Advanced Neural Science for Engineers

Professor Hardik J. Pandya
Department of Electronic Systems Engineering, Division of EECS
Indian Institute of Science Bangalore

National Institute of Mental Health and Neurosciences (NIMHANS)
Lecture - 40
Newborn Hearing Screening – I

Hi, so today we will be discussing about neonatal hearing screening. This is a part of our Advance Neural Science for Engineers course and what do you mean by neonatal hearing screening? First of all, what do you mean by hearing screening? So, hearing screening means if person can hear or not. To screen the person that means to not really diagnose, but to make an attempt whether a person is able to hear process the signal or it does not look like.

Now, there are very standard procedure to do so and this is done by applying stimulus to the ears and corresponding change in the EEG signals are observed from the scalp of your head. So, you have frontal electrodes, you have prefrontal, frontal, right central, occipital, temporal, parietal as we have seen in the last few lectures. So, the ABR which is called Auditory Brain Response or brainstem response is a far fetch signal that means it is almost we can measure from any part of the head.

But the easiest way would be through the forehead why? There is no hair here it is easier and the system that is used to screen neonatal or neonates is called BERA. This system cause somewhere around 14 to 15 lakh and most of our primary centers in fact 99 percent of our primary center does not have BERA. Now, this is as per the literature. If some primary centers has it is good.

But most of them do not have it and so is the situation with our secondary health center, but the tertiary clinics they have it, Indra Gandhi Hospital they have it, most of the hospitals in and around the city would probably have it, tertiary clinics has it. Now, to perform the screening also you require a technician, a skilled person and to have this kind of system in every village is kind of very difficult, but it is important.

Why it is important? Because if we do not screen the baby. If we do not screen when the baby is born which we call neonate then only when they are 2 years to 3 years to 4 years old the parents would know that the baby cannot hear and late intervention will affect not only the

hearing, not only the speech, not only the brain activity, but overall performance of the child because hearing is related to the speech development.

Hearing is related to your brain development cognition. So, screening at earlier stage is recommended. So, there is a problem, the problem is that we do not have a screening platform affordable screening platform that can be used by semiskilled personnel in our villages are primary health centers. Now, if we have learned through this particular course and few earlier classes is a subset of this course or in fact the part of this course about EEG.

Then we should be able to design a system that can be affordable, that can be easy to use and that can be used to screen those babies and thus help in early intervention if the neonate cannot hear. So, that is what is the topic for today. So, if we remember the procedure of EEG we had a particular montages, how to place number of electrodes on 10, 20 systems and number of electrodes when 21 electrodes link to various ways.

The ways are montages and you definitely remember the front part this part nasion, inion, frontal, prefrontal, frontal, central, parietal, occipital, temporal this must been understand. So, temporal T, parietal P, occipital O, frontal F, central C and we also know that the even number of electrodes are at the right side, the odd number of electrodes are on the left side, the Z one is center Z or Z is in the center.

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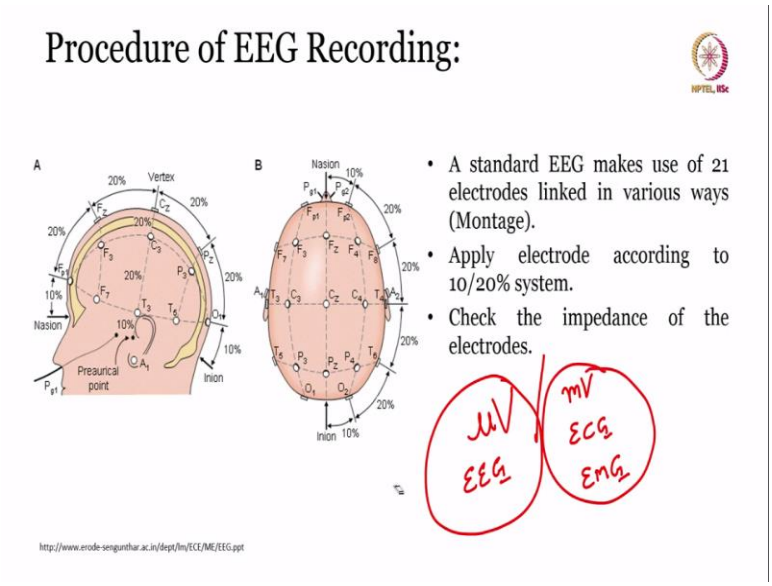

So, if you see the screen this is what we have done how to record the electroencephalogram. Now, we also know that the EEG is of microvolts range compared to your ECG which is of

millivolt range. EMG millivolt range, EEG microvolts range microvolts versus millivolts. So, do we require all these electrodes like 21 for neonatal hearing screening the answer is no, that means we need to come up with a better technology.

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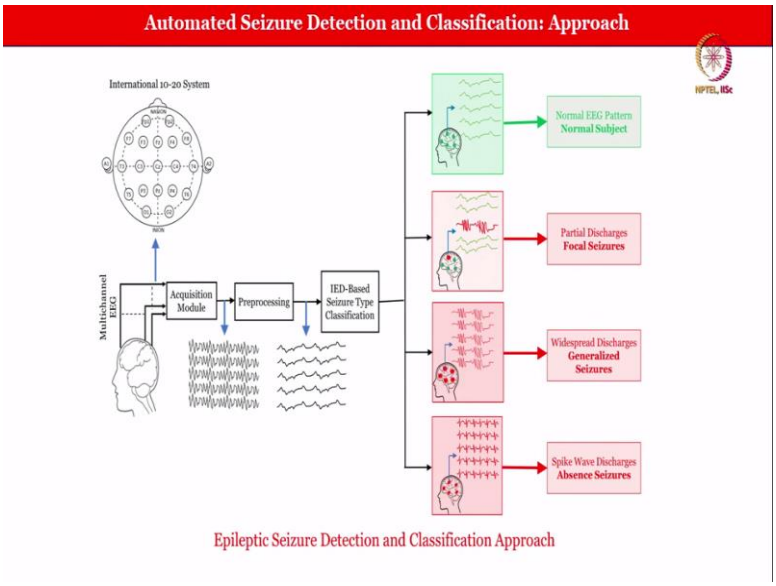

This we have seen in the last class that if you have these 21 electrodes the advantage is that you are not missing any part of the brain, but it is bulkier, it had to be used by a skilled personnel, a lot of data acquisition will happen. You require a good understanding about the EEG signal, feature restrictions, understanding the signatures of EEG and lot more. So, we do not want to go through this particular approach and that is why we will go through some other approaches.

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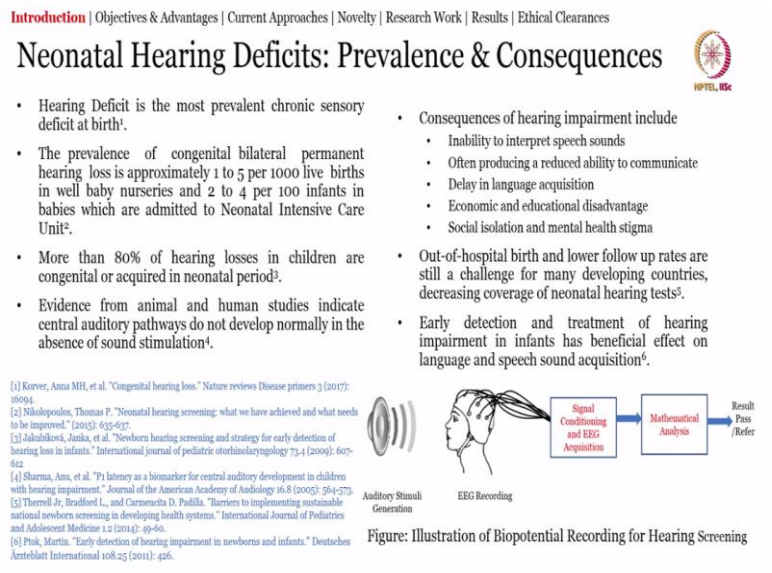

So, in terms of importance, this is one of the most important research that needs to be done so that we have a technology that can be used by a semiskilled personnel like our ASHA workers and can be used to screen the babies in most of the primary health centers or even secondary health centers. So, hearing deficit is one of the most chronic sensory deficit at the birth that is most important thing that you need to remember.

If you see the screen the prevalence of congenital, bilateral permanent hearing loss is approximately 1 to 5 per thousand live birth that is a huge number because out of every thousand birth 1 to 5 babies will lose the hearing ability permanently. While 2 to 4 per 100 not even 1,000 in once which are admitted to Neonatal Intensive Care Unit or NICU. So, the neonate who are born and are kept in NICU this number is even worst 2 to 4 babies per 100 or 2 to 4 infants per 100.

The earlier one was 1 to 5 per 1000 normal in a healthy baby. The next is more than 80 percent of the hearing loss in children are congenital or acquired in neonatal period. So, if you screen those babies in earlier time that means that after the birth within first 3 days to 5 days then lot of things would be solved if there is a hearing loss there can be intervention at right time and it is just not that it will affect the speech and other things.

But the evidence from both human and animals trails or studies clearly indicates that the central auditory pathways do not develop normally in the absence of sound stimulation. If you do not have sound stimulation the ordinary pathway will not develop normally. So, what are the consequences of the hearing impairments this includes the inability of interpret speech sound.

This often produce a reduced ability to communicate because of that there is a delay in language acquisition. There is disadvantage in terms of economic and educational advantages. There are disadvantage that a baby cannot hear, cannot communicate. Finally, there will be social isolation and mental health stigma. So, these are the 6 points which are the consequences of neonatal hearing deficits.

The second point to note that is that out of hospital birth and lower follow up rates are still a challenge for many developing countries, decreasing the coverage of neonatal hearing screening When the baby is born outside the hospital and there are certain test that has to be done like there can be done even if the baby is born out of the hospital which can be done if the follow up that means that you can take the baby or parents will take the baby to the hospital let the test run through.

And that will help at least in terms of neonatal hearing deficits to understand the deficits. Early detection and treatment of hearing impairment in infants hairs benefits effect on language and speech sound acquisition. So, that is a advantage or benefits. So, how does it work so you have to have auditory stimuli generation. Now, you do not require all these things because these are not a young adults or a fully grown humans.

These are infants and not even infants actually the babies who are born within that means after that birth within 3-4 days of that birth we need to measure this. So, keeping all these things is cumbersome is not advisable and that is why we have to come with a alternate technology. Now, when we say we are there anyone who has already thought about it yes there are groups who has thought about it.

And we will look into those some of the products available or one or two products available. Now, what do you do? Once you have these EEG signals acquire from the scalp you had to go for signal acquire conditioning and EEG acquisition that signal conditioning is important because there was signal who have lot of noise and those noise can be filter out using a particular filtering technique.

Generally, we have learn in our undergrad is that there are low pass filter, high pass filter, band pass filter, band reject filter or we can say notch filter, but what about Kalman filter, what about adaptive filters. So, look into those terms as well and finally after looking at the signals where we have to do the signal analysis we can give the results.

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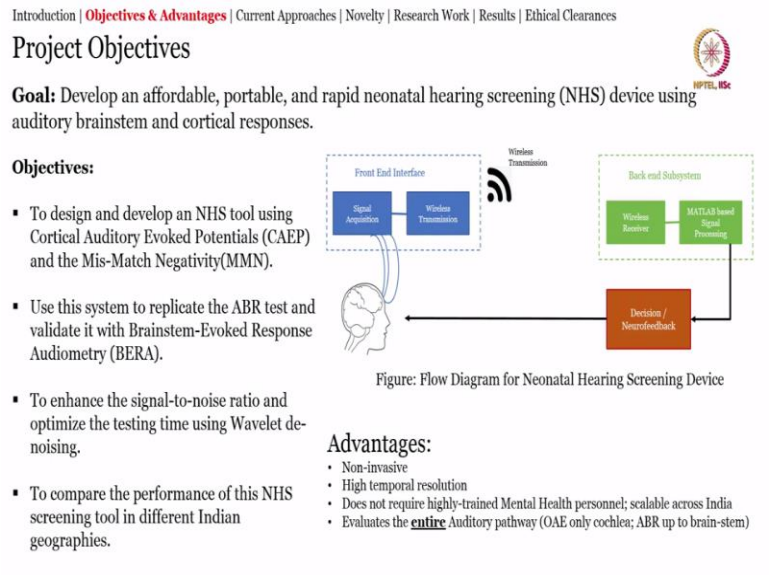

So, the project objectives is not to just develop neonatal hearing screening device, but also to understand are there any other biomarkers either we can add to further improve the screening technique and can we reduce the time that is taken by the current technology significantly. So, for any systems that you generally come across there is a front end and there is a back end.

In front end is a signal acquisition and wireless transmission. The backend system is wireless receiver MATLAB based signal processing, we can use MATLAB, we can use other techniques as well and then the decision and feedback is depending it is given back to that person. So, these are flow diagram or flow diagram of neonatal hearing screening device. So, to design and develop an NHS tool this is what we will look into.

And that is why I have written in terms of project and objectives. So, NHS tools using CAEP; what is CAEP means? CAEP means Cortical Auditory Evoked Potentials and we come with a new term now which you can see here mismatch negativity or MMN. So, we would like to replicate the ABR test which is a gold standard for neonatal hearing screening and we would like to validate it with the brainstem evoked response audiometry which is a BERA system.

We also would be using wavelet denoising to improve the signal-to-noise ratio and finally compare the device with the existing BERA system and then followed by screening few babies in different geographies. To start with as I told you we require human ethical clearance to utilize the device on and by placing it on the neonatal head for improving the hearing screening.

So, we have the ethical clearance so we are going to use this system. The advantages are non invasive, high temporal resolution, do not require high trained mental health of personnel and that is why it is scalable across our country here in India, evaluates the entire auditory pathway OAE only cochlea were ABR up to brain stem that is another advantage that we want to put it further because now we understand how the EEG looks like is to not only look at the outer hair cell for about a year. But also, to look at the brainstem and also to further go and look at the completely auditory pathway.

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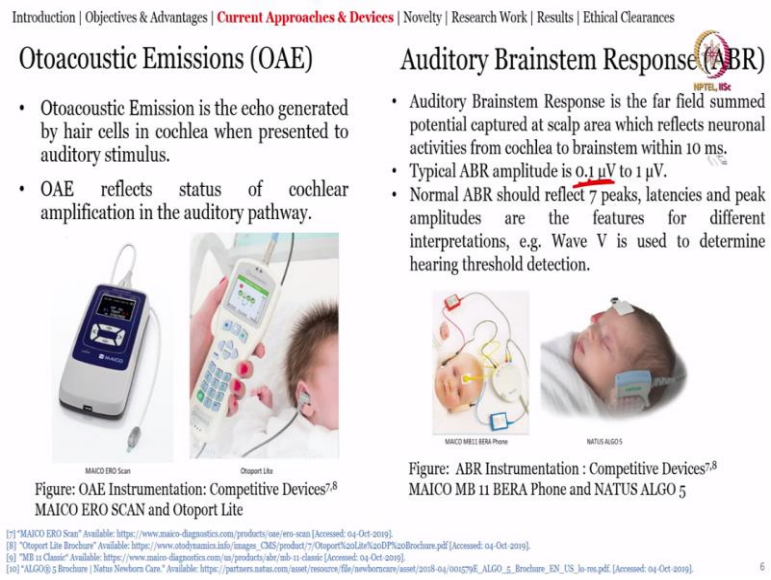

So, like we discussed OAE is nothing, but otoacoustic emission and it is the echo generated by hair cells in cochlea when presented to the auditory stimulus. So, the OAE reflects status of cochlear amplification in the auditory pathway and the image that you see or the picture that you see is one such system which is from competitive devices is Maico ero scan and otoport lite.

And these are the devices used for otoacoustic emissions. The second and the most normally used system is a BERA system and you can see here again from same company we have MB 11 BERA phone and Natus Algo 5. So, these are two different systems that are used currently and the auditory brainstem response is a far field summed potential captured as I told you earlier which reflects in neuronal activities from cochlea to brainstem with first 10 millisecond very important to look at the numbers.

Typical ABR amplitude is between 0.1 microvolts to 1 microvolts normal ABR should reflects 7 peaks latencies and peak amplitudes are the features for different interpretation examples wave 5 is used to determine hearing threshold detection. So, the ABR amplitude is 0.1 microvolts to 1 volt and as we see normally 7 peaks and the time to capture the data is 10 milliseconds and finally the wave 5 is used to determine the hearing threshold.

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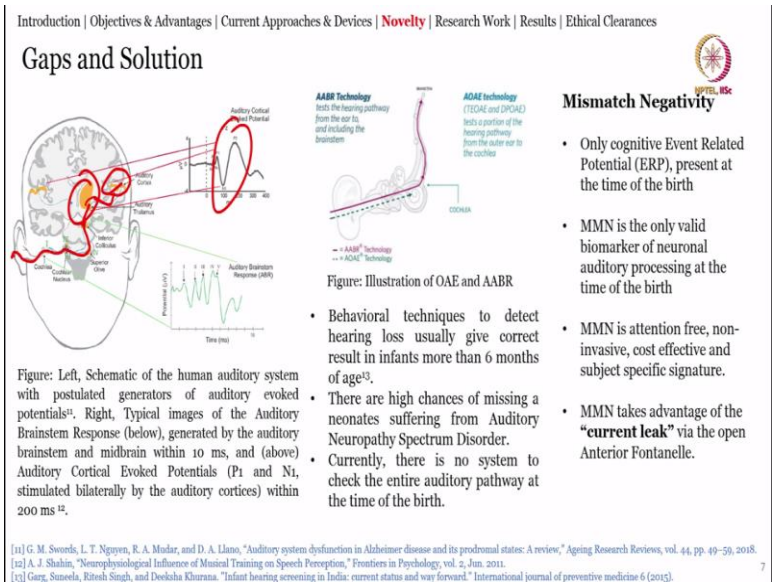

It is a very important slide if you look into the gaps and solutions. What are the gaps? So, like I said for the ABR we just look at first 10 milliseconds and that is it, but for your mismatch negativity we go from P 1, N 1 P 2, N 2. Now what is the advantage because if you see when a stimulus is given the process it passes through cochlea goes here and then superior olive goes to inferior.

And then goes to your auditory thalamus here it processes it is a path for the ABR. What we want to do is we also want to look at the P 1, N 1, P 2, N 2 because in that case it will reach further from you are not just the half path of the auditory pathway, but from auditory thalamus it will further process down and it will leads the auditory cortex that means that you are looking at the full entering signal pathway.

In ABR as we have seen there are 7 peaks which are observed here and peak 5 is a one which says that okay it is the hearing peak. This is the illustration of OAE and AABR. So, behavioral techniques to detect hearing loss usually give correct results in infants more than 6 months of age. So, behavioral technique is only useful only 6 months of age not for neonates that is one important thing to understand.

The second thing is there are high chances of missing a neonates suffering from auditory neuropathy spectrum disorder. This is very important to understand and currently there is no system to check the entire auditory pathway at the time of birth very few in fact none are there who are claiming to or with the devices which are claiming to perform the entire auditory pathway at the time of birth.

Now, I told you a term called mismatch negativity which is P 1, N 1, P 2, N 2 the mismatch negativity is the only cognitive event related potential and event related potentials are also called ERP present at the time of birth. The mismatch negativity is the only valid biomarker neuronal auditory processing at the time of birth only biomarker. The next thing is that the MMN is attention free, non-invasive, cost effective and subject specific signature.

So, from babies to babies when one baby comes and you place the device and the signals that you generate and the second baby comes the mismatch negativity values would be different. So, can mismatch negativity will be a brain biomarker to understand the neonatal hearing screening that is our interest. So, mismatch negativity is attention free, non-invasive, cost effective, subject specific signatures.

Why it is useful for neonate because the current peak will happen since the anterior fontanelle this is the fundamental importance or fundamental parameter for us to understand that when the babies are born the bone is completely fuses into the skull and that is why there is current leak which will help us to measure the mismatch negativity.

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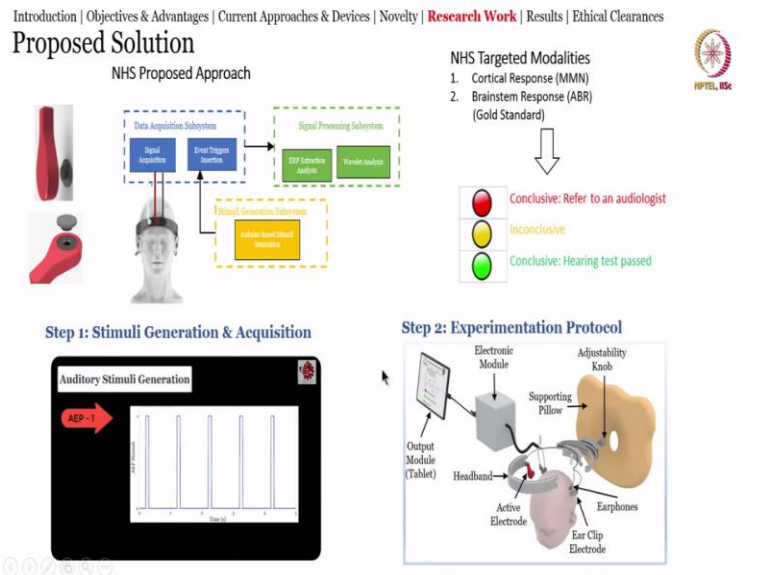

So, let us see this auditory stimuli generation in the bottom left of my slide and this is the proposed solution that means a person wearing the headband and in this case we do not require many, many electrodes we require only few and then the data acquisition system takes over where you have signal acquisition and extent triggers insertions while the next type would be signal processing here ERP extraction analysis and wavelet analysis.

What is wavelet analysis? We see in a very simple term I will tell you suppose you require 80 epochs or 100 epochs that means 100 times you have to give the stimulation so that you can get the signal at the prefrontal area and then you average it out to get the mismatch negativity or your other bio potentials like ABR, but if you want to reduce the time of the processing, acquisition everything you go for the of course not acquisition once you acquire it then.

So, you go for the wavelet analysis it reduce time significantly and the stimuli generation is done using Arduino based stimuli generation board, but we can also use other parameters and there is a presenter software if you remember, if you know so let us understand this one and it has some sound at certain interval.

So, you see there are three different sounds first is your AEP, then your MMN and then your NHS. NHS is a signal that can arrive at anytime. So, there were 3 different stimuli that I have shown it in this particular slide. So, the NHS target modalities, cortical MMN, brainstem response ABR and this is experimental protocol where you have the band on the baby's head, there is a supporting pillow and then electronic module which is connected to your tablet.

So, this is the way that stimuli is provided and corresponding the signals are acquired. So, what we will do, we will stop here and we will take the solution of how if you have the stimuli, if you apply the stimuli and corresponding if you acquire the signals, how the signals can be processed further and what kind of band we can design for the neonatal hearing screening. So, we will take in the next class.

I do not want to like again put too many things to you in one single sitting that will be too difficult for you to digest as well. So, let us meet in the next class and understand further how this process can be done and then we will talk about the micro electrode array for not only epilepsy, but also for Parkinson to go to the next set of lectures. So, if you have any questions again I have tried my best to answer the questions that you asked on the forum through my TA.

And I hope you continue asking, continuing being curious, continuing being interested in learning and some other terms that I may not go into detail you have a chance, you have a time to go back and see what terms has been used. A very simple terms like wavelet analysis what is it. Adaptive filtering what is it, Kalman filtering what is it. So, some of the terms that I give it to you during the interaction you can take it. And you can use it to understand how or

what exactly that term was used for during that particular slide. So, I will see you in the next class and continue from there till then you take care bye.