Possibility of Using ABR for Diagnosing Autism

Ms. Halley Parihar Gitonga
OUTLINE

Autism

Auditory Brainstem Responses

Auditory Brainstem Responses in Autism
AUTISM

Neurodevelopmental/ developmental neurobiologic disorder with predominant involvement of central nervous system dysfunction.

Characterized by severe impairments in social interaction and communication and a restricted and repetitive behaviour

Autistic Traits [1]
• Hyperactivity
• Stereotypic behaviour
• Cognitive dysfunction
• Inattentiveness
• Language comprehension differences

Autistic Traits
• Increased/decreased senses
• Difficulty adapting to new situations
• Do not like their ears being touched
• Increased anxiety
• Habituate to stimuli very slowly/quickly
• Often do not tolerate headphones/inserts

1. Rosenhall et.al. (1999)
In addition to delayed development of spoken language, auditory abnormalities and unusual responses to auditory stimuli have been reported in autism [2, 6].

Indeed, the existence of unusual sensorial responses is considered a trait that accompanies autism [2, 5].

For example, children with autism may show hyposensitivity or hypersensitivity to touch or textures, lights, and sounds [5, 6].
Auditory characteristics in children with ASDs

• Hyper-/hyposensitivity to sound
• Difficulty listening in background noise
• Difficulty maintaining focus to auditory information
• Unresponsiveness to certain sounds (e.g. verbal commands, environmental sounds)
• Middle ear problems

• Some of the auditory sensory issues that children with autism often present with, like hypo/hypersensitivity to sound, have been theorized as being a result of a brainstem abnormality or a cortical or subcortical involvement.

• It has also been hypothesized that auditory sensory deprivation may contribute to the cause of autism.[1]

• Several studies [8, 9] have reported that the auditory sensitivity of individuals with autism might be associated with a reduction in the function of the medial olivocochlear (MOC) system or an unusual MOC system asymmetry and suggested that this asymmetry indirectly reflects more central auditory processing alterations [8, 9]

• As a consequence, many researchers persuade the idea that impairment of the auditory system (particularly the brainstem) is involved some or other way in autistic traits.[7]
• Much information can be obtained about the **functionality of auditory pathways** throughout the brainstem using the ABR.

• In recent research, **ABR** is under spotlight and is being considered as **the perfect tool** to investigate autism in infants, toddlers and children.

• As it does not require active participation from subjects, which would be particularly useful in uncooperative subjects like those often seen with ASD.
Best testing methods for children with developmental disabilities:

- Auditory Brainstem Response (ABR): Measure of the brainstem response to auditory stimulation
  - High specificity
  - Sedation available for those who cannot sufficiently relax or sleep for testing

- Conductive hearing loss, sensorineural hearing loss and sensory integration issues could all be measured using brainstem evoked response
  - Larger I-V interwave would suggest a conductive hearing loss. This delayed conduction is common latency in children with ASDs.

- Elevated thresholds without change in wave latency would suggest a sensorineural loss

- Late potentials amplitudes have been found to be lower in children with autism, implying possible sensory integration issues.
ABR: Auditory Brainstem Response

- The activity of the nervous system produces electrical signals that can be picked up by electrodes placed on the head, and can then be displayed on the screen of a recording device.
- A change in the **activity of the nervous system** occurs when it reacts to a stimulus (such as sound).
- This change also **produces a change in the electrical signals** picked up by the electrodes.
- As a result, the nervous system’s reaction to a stimulus can be seen as a change in the electrical signals that are displayed on the recording device.
- These electrical responses of the nervous system elicited by a stimulus (sound), they are called **auditory evoked potentials (AEPs)**.
• AEPs is made up of a characteristic **grouping of peaks and troughs** that occur within certain range of latencies.

• **Latencies** is simply amount of time that has elapsed (delay) since the stimulus was presented.

• The range of latencies in AEPs is identified as the **short, middle and long latency responses**.

• The group of waves identified as the ‘**short latency response**’ are known as the **Auditory Brainstem Response**.

• They include up to **seven peaks** that normally occur within about **8msec** following the onset of the stimulus.
• These seven peaks are positive peaks, called as waves, that are recorded in the upward direction and numbered from I to VII.

• This formation of positive peaks (waves) are called ABR Waveforms.
Generators/ origin of ABR waves

The waves are numbered in accordance with increasing distance of travel through the auditory system:

• Waves I and II are associated with the **auditory nerve**

• Waves III-V are associated with **brainstem structures**

• **Wave III** is derived from the cochlear nucleus and superior olivary complex of the pons, including the **medial olivocochlear system (MOC)**. The MOC as being involved in filtering ascending auditory inputs and integrating feedback from higher-order auditory nuclei and cortices.

• **Wave IV** arises from the **superior olivary complex and lateral lemniscus area**.

• **Wave V** comes from activity in **ascending axons of the lateral lemniscus**

Interpretation of the ABR waveform

- Clinical ABR measurements are concerned with the first five peaks (I to V) and concentrate on peaks I, III and V.

- The ABR waveform is usually described and interpreted in terms of the **latencies and amplitudes** of these peaks, as well as the morphology or the overall configuration and appearance of the waveform.

- A given wave’s absolute latency is simply the time delay from 0 msec (where the click is presented) until its peak occurs.

- The time interval between two peaks is called an **interwave latency** or relative latency.

- Interwave latencies are usually measured between waves I & V, I & III and III & V.

- **Wave V** is the most prominent and robust of these peaks and is also closely associated with wave IV.
As the stimulus intensity gets lower, the peak latencies becomes longer and their amplitude become smaller.

The latency shift is seen vividly by the rightward shift of wave V as the intensity drops progressively.

Also, the earlier peaks become less distinctive and eventually disappear with progressively lower stimulus levels.

Even though wave V becomes less distinctive and later with decreasing intensity, it is generally still discernible at levels as low as the behavioural threshold for the click, which is typically down to 0 dB nHL.

The thresholds can also be represented in a graph that plots latencies of waves I, III and V as a function of stimulus (click) level. Such a graph is called a latency-intensity function.
• Different abnormalities affect the ABR in different ways, so that it can used for differential diagnosis.

• **Maturation, gender and aging** need to be considered when developing norms and interpreting the results.

• Wave I, III & V are observed in newborns, but the absolute latencies of waves III & V are prolonged relative to adult.

• As the infant matures, the other peaks emerge, the latencies of the waves shorten, and their amplitudes change. Eventually achieving adult characteristics by roughly 18 months of age.
Table 2. Summary of latency values for auditory brainstem responses elicited with click and tone burst stimuli at selected intensity levels.

<table>
<thead>
<tr>
<th>Click Stimulus</th>
<th>80 dB nHL</th>
<th>20 dB nHL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L</td>
<td>R</td>
</tr>
<tr>
<td>n</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>mean</td>
<td>1.64</td>
<td>1.7</td>
</tr>
<tr>
<td>min - max</td>
<td>1.40 - 1.91</td>
<td>1.5 - 2.0</td>
</tr>
<tr>
<td>95% CI</td>
<td>1.59 - 1.89</td>
<td>1.65 - 1.75</td>
</tr>
</tbody>
</table>
Is there a possibility of using ABR to detect risk of Autistic features in infants and toddlers??

YES!! Various researchers support it.
**STUDIES**

- Dabbous (2012)

<table>
<thead>
<tr>
<th>CHILDREN WITH ASD</th>
<th>TYPICAL DEVELOPING CHILDREN</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>1 YEAR 6 MONTHS – 3 YEARS 3 MONTHS</td>
<td>1 YEAR 6 MONTHS – 3 YEARS 3 MONTHS</td>
</tr>
<tr>
<td>Delayed language development</td>
<td>Healthy, without any psychiatric or medical disorders.</td>
</tr>
<tr>
<td>All had intolerance to noise</td>
<td>Normal hearing thresholds</td>
</tr>
<tr>
<td>Normal hearing thresholds using auditory brainstem response (20 dB nHL or better) were included.</td>
<td>Normal hearing thresholds</td>
</tr>
</tbody>
</table>
Morphology good (does not reflect physiological changes).

Earlier appearance of autistic children ABR wave I than the controls indicate quicker synaptic processes in the organ of Corti.
• The prolonged wave III and longer IPI: I- III reflects a retro-cochlear dysfunction in ASD that may be related to their difficulty discriminating, leading to difficulty communicating with others, and at the same time a normal peripheral auditory function that can hear the meaningless sounds which may be related to their abnormal reactions to sounds.

• Kwon et al. (2007), Magliaro et al. (2010), Rosenhall et al. (2003), and Wong and Wong (1991), found an increase in absolute latencies of wave V and inter-peak I-V and III - V in those with autism compared to controls. This indicate that children with ASD have a dysfunction or immaturity of the central auditory nervous system.

• Yongsheng et. al. (2010). As compared with the values in the control group, the latency of wave V for both ears, wave I - V and wave III - V intervals for the right were significantly prolonged in the ASD group.

• The brainstem abnormalities may be partly responsible for deviant language, cognitive and social development in children with ASD.
INCREASED CONDUCTION TIME

• These prolonged latencies were **reflective of increased conductance times** throughout the auditory nerve and brainstem. These observations led to the hypothesis that there are myelination problems during development in ASD, which may **contribute to structural abnormalities and lead to symptom.**
INCREASED WAVE AND IPL LATENCIES IN ABR: WAVE III, V, IPL III-V

- Miron, Henkin, et. al. (2016) Examined reports of the 70 infants born between 1997 and 2013 who were later diagnosed with ASD.
- They were all tested between 2.0 and 5.5 months of chronological age which after correction for prematurity was between 0.5 and 3.4 months.
- Absolute latencies and IPLs of the ABRs were compared between infants with ASD and case-matched controls.
- Infants who were later diagnosed with ASD exhibited significantly prolonged latencies of ABR wave V and the IPL of I–V in ABRs during stimulation of either the right or left ear.
- The strongest difference across groups was noted in the absolute latency of wave V in the right ear.
The majority of infants who later develop ASD exhibit abnormally prolonged ABRs already during the first three months of life, even when having normal hearing thresholds.

- This abnormality, which was evident in significant prolongation of ABR wave V latency in both the right and left ears, enabled accurate identification of infants who later developed ASD with 70% accuracy and that of controls with 80% accuracy.
- Prolonged wave V latencies are due to impaired progression rates of myelination of the auditory system in children with ASD, with some research pointing to marked delays [Perkins et al., 2014; Peterson, Mahajan, et. al., 2014; Roberts et al., 2013; Wolff et al., 2012]
- ABR abnormalities in ASD seem to already appear at birth and persist throughout early development, as reported in toddlers and older children
What to look out for in ABR

Increased Conduction Times in ABR

Increased Wave and IPL Latencies in ABR: Wave III, V, IPL III-V

Correlation with DPOAE, TEOAE.
• There are many studies that report **no difference in ABR findings** for both typically developing children and children with Autism. So, there is divided thoughts on whether ABR can be used as an indicator of Autism.

• **More studies are needed** to substantiate the ABR findings.

• ABR is a **battery test** and should not solely to diagnose clinical population. It should **collaborate with OAE, PTA and Immittance**, to come to diagnosis or Autism risk factor.

• All the procedures, psychological assessment, behavioural assessment, electrophysiological, etc. should be considered to describe key aspects of Autism and to enable the understanding of clinical manifestations of this population.

• **Cross-check principle**: more than one test should be implemented to form a battery

• Behavioral and physiological assessment

• Provides supplemental information to better understand the child’s auditory abilities
THANK YOU