on Phineas Gage and how frontal lobe damage had affected many of these functioning almost all of these that we mentioned here right now. Now, we spoken about the frontal cortex, but is it only the frontal cortex? No. It is a Fronto-cortical system.

Now, what is actually responsible for these cognitive functions?

So, it is not the frontal cortex specifically. The system that is responsible for these cognitive functions is known as a Fronto-striatal system. So, the fronto-striatal circuits are neural pathways that connect the frontal lobe regions with the basal ganglia.

Now, we are moving from the frontal lobe to the subcortical areas and here we have the basal ganglia that is the striatum that mediate motor, cognitive and behavioral functions

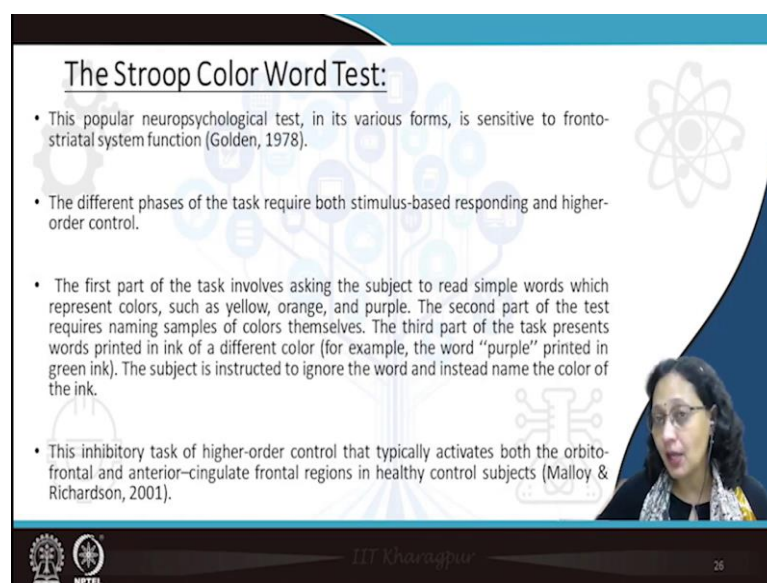
within the brain. These receive inputs from the dopaminergic, serotonergic, noradrenergic and cholinergic cell groups that modulate information processing. Now, we look at this.

So, we have the lobal areas, in this case the frontal cortex. We have the subcortical areas of the basal ganglia and we have the certain specific neurotransmitters that act as a modulator ok. Now, the frontal striatal system directs problem solving behavior. So, for novel situations the fronto-striatal systems develops problem solving behaviors by determining the stimulus based characteristics of the problem. So, this is from the sensory inputs of the problem and by applying behaviors to fit that context in now this is for novel situations.

In familiar situations the frontostriatal system selects the most appropriate stimulus based automated behavior that fits into the current context. So, it is like a template matching. So, it is like a machine that is template matching to get for familiar context just to template match and choose the best action for a novel situation the action is a little different.

So, since a fundamental purpose of the frontostriatal system is to adapt to the environment, this would naturally include making that which is initially novel into a familiar.

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The Stroop Color Word Test:

- This popular neuropsychological test, in its various forms, is sensitive to fronto-striatal system function (Golden, 1978).
- The different phases of the task require both stimulus-based responding and higher-order control.
- The first part of the task involves asking the subject to read simple words which represent colors, such as yellow, orange, and purple. The second part of the test requires naming samples of colors themselves. The third part of the task presents words printed in ink of a different color (for example, the word “purple” printed in green ink). The subject is instructed to ignore the word and instead name the color of the ink.
- This inhibitory task of higher-order control that typically activates both the orbito-frontal and anterior-cingulate frontal regions in healthy control subjects (Malloy & Richardson, 2001).

The slide features a blue and white background with faint icons of a brain, a gear, and a circuit. A video inset in the bottom right corner shows a woman with glasses speaking. The bottom of the slide contains the IIT Kharagpur logo, the NPTEL logo, and the text 'IIT Kharagpur' and '26'.

So, what does that imply? That there is learning; there is learning of the novel situation adapting it and making it into a familiar context. So, with past associations and representations making it a familiar concept so that henceforth if this a same or a similar set of circumstances occur the brain will have a pre programmed stimulus based response available. So, see how optimized the brain functions are.

Now, let us look at this frontostriatal system in action in some of these cognitive tests. Again to remind you these are part of neuropsychological testing. So, the first one and the most common cognitive test is the Stroop Color Word Test. So, it is often known as this Stroop task and this is a popular neuropsychological test in its various forms. So, in most of the neuropsychological test batteries that you come across you will get a form of the Tower of London the and the Stroop test.

Now, there are many adaptations of Stroop test that are also available in apps. So, what kind of and it is easy to make. So, it is a how do you how do you see the it is sensitive to frontostriatal system function. So, what exactly does it do? So, it this task requires us an individual to reach simple words which represents colors like yellow, green, red, blue. The second part of the test; so, this is the first part of the test.

The second part of the test requires samples of colors. So, there is a color, but the word is written with different color. So, the in the second one you just have to name the color. So, there is nothing written in the third part of the task presence. The words printed in ink in a different color.

So, the word purple is printed in green. So, the subject is instructed to ignore the word and instead name the color of the ink. So, I have red written in purple and this is in the third step of the task and what am I asked to do as a participant, as a subject? I have been asked to read the color. So, I have been asked to read purple instead of what is written in the script. So, if the script reads red, I am supposed to say purple.

So, what does this imply? That the automated action by the frontostriatal system would be to respond in script. So, respond by reading the word that is what we have learnt throughout ok with training, but the what is the action that needs to be taken to stop it to inhibit the action and read the color. So, this engages the frontostriatal system because it changes the stimulus based characteristic of the task.

So, we are again what would be the stimulus that would draw our attention? Writing of the word which we have learned over the years and it was also practiced as a part of you know set 1 and set 2, but. So, this becomes a part of the automated processing, but in the naming of colors written in different colors of ink significantly, changes the stimulus based characteristics of this task.

The stimulus based responding that runs on acquired associations no longer works and to solve the problem you know to solve the problem that it this represents. So, what do we have to do? The subject must inhibit the previously acquired association that is of reading the word red in order to perform the task.

So, stop reading the word red, inhibit your system from reading the word red. This is thus a task of inhibition and this task this taxes the frontal strategy system. So, the now what does it require? I have inhibited reading the word red.

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Wisconsin Card Sorting Test

- The Wisconsin Card Sorting Test (Heaton, Chelune, Talley, Kay, & Curtis, 1993) is, a categorization test
- It is a rule-based category-learning task where the categories can be learned through an explicit reasoning process. Subjects make a response about category membership and then receive positive or negative feedback in order to learn the categorization dimensions. These types of tasks activate the prefrontal cortex, and the head of the caudate nucleus and other regions of the basal ganglia.
- Performing the task not only activates the dorsolateral-prefrontal cortex, but also the head of the caudate nucleus, as well as other cortical and subcortical brain regions like the inferior parietal lobule, inferior temporal cortex, and the cerebellum.

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Now, the task requires me to inhibit the impulse to attend and respond in the habitual way and switch the action to a new action. So, the next time I. So, with a couple of revisions I will be able to automate this into my regular actions as well. Now, this stopping this inhibiting task switching and reading the color is a higher order control.

So, this is the task of higher order control that typically activates both the orbitofrontal cortex and the anterior cingulate frontal regions in healthy control subjects. This has

been seen through neuroimaging. And, the individuals who work quickly are likely to have an intact frontostriatal system. The subjects who worked slowly on the color work segment of the task engaged in a more taxing cognitive control episode.

So, this two paradigm primarily works upon inhibitory processes, ok. This is a very very popular task especially when we are trying to see cognitive functioning in the elderly. In fact, as a neuropsychological test for brain injured traumatic brain injury also this is a very very effective task.

The next one again that we come to is the Wisconsin Card Sorting Test and this was developed by Heaton et al., in 1993 if, this is a categorization test. The act of responding differently to objects or events that belong to separate classes or categories is called categorization. And, WCST as I said is a rule based category learning task. So, what is done in rule-based categorization?

Here in rule-based categorization task the categories can be learned through an explicit reasoning process. So, how is that reasoning process developed? It is by instructions. Now, the instructions sometimes may be direct, may be hidden. Now, what is done in and generally it is learned through trial and error. So, what is done in WCST? The participants make a response about a category membership and then receive positive or negative feedback in order to learn the categorization dimensions.

So, I choose a color say and on the color they are given a feedback when I; so, it is a positive feedback or a negative feedback. So, this these types of tasks activate the PFC; the prefrontal cortex and the head of the caudate nucleus and other regions based on the of the basal ganglia. Again, you see that it is not only the frontal regions the frontal cortex that is into play in a cognitive task.

Now, rule based categorization is classically a cognitive task. But, you see that the subcortical areas are also active. Now, the here the subject generates hypothesis and learns the sorting principles through direct feedback about responses being right or wrong. So, he has to sort the cards as per a particular room and based on the feedback he changes the rule the or remains with the rule. The subject generates and hypothesis and learns through direct feedback of responses whether it is right or wrong.

And, the characteristics that need to be described discovered comprise color, form and number. Now, performing in this task not only activates again let us look at the prefrontal areas that are involved. So, that is the dorsolateral prefrontal area, the head of the caudate nucleus and other cortical and subcortical areas like the inferior parietal lobule, inferior temporal cortex and the cerebellum.

Now, you see we have moved from the cerebrum to the cerebellum. So, when we talk of cognitive functions we so far have not spoken about the cerebellum per se. We have generally we talk about movement and balance when we talk about cerebellum, but here you see the role of cerebellum in a cognitive task of categorization. The parietal and the inferior temporal visual association cortices project to the tail and body of the caudate nucleus in the subcortical areas.

And, therefore, although the WCST is a fronto-striatal task that taps the dorsolateral executive unit so, the task is dependent upon a brain network and it is not just the frontal lobes. Now, a very interesting thing about WCST is that it can also be used as a working memory test. Most of the times this is not a standard working memory test. So, we have wish a Wechsler Memory Scale as a standard working memory test, but WCST because of the areas that it taps can also be used as a working memory test. How?

So, thinking through the principles of color, form and number generates a high demand on working memory because thinking is required to figure out what to do on this problem solving task and this has to be done dynamically. So, consistent with the function in neuroanatomy this also activates the as we mentioned the caudate and the dorsolateral prefrontal cortex.

Now, this the model would also predict that when matching to the correct principle working memory demand declines. So, you know that well you this is correct. So, you do not have to remember the past mistake to alternate in the next session next step and that this should be observed in the so, what is seen is less caudate activation. Now, this is actually seen visible through neuropsychologic sorry, neuroimaging techniques.

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Tower of London Test (TOL)

- Successful performance of the TOL is a function of a person's ability to determine the stimulus-based characteristics of the task (Hodgetts & Jones, 2006).
- The subject works from an initial starting position in which the balls are placed on two of three upright polls and must move the balls to a new predetermined position with the balls on one or more of the polls.
- The task's stimulus-based characteristics relate to the constraints or "rules" placed upon task performance.
- Neuroimaging studies indicate that the TOL activates the dorsolateral- prefrontal cortex, the anterior cingulate, the cuneus and the precuneus, and the insula. Parietal lobe activation is seen in the supramarginal and angular gyri (Lazeron et al., 2000). Cerebellar activation is also found (Schall et al., 2003).

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And, there is also another thing that is seen that is cognitive control episodes occur at times of switching in response to negative feedback and this also activates the caudate regions this has also been; so, which is again a part of working memory demand. This is also being seen through visible through neuroimaging.

So, though WCST is not a standard working memory tool, but you can also use it considering the areas and the functions that it taps. I did not talk about the role of the globus pallidus in this case, but you know probably I will provide a note with the details of how WCST is related to working memory. So, you can look through it in the notes.

At the third test a neuropsychological test that I will talk about is the Tower of London and you will see again various forms of it you will see apps of it and you will it is it is a part of regular cognitive test battery. The Tower of London in fact, a similar form is used by computer scientists and AI people as the Tower of Hanoi test ok and they look at it as a recursive function test.

So, the Tower of London is a problem solving task that is not dependent upon categorization like WCST. However, successful performance is on the TOL is a function of a person's ability to determine stimulus based characteristics of the task. So, what is the subject asked to do? So, I am sure many of you are familiar with the Tower of London. You can see it in the slide also. The subject is here is required to plan ahead in order to determine the order of moves necessary to rearrange 3 colored balls.

So, there is a final set that is provided and there is an initial set and the subject has to move the balls from the initial set to the final set. So, now, there are some rules again so, which or constraints that the individual has to follow. So, what are they? Only one ball can be moved at a time. The balls always have to be moved from peg to peg and therefore, always must be placed on a peg.

So, you cannot keep one in hand and you know put a smaller one and then the another one and the number of balls that can be placed on a post is specified by the length of the poles. So, on a 3 peg pole Tower of London the first peg can hold one ball, the second one 2 balls and the third one third peg can hold 3 balls. So, each problem has to be.

So, with all these constraints in place one has to solve the problem to reach the final state and there this the minimal number of moves can be calculated for this and each problem is to be completed with the least number of moves. Any problem that can be solved with the minimal number of moves now that as I said is can already be calculated.

So, what are the cognitive functions that this test taps? So, this taxes the working memory functions and all the rules of the tasks must be kept in mind while planning needs to be reorganized as the positions are mentally manipulated before executing them in action in motor actions.

So, the this implies visuospatial rehearsal number one and subjects can either visualize a sequence of movements. So, plan it you know visually in memory before action. Self verbalize a plan of action or engage in a combination of both strategies, but it is generally seen that visuospatial working memory plays a stronger role than verbal working memory. So, very few people actually mouth it out before doing it. So, it is more like looking at it and planning it.

So, now this task is scored according to the number of moves as I told you. We can calculate the minimal number of moves; it is just a mathematical function. And, so, you know how deviated how much the individual has deviated from the minimal number of moves and the test also provides temporal indices such as response planning time the first initiation time and total time etcetera.

In one of my lab experiments what we try to do is we try and see how the individual plans the action. So, through so, in most of these cognitive tasks so, we try and see it

through eye tracking. So, with so, if we say that this is a there is a visuospatial planning or visuospatial working memory that is in action. Then how is that planning being done, how many errors are being made and how many recursive actions, how many repetitions, whether the individual is falling into a loop in such tasks?

So, this is what we try and capture through our eye trackers and you know through a colorimetric techniques in our lab. So, now, neuroimaging studies have shown that the Tower of London activates the dorsolateral prefrontal cortex, the anterior cingulate, the cuneus and the precuneus and the insula. Parietal lobe activation is also seen and cerebellar activation is also found.

So, now in as I was telling you just look at the number of areas that are involved in a cognitive function.

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Continuous Performance and Go-No-Go Tasks

- The continuous performance test (CPT) paradigm evaluates sustained, focused attention.
- This test paradigm consists of sequential stimuli presentation, usually strings of numbers or letters. These stimuli are presented over a long time, such as six to approximately 20 minutes, depending upon the specific CPT in question
- CPT tasks can be administered in both auditory and visual modalities. Though the same neural mechanisms control attention and influence perception across different sensory modalities (Shinn-Cunningham, 2008)
- In go-no-go paradigms, the subject is required to respond in one way to a predetermined "go" signal and not respond to a similar signal.

The slide features a blue and white background with decorative icons of a gear, a brain, and a network. A video inset in the bottom right corner shows a woman with glasses speaking. The bottom of the slide includes the IIT Kharagpur and NPTEL logos, the text 'IIT Kharagpur', and the number '29'.

So, if we are saying that this is an executive function test, it does not mean only the frontal lobe in action. So, let us move from the cortico-specific lobel specific testing or you know explanation of cognitive functions to the systems that are in place. So, for this we need to understand the neuroanatomy also way better.

In the in you know the mapping planning networks the basal ganglia has also been seen to be very active. This is again through neuroimaging your information through neuroimaging. So, we already know about the parietal lobe functioning and the dorsal

dorsolateral prefrontal cortex and the right dorsal cortex nucleus are active in the Tower of London planning network.

So, from here we move to another kind of task that is known as continuous performance and go-no-go task. Most of you are familiar with continuous performance task for go-no-go task especially and most of these games on attention and cognitive retraining that we find on apps available online try and tap the go-no-go network. So, what exactly is it?

So, the CPT or the continuous performance tasks paradigm evaluates sustained focused attention. So, this test paradigm consists of sequential stimuli presentation and usually it is a string of letters or numbers or patterns like symbols and these are presented for a long period of time between 6 to approximately 20 minutes. And, now during this time the individual is required to indicate when a particular number or an image or a symbol pops up.

So, they may be should be shown letters and as the letters pop up for say a long time continuously there is a you know maybe a number pops up inspect you know in the sequence. So, the individual has to identify the signal. So, it is more like a signal detection task and in if it is a digitized version, it is a computerized version then there is a tap of a key or you know in if it is a manual version again that would be through pressing a bar or pressing a signal.

Now, this these tests may be both on visual modality or auditory modality, but the pathway for the you know for attention in this case the neural mechanisms that control attention and influence perception are the same whether you are looking at the auditory modality or the visual modality.

In go-no-go paradigms, the subject the task is a little different than CPT. So, here the individual is required to respond in a way that is a predetermined go signal and not respond to a no-go signal. So, the again the no-go signal is similar to the go signal. Now, this is you know like just to mention in the Posner's task it is based on a go-no-go paradigm.

If you; so, what does what do these tasks incorporate? So, you have say you have when you see a red arrow you press the key, but when you see a green arrow you do not press the key. So, it keeps coming and so, there is an instruction specific instruction for a you

know so, it may go like the specific instruction to press the key and specific instruction to not press the key. So, for other letters you do not press the key say for only red you press the key.

Now, in Posner's task like it is the direction of the arrows ok. So, you can find a version of the Posner's task online and it is again a test for executive and selective attention. So, these tasks not only require sustained focused attention, so, be it the go-no-go or the CPT they both require focused attention, but also response inhibition. So, the act of paying attention consists of 2 functions.

We will discuss this more when we talk about attention. So, one is and I will also talk about Posner's task when we talk about attention.

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- CPT and go-no-go paradigms thus assess both the capacity to attend and the capacity to inhibit.
- **Errors of omission** refer to the subject's failure to attend to stimulus presentations or to "miss" stimuli. **Errors of commission** refer to the subject's failure to inhibit responses to competing stimuli.
- Errors of omission reveal inattention along a passive dimension. This type of attention is dependent at least in part on posterior cortices (Robertson, 2004). Errors of commission identify a deficit within the inhibitory component of attentional focus and control. The inhibitory component is dependent upon anterior, frontostriatal brain regions.
- We can thus see that the process of attentional focus is mediated by the frontostriatal system.

So, one is alertness, the 2 major functions of attention are one is alertness, the other is vigilance and the third again is very important alertness, vigilance and inhibition. So, when a person pays attention to one thing he has to remove the distractors that are there in the environment and these distractors try and grab your attention. So, there is a processing, there is a focus and there is a inhibition ok. So, this inhibition, so, this is what should I say? It is like vying for attention.

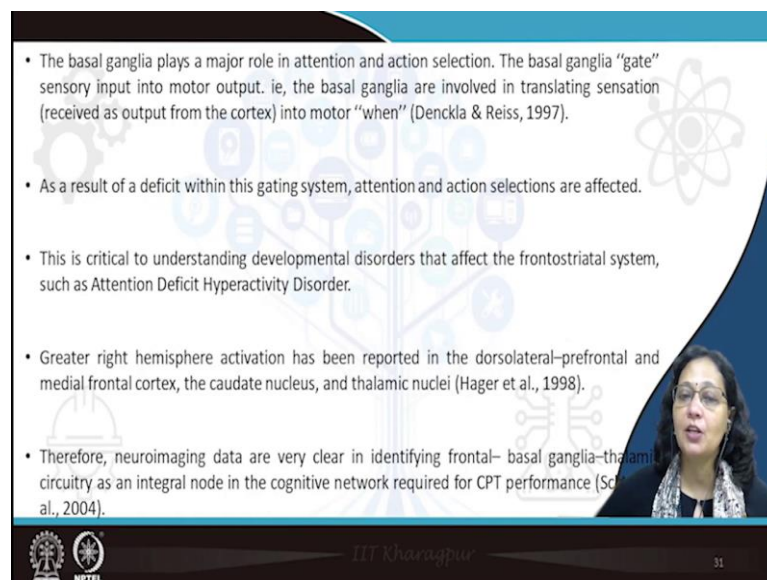
So, may now this vying for attention may come from both internal stimuli as well as external stimuli. And these may be innumerable and again because the attentional

resources are limited there may be a switch. So, therefore, the ability to pay attention to anything requires inhibitory capacity.

So, the CPT and the go-no-go paradigms assess both the capacity to attend and the capacity to inhibit. And, to perform this successfully the individual is required to detect the proper stimuli. So, there should be a signal detection while inhibiting response to competing or distracting influences.

So, there can be 2 kinds of errors that you see here – one is the error of omission, the other is the error of commission. So, what is the error omission?

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- The basal ganglia plays a major role in attention and action selection. The basal ganglia “gate” sensory input into motor output. ie, the basal ganglia are involved in translating sensation (received as output from the cortex) into motor “when” (Denckla & Reiss, 1997).
- As a result of a deficit within this gating system, attention and action selections are affected.
- This is critical to understanding developmental disorders that affect the frontostriatal system, such as Attention Deficit Hyperactivity Disorder.
- Greater right hemisphere activation has been reported in the dorsolateral–prefrontal and medial frontal cortex, the caudate nucleus, and thalamic nuclei (Hager et al., 1998).
- Therefore, neuroimaging data are very clear in identifying frontal– basal ganglia–thalamic circuitry as an integral node in the cognitive network required for CPT performance (Schoen et al., 2004).

It refers to the subject’s failure to attend to stimulus presentations or miss the stimuli. So, in a CPT I have missed a signal. I did not see one letter amongst the numbers say and the error of commission is responding early. So, seeing you know considering the noise as a stimuli.

Now, this type of this. So, the error of omission reveals inattention along a passive dimension, while error of commission refers to the subject’s failure to inhibit responses to computing to stimuli. So, that is attending to noise as a signal. So, this type of attention is dependent on the posterior cortices and that is for error of omission.

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The slide features a blue and white color scheme with a background of faint icons related to cognitive science. The main title is 'Commonly Used Neuropsychological and Cognitive Tests: What Do They Measure? Performance and Processing speed.' Below the title, there is a small 'word of caution' icon. The slide contains three bullet points: 1. 'Processing speed is defined as the speed with which different cognitive operations can be performed or executed (Reichenberg & Harvey, 2007).' 2. 'There is a pattern of decreased global activation as well as a shift in activity from cortical to subcortical areas as automaticity is achieved (Saling & Phillips, 2007).' 3. 'One thing that is important to remember when we study Cognitive tests or neuropsychological tests at large is - Cognition is organized according to brain networks, we cannot expect any single test to be able to localize all regions of the network.' A small inset video shows a woman with glasses speaking. At the bottom, there are logos for IIT Kharagpur and NPTEL, and the slide number '32'.

And, for commission it is to identify a deficit with the inhibitory component of attentional focus and control. So, and for this the major areas that are responsible are the fronto-striatal brain regions. So, we can see the role of a fronto-striatal system you know important for attentional selection and as well as attentional inhibition.

So, now this is very critical in understanding disorders like attention deficit hyperactivity disorder. So, the right hemisphere activation has been reported and activation in the dorsolateral prefrontal and medial frontal cortex, the caudate nucleus and the thalamic nuclei again if you notice these are the frontostriatal regions. The so, there is also a role of the basal ganglia and thalamic circuitry responsible for attentional focus and inhibitory control.

Now, why when we are talking about neuropsychological test when we are talking about cognitive tests we must remember one thing ok that is that you know there should be a word of caution when we are talking about neuropsychological test and cognitive test. So, the these tests aim to measure the functions carried out by the individual to interact with the environment.

So, that is basically the function of the individual to survive and to survive the individual needs to understand and adapt to the environment. So, the neuropsychological test measures the functions carried out by the individual to do you know to interact with the

environment to adapt to the environment to gather and process information and plan and execute an action.

But, the word of caution is that it is important to remember that when we study cognitive tests or neuropsychological tests at large they this is not the test are do not measure a function you know it cannot be mapped to a localized area for a certain function. So, cognition is organized according to brain networks and we cannot localize a specific anatomical area.

Now, I keep repeating this though you will see me talking about Broca's area in memory in language articulation, but there are also other associated areas in language functioning. Similarly, you know in neuropsychological tests we must remember that these are integrated systems in action.

So, whether it is the basal ganglia thalamic circuit, whether it is a fronto-striatal circuit, whether it is the any other executive circuit that at that is in action. So, this we and another thing that we need to remember is that you know a single test cannot measure all these functions. So, if you are talking about executive functions one test will not be able to measure executive functions. If you are talking about working memory one test will not be able to measure working memory.

So, these are words of caution that have actually brought in new thoughts into understanding neuropsychological and cognitive testing. The reason being you know we are much more aware of the neural, the brain functioning the dominant networks within the brain that can be related to different behavioral mechanisms and you know information processing units.

And, so, now we; so, we must remember this before we use or build new neuropsychological tests. So, regarding this I will be revisiting many of these tests, many of these functions as we progress through the sessions, but for now this is it.

Thank you.