

Cognition and its Computation
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Lecture - 27
Alerting Orientation and Executive Network

Hello and welcome back to this session on Attention, in today's session we are going to talk about the different Attentional Network and we will talk also talk about attentional disorders. In that section we will I will specifically talk about attention deficit and hyperactivity disorder. So, what do we know about attention? So, far we studied about the types of attention, we discussed about the different theories of attention and today we are going to talk about a primarily about the neurobiological aspects of attention.

(Refer Slide Time: 01:00)

**Alerting Orientation and Executive Network,
Disorders of Attention**

- **Alerting** is defined as achieving and maintaining a state of high sensitivity to incoming stimuli;
- **Orienting** is the selection of information from sensory input;
- **Executive control** is defined as involving the mechanisms for resolving conflict among thoughts, feelings, and responses.

The three brain networks differ in their functional anatomy, the circuitry of their component operations, and the neurochemical modulators that influence their efficiency



But this will be taken up later in the next week in details, but just to give you an orientation of the attentional networks. So, when we talk about attentional networks there are three primary systems that we talk of one is the alerting system, the orientation system and the executive system or the executive network. So, attention as we know is a primary cognitive function that is critical for perception, for language, for and for memory.

And many researchers have tried to study attentional operations and attentional data from different domains and they suggest these 3 brain networks. Now, these networks carry out the function of alerting orienting and executive control and that is how they got their names. So, what exactly is Alerting?

(Refer Slide Time: 02:07)

Alerting

- Moruzzi and Magoun (1949) - brain-stem and reticular system important in maintaining alertness
- Alerting studied as - a warning signal prior to a target event
- Alerting studied as - tonic alertness. These include studying the circadian rhythm
- Alerting studied through vigilance tasks – involvement of right cerebral cortex



Alerting is defined as achieving and maintaining a high state of a state of high sensitivity to incoming stimuli. Now this was initially way back propounded by Moruzzi and Magoun in their classical work of 1949 and they emphasized the role of the brain stem and the reticular system in maintaining alertness. And with further research in the years after that we understood that the neuro modulatory mechanisms of the brain stem and the thalamus are important for arousal in general and it can be differentiated into 2 components.

So, one way of studying alerting is to use a warning signal that is prior to a target event and if a speeded response to the target is target event is required target is required reaction time improves following a warning. So, when an individual is pursuing a target and there is a warning before the target which we generally do in psychological experiments as a ready signal, then the alertness improves. This improvement in reaction time which is marked by a response in reaction time this improvement is accompanied by vast changes in the physiological state of cognition.

The several other methods are also used to study alertness and this basically we are talking about tonic alertness and what do they include they show they are primarily works on circadian rhythm. Many of you are familiar with the term circadian rhythm who are not it is basically the functioning affected due to different diurnal variations. So, and it has been seen that reaction times are usually longer in the early morning and decline over the course of the day and rise again during the night and peak in the early morning.

So, that is the time when reaction times are longer, because that is when we are more drowsy or sleeping. These measures reflect other diurnal changes such as body temperature and cortisol secretion. One approach to study tonic alertness is to use a long and boring task to measure sustained attention or vigilance and in fact in vigilance task it is seen that they are vigilance task are dependent on mechanisms of the right cerebral cortex. And this we know because of recent studies and recent imaging data that show that tonic alertness is heavily lateralized in the right hemisphere.

(Refer Slide Time: 05:30)

Alerting network – recent research

- Neuromodulator norepinephrine (NE) is important to the alerting system.
- A warning signal causes activity in the locus coeruleus, the source of Norepinephrine.
- Warning-signal effects blocked by drugs -guanfacine and clonidine, which decrease Norepinephrine release
- Drugs \uparrow NE release \rightarrow \uparrow warning signal effect
- NE pathway \rightarrow major nodes in the frontal cortex and in parietal cortex relating to the dorsal but not the ventral visual pathways



The recent research on alertness has also given us more information about the neuro physiological mechanisms involved in the alertness system and we have found out that studies show that the neuro modulator that norepinephrine is important to the alertness system. A warning signal a company is accompanied by activity in the locus coeruleus and is this which is the source of neuro norepinephrine. And warning signal effects can

be blocked by drugs such as guanfacine and clonidine and this decreases the norepinephrine release.

So, this definitely impacts the alertness system and it has been seen that the drugs that increase the norepinephrine release has enhancing effects on the warning signal effect a warning signal. And the norepinephrine path norepinephrine pathway these include major nodes in the frontal cortex and in the parietal areas relating to the dorsal visual pathways. Now coming to the orienting network, so what is the orienting network?

(Refer Slide Time: 06:52)

Orienting network

- **The orienting network** focuses on prioritizing sensory input by selecting a modality or location. Imaging studies indicate that frontal as well as posterior areas are involved in orienting
- Parietal areas involved in orienting network → directed motor or eye movements
- The functions of the parietal lobe are not restricted to orienting to sensory stimuli



The orienting network is a selection of information from sensory input. So, where do I look how? So, what draws my attention? So, focusing on that area ok, now this is primarily as you can understand is prioritizing sensory input by selecting a modality. So, should I is this a sound and orienting my head towards that sound or is it a visual stimulus, so orienting my head towards the visual stimulus. So, whatever be the stimuli by selecting the stimuli to be attended from a specific modality and orienting your movements ones movements towards that location.

Now, imaging studies have shown that frontal as well as posterior area areas are involved in orienting and human and animal studies have specified on frontal eye fields in the that are involved in the process. Now parietal areas are also involved in the oriental orienting network, this is seen in direct motor or movement eye movement. And the functions of the parietal lobe are not restricted please understand this very clearly are not restricted to

orienting to sensory stimuli. But also the parietal lobe also are involved in multiple other processes.

(Refer Slide Time: 08:34)

Orienting network – recent research

- Two brain systems are related to orienting to external stimuli -
 - A dorsal system – Frontal eye Fields, Intraparietal sulcus in rapid strategic control over attention.
 - The temporo-parietal junction (TPJ) and the ventral frontal cortex during a task switch
- By Anatomical origins: the source of the orienting effect is in the network of parietal, frontal, and subcortical areas. But there are sensory specific areas in bottom up processing.
 - vision – orienting responses are activated in the primary visual cortex and the extrastriate areas moving forward toward the temporal lobe



Now, recent research has shown that there are 2 brain stems sorry 2 brain systems that are related to the orientation response or orienting response. So, one is a dorsal system that includes the frontal eye fields and the intraparietal sulcus in rapid strategic control over attention. And the second one is the involvement of the temporo parietal junction and the ventral frontal cortex during a task switch.

So, as you can see one is for the orienting towards the stimulus, the other is for the task switch orienting to a different stimulus. And if you go by the anatomical origins the source of the orienting effect in the network is in the network of the parietal frontal and subcortical areas, but there are sensory specific areas in bottom up processing also. Now, when say if you if you are talking of a specific sensory modality like the eye, in vision the orienting response are activated in the primary visual cortex and the extrastriate areas moving forward towards the temporal lobe.

So, you can well understand the pathway. And this actually this pathway this involvement of the primary visual cortex and the extrastriate areas this involves a synchronization between activity in the dorsal attention areas and in the ventral visual areas. This synchronization leads to a greater sensitivity in the visual system and that

allows faster responses to visual target. The third network system is the executive network.

(Refer Slide Time: 10:39)

Executive network

Executive network:

- Focuses on target detection - The moment of target detection produces interference across the attentional system, and slows the detection of another target. This is due to the limited capacity of the attention system, and is called focal attention
- Focal attention → entry to the conscious state,
- involves connections from the midline cortex and the anterior cingulate cortex to produce a conscious awareness.
- The medial frontal cortex and the adjacent ACC are important for target detection and awareness of the target (Posner et al.)



And many of you are already familiar with the Executive Network system. Now the what does the executive network system do? So, the executive network system which is more often very popularly known as executive control is defined as involving the mechanisms of resolving conflict between 2 stimuli. So, whether to select a or to select b stimuli ok and this system again focuses mainly on target detection.

And initially in fact Posner and Peterson during their early work there is a wonderful paper by Posner and Peterson in 1990 in annual reviews. And then they have published again in 2012 speaking about the 25 years of attention and you will see in their earlier work they spoke more about target detection and they spoke about how the executive network helps in the target detection and switching in the task.

So, as you can see it is very closely related with the orienting network. And because, the attentional capacity system is limited, so the if there is an interference that of another stimulus of another competing stimulus that slows down the detection of the target. So, this work was some of the initial findings and it has been seen that focal attention is the entry to the conscious state.

And involves connections from the midline cortex, the anterior cingulate cortex which is again one very important area in attentional control and these 2 combined produce a conscious; produces a conscious awareness. Posner and his associates found that the medial frontal cortex and the adjacent ACC as just now I mentioned about the anterior cortex cingulate cortex are very important areas for target detection and awareness of the target again.

(Refer Slide Time: 13:13)

Executive Network – recent research

- There are two separable executive control networks
 - The frontoparietal network
 - The cingulo-opercular network
- The two executive systems act independently in producing top-down control
- The cingulo-opercular control system shows maintenance across trials and acts as stable background maintenance for task performance
- The fronto-parietal system is involved in task switching and to adjustments within trials in real time



Recent research on attention and on executive networks specifically show that there are two separate attentional executive networks. The first is the frontoparietal network and this is and the second is the cingulo-opercular network and these 2 executive systems they function independently introducing top down control ok. So, we are here we are talking of consciously focusing attention to a particular stimulus and switching attention from there to another stimulus.

As you can well understand whenever we are talking about the alerting response to moving from the alerting to the orienting and the executive network these would involve. Because it is a conscious selection of stimuli executive network would more imply the involvement of the frontal areas or the higher cortical areas in selective attention.

Now, so recent research ok so this they has this has been see it has been seen that the frontoparietal system is involved in task switching and initiation to adjustments within trials and time. While the cingulo-opercular system shows maintenance across trials.

Now a recent research in executive networks have moved further on to you know further imaging studies of these areas of these 2 executive areas.

Now, again moving on from there attentional network studies have moved beyond the anatomical structures as imaging has advanced it has helped us to understand the networks the neuro anatomical areas better. But along with it the studies on attention has moved from the these anatomical areas and functional areas to a study of genes to cells to network to behaviour.

So, trying to identify the connections between the 4 recent studies on attention have also focused on how the attentional network systems these 3 systems develop over age and over different stages of development across the lifespan and which of the systems are more active in a certain lifespan and how they influence the perception of information.


Some of the futuristic works in this area of attentional networks focus on attention pathology and to translate these finding on attention pathology to real time disease diseases and disorders and especially in other clinical groups.

(Refer Slide Time: 16:39)

Disorder of Attention

Mirsky and Duncan, 2001

- **Familial/Genetic etiologies** – Sustained attention deficit is found in:
 - first degree relatives of patients with schizophrenia.
 - Female patients with absence seizures
 - Juvenile Myoclonic Epilepsy (JME)
- **Metabolic etiologies** –
 - Patients suffering from Uremia, in their end stage, exhibited impairment in sustained attention.
 - Toxins associated with kidney failure have similar affect in EEG pattern as seen in absence epilepsy
- **Environmental etiologies** –
 - Impoverished environmental conditions due to ignorance, malnutrition and infection are persistent problems of underdeveloped countries. This is associated with impaired cognitive development and may affect attention
- **Other etiologies** –
 - Cerebral insults results in attention impairment
 - Sleep-breathing disorders have negative influence on attention as has been revealed in attention Performance Test
 - Other disorders where sustained attention deficit is found - are idiopathic epilepsies, narcolepsy, ...



In this context today we are also going to talk about the disorders of attention and so to talk about the disorders of attention it has been seen that apart from normal attentional lapse impairment of attention is a symptom of neuro psychiatric disorders, neuro developmental disorders, anatomical lesions and may be classified into multiple types.

Today we are going to focus on attention deficit hyperactivity disorder, but before that I will just familiarize you with a few brief nosology. So, the first one is familial or genetic etiologies and it has been seen that sustained attention deficit is found in first degree relatives of patients with schizophrenia. And female patients with absent seizures have been seen to be to have difficulty in sustained attention.

The other disorders where sustained attention deficit is found is in the pro bands of Juvenile Myoclonic Epilepsy, idiopathic epilepsies, narcolepsy, deafness autosomal dominance and ADHD. And a marker for epilepsy gene has been identified as important for attention. Some of the metabolic etiologies include patients suffering from Uremia and enduring that their end stage the many a times exhibit impairments in sustained attention.

The toxins associated with kidney failure have similar effect in the EEG patterns of alertness in absence epilepsy. Regarding environmental etiologies I am not really sure whether we should put this under impaired cognitive development or as an attentional disorder. But it has been seen that impoverished environmental conditions due to ignorance, malnutrition, infection are a reason for impaired cognitive development and likewise also affect attentional focus and sustained attention.

Some of the other etiologies that affect attention are cerebral cerebellar insults cerebral insults in and sleep breathing disorders and also attention deficit disorder, we are going to talk about that right now. So, what exactly ok and some other sleep disorders like narcolepsy and idiopathic epilepsy we have already spoken about that.

(Refer Slide Time: 19:58)

Attention Deficit and Hyperactivity Disorder

DSM-5® DIAGNOSTIC CRITERIA FOR ADHD IN ADULTS

All criteria must be met for a diagnosis of ADHD in adults:

- Five or more symptoms of inattention and/or ≥ 5 symptoms of hyperactivity/impulsivity must have persisted for ≥ 6 months to a degree that is inconsistent with the developmental level and negatively impacts social and academic/occupational activities
- Several symptoms (inattentive or hyperactive/impulsive) were present before the age of 12 years.
- Several symptoms (inattentive or hyperactive/impulsive) must be present in ≥ 2 settings (eg, at home, school, or work; with friends or relatives; in other activities).
- There is clear evidence that the symptoms interfere with or reduce the quality of social, academic, or occupational functioning.
- Symptoms do not occur exclusively during the course of schizophrenia or another psychotic disorder, and are not better explained by another mental disorder (eg, mood disorder, anxiety disorder, dissociative disorder, personality disorder, substance intoxication, or withdrawal)

Diagnosis should be based on a complete history and evaluation of the patient



Now what exactly is attention deficit hyperactivity disorder? ADHD is disorder most of us are familiar with and many of you have already come across peers, friends, family you know who suffering from ADHD. It is generally diagnosed by an early age, but we often come across a lot of young adults and adults moving around with inattention problems or hyperactivity or impulsively gradually with age the hyperactivity reduces.

So, you might have come across somebody in school whenever the teacher asks who can participate in dance or who can participate in singing, there is one person who puts up his hand in every turn. This person may be suffering from an impulsivity or you may have come across a lot of people who especially in children you might have seen that you know they are always shaking their hands or their legs and if you stop them if you stop the hand then it is the leg they are moving if otherwise they are looking here and there and everywhere.

Now, they cannot pay attention to what is being taught or you know, if there are distractors available if there are competing stimuli their attention gets diverted very easily. A very common feature is that you know somebody just forgetting what he or she was saying in the middle of a sentence, I am not talking to somebody who has a memory deficit, but many times when people start saying something you will come across attention deficit children as well as young adults who I often see among students in college.

Where they are saying something, but something else draws their attention and you know they have lost what they were saying. So, now looking at the diagnostic and statistical manual for mental disorders the fifth version we can see that the DSM 5 are shows that there are 5 or more symptoms of attention that need to be present. And symptoms of hyperactivity, impulsivity must have been persisting for 6 months or more to a degree that is con inconsistent with the developmental level and negatively impacts social and academic and occupational activities.

The severe several symptoms that is inattention or hyperactivity or impulsivity must be present before the age of 12 years. And symptoms of again in attentiveness or hyperactivity and impulsivity must be present in less in 2 or more settings like home school and work friends, so at least 2 or more 2 settings or more ok for somebody to be identified with attention deficit disorder.

Many times we see that a child is very disturbing in school, but it is pretty ok at home and in other surroundings. You the problem behaviour is only visualized in a certain location we cannot diagnose this as ADHD if the other symptoms are not present.

Now, there is a clear evidence that the symptoms interfere with or reduce the quality of social academic and occupational functioning. So, there has to be a loss of functioning due to this impairment and symptoms do not occur exclusively during the course of schizophrenia or in another psychotic disorder. The reason for this is we have already seen that individuals with schizophrenia have attention problems.

So, that should not be the cause. So, this is where the differential diagnosis comes in and along with that they it mean should not be explain better explained by another mental disorder like mood disorder, anxiety disorder, dissociative disorder, personality disorder, substance intoxication or withdrawal. So, if any of these symptoms can be explained by the last bullet, then you cannot call it ADHD.

And diagnosis should be based on a complete history and evaluation of the patient and amongst the criteria there should be several symptoms as I mentioned earlier which is which is a very important point, that it has to be present in two or more settings across a period in time before the age of and has the onset has been before the age of 12 year.

(Refer Slide Time: 24:55)

ATTENTION DEFICIT HYPERACTIVITY DISORDER

ADHD SYMPTOMS OF INATTENTION	ADHD SYMPTOMS OF HYPERACTIVITY / IMPULSIVITY
<ul style="list-style-type: none">• Makes careless mistakes/lacks attention to detail• Difficulty sustaining attention• Does not seem to listen when spoken to directly• Fails to follow through on tasks and instructions• Exhibits poor organization• Avoids/dislikes tasks requiring sustained mental effort• Loses things necessary for tasks/activities• Easily distracted (including unrelated thoughts)• Is forgetful in daily activities	<ul style="list-style-type: none">• Fidgets with or taps hands or feet, squirms in seat• Leaves seat in situations when remaining seated is expected• Experiences feelings of restlessness• Has difficulty engaging in quiet, leisurely activities• Is "on-the-go" or acts as if "driven by a motor"• Talks excessively• Blurts out answers• Has difficulty waiting their turn• Interrupts or intrudes on others

Symptoms must occur frequently



Now, I have been talking about inattention hyperactivity and impulsivity. So, what are the differences let us look a little into the details. So, somebody who has been suffering from somebody who has been suffering from symptoms of inattention, they make careless mistakes, lack attention to detail, difficulty in sustaining attention as I was just mentioning about losing track of what the individual is saying.

And does not seem to listen when spoken to directly, this main may be present in some other disorders like if you are looking at neuro developmental disorders like autism the patient there the individual with autism may not seem to listen or may not be paying attention to what you are saying. Now, that is a different psychopathology this is not related to ADHD though autistic patients may be having a comorbid ADHD they fail to follow through on tasks and instructions exhibits poor organization.

One very common feature is if you are giving them an instruction they will listen to it half way and they have forgotten the rest of it or maybe they have not even paid attention to the whole process. Now, avoids likes avoids dislikes tasks required that requiring sustained effort. So, if you give them something like a putting cards together as a pile you know or as a tower they are not going to prefer such tasks which requires which demand sustained effort. And they lose things very easily they are easily distracted and forgetful.

So, here as you can see forgetfulness or a memory deficit is due to the attentional deficit for the retention not having been made. So, it has nothing to do with a memory problem, but more of an attention problem. Now, ADHD is the symptoms of hyperactivity and impulsivity you will often see them fidgeting with taps or you know tapping their hands or feet or you know moves around in the seat cannot sit in a you know in a one place for long.

Experiences feelings of restlessness has difficulty engaging in quiet leisurely activities is always on the go and as if you know the person has to get up and run around a little. I often come across people you know who are a little hyperactive, they cannot sit in aircrafts or in trains. The advantage of you know traveling by train in India is you can move around and you know you can just walk around because it is well extended and spread out.

But on a flight you often come across people who mostly the hyperactive people who cannot sit in one place and they have to get up and move around a little as if you know they have to go to the washroom or they have to follow up with somebody on a different seat. So, gets up and moves a little and comes backs comes back and sits down. It is even when they are sensible adults understanding that this is not something to be done which is not the norm in an aircraft, sometimes individuals cannot stop themselves.

And if they are made to sit on a seat then they constantly fidget a lot stretching their arms and legs or you know trying to adjust the belt seat belt and soon. So, I just had a very decent experience of somebody traveling like this. So, you know I thought of sharing ok. And generally ADHD hyperactive or impulsive people they talk a lot blurt out answers especially it is very classical in a school rooms, where teacher may be asking a question. And even if the person does not know or you know he has to put up his hand or say they just repeat what the teacher has said.

And these individuals generally have a difficulty waiting their turn you will see them fidgeting on the queues to you know in a shop they have problems or on the ATM counter if they have to wait in queue they have a problem. And they generally cannot be patient when somebody else is continuing a conversation. So, we have to interrupt or stop them shot and say something that has come to their minds it is like blurting out

things that they wish to say, wish to share. Now these symptoms have to be frequent occurring frequently to be considered as you know ADHD.

Again we spoke about the diagnostic criteria we spoke about some of the symptoms, in this session we spoke about the networks attentional network. And many of you might find these ADHD symptoms very familiar if not with yourselves, but with some people you know. So, we will end today's session on this note and do join us for the next class.

Thank you.