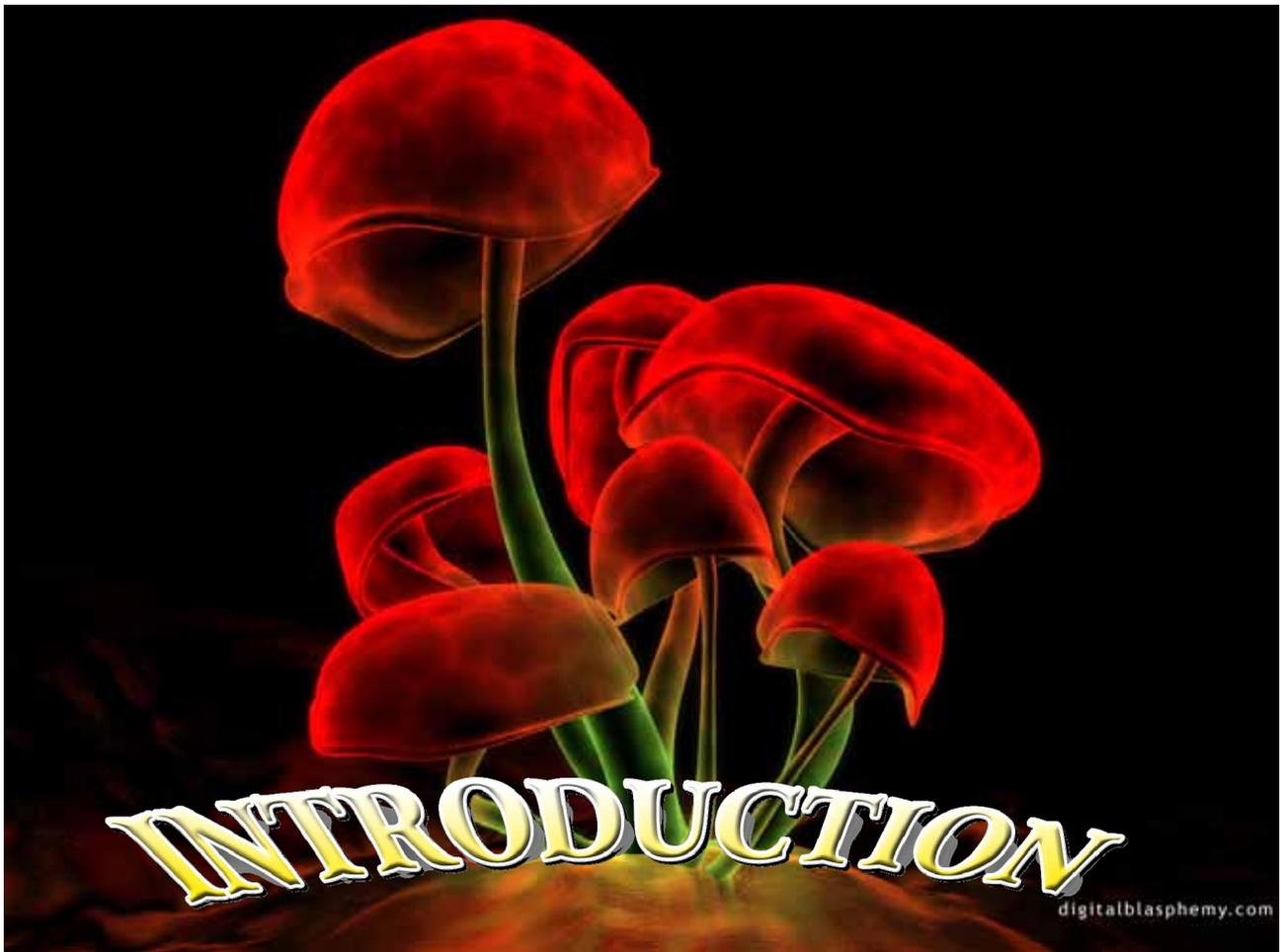




**Mismatch Negativity as an Objective
Tool for the Assessment of
Cognitive Function in Subjects with
Unilateral Severe to Profound
Sensorineural Hearing Loss**

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■ **Auditory nervous system is the most complex of all sensory pathways. Although complex, yet it is highly ordered** (Musiek and Oxholm, 2000).

■ **Perception is the gate of cognition which requires registering, transforming and acting on sensory inputs** (Gazzaniga, 1996).

■ **Asymmetry between the two hemispheres in human brain is found to be present at the functional as well as anatomical levels** (Toga and Thompson, 2003).

■ **The function of the two hemispheres complement each other. One hemisphere may be dominant for one process and the other is dominant for a different process** (Musiek et al., 2002).

■ **The best example of lateralization in humans brain is speech perception.**

■ **Left hemisphere is responsible for processing of the temporal aspects of speech.**

■ **While the right hemisphere is responsible for processing the spectral aspects** (Hickok and Poeppel, 2000).

Unilateral Hearing Loss

- It is the unaidable hearing in one ear and normal hearing in the other.
- The unaidable ear may be: profound HL with no benefit from amplification, very poor word recognition, or marked intolerance of amplified sounds (Valente, 2002).

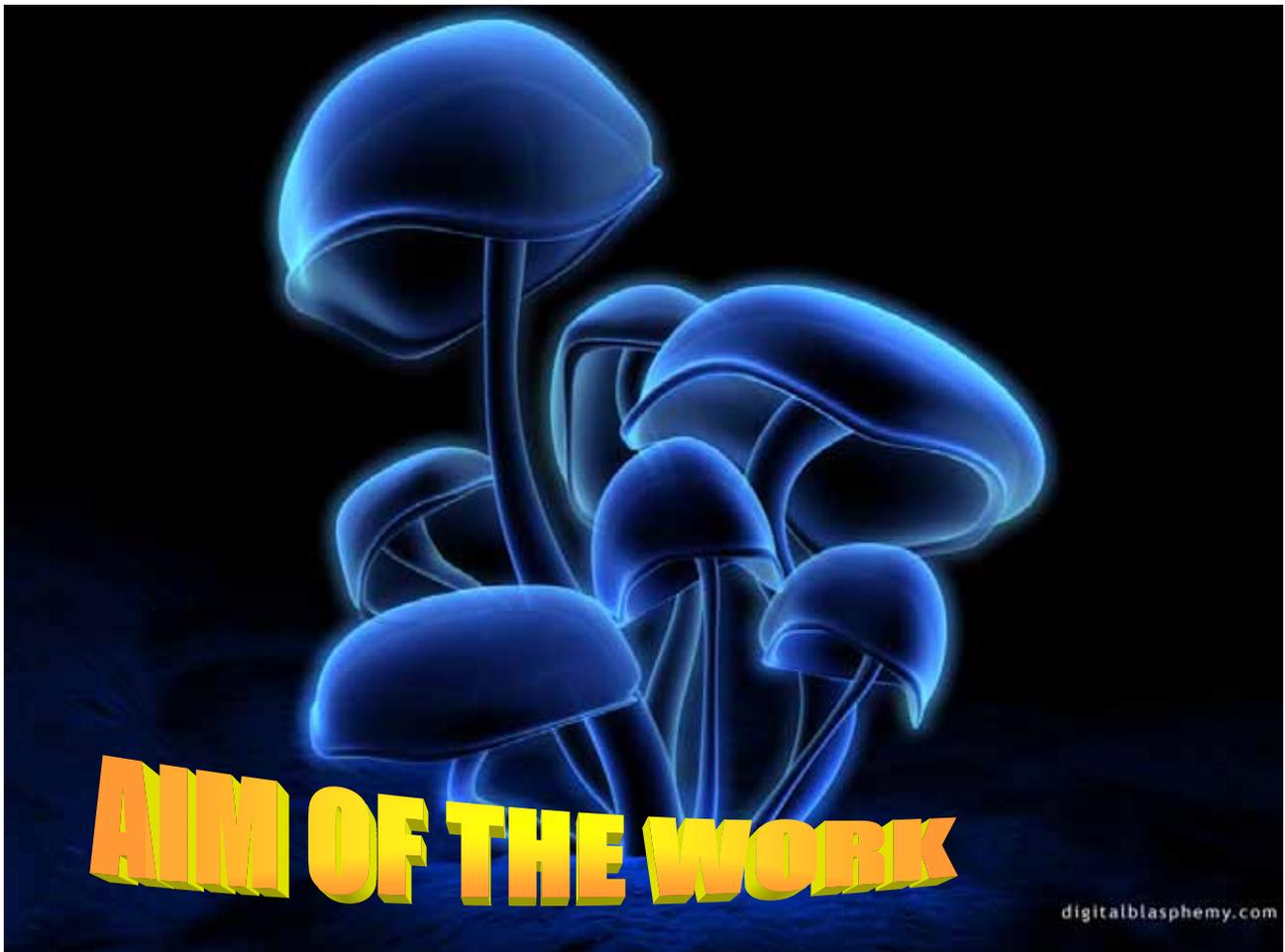
■ After UHL, reorganization of auditory cortex occurs with increased activation of the ipsilateral pathway which may be dependent on the side of UHL (Kholisa et al., 2003).

■ This indicates that the auditory system is plastic & is able to reorganize its structure and function after partial or total loss of receptor function.

Mismatch Negativity (MMN)

- It is one of the cognitive component of the ERPs, which reflects the processing of a stimulus beyond its physical features.
- It provides a measure of auditory sensory (echoic) memory (Näätänen et al., 1997).

- MMN can be used clinically in studying lateralization of speech and non speech memory traces in subjects with either bilateral or unilateral hearing loss (Shtyrov, 2000).



- **The effect of acquired UHL on the cognitive function.**
- **The impact of UHL & its duration on normal cortical asymmetry.**
- **Comparing UHL in right ear versus left.**
- **Processing of speech and non-speech stimuli using MMN.**



Subjects and Method

I. Subjects:

1. The control group:

50 right-handed subjects with bilateral normal peripheral hearing and bilateral normal middle ear function.

2. The study groups:

- a) **RES subgroup: left ear severe to profound or total HL and right normal peripheral hearing.**
- b) **LES subgroup: right ear severe to profound or total HL and left normal peripheral hearing.**

II-Method:

- **Equipment:**

- **Sound treated room: Tracoustic Model No RE. 241.**
- **Pure tone audiometer: Interacoustic Model AC30.**
- **Immittanceometry: Hansaton Model Az7.**
- **Two-channel SmartEP including software for MMN**

III-Procedure:

1-Full audiological history .

2-Otological examination.

3-Basic audiological evaluation including:

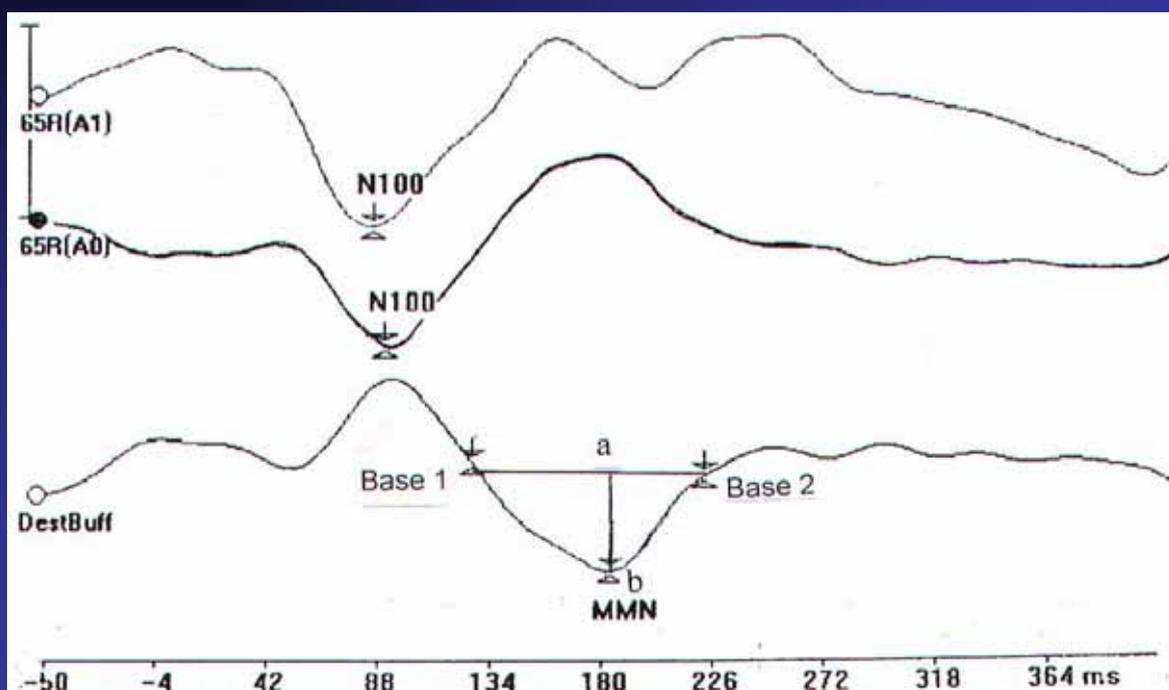
- Pure tone audiometry.**
- Speech audiometry.**
- Immittance test.**

4-Mismatch Negativity (MMN):

The stimuli used were of two paradigms :

1. In the first paradigm: CV syllables /da/, /ga/ were used. The first was the standard while the second was the deviant.
2. In the second paradigm: 1KHz & 2KHz were used. The first was the standard stimulus and the second was the deviant.

Calculation of MMN





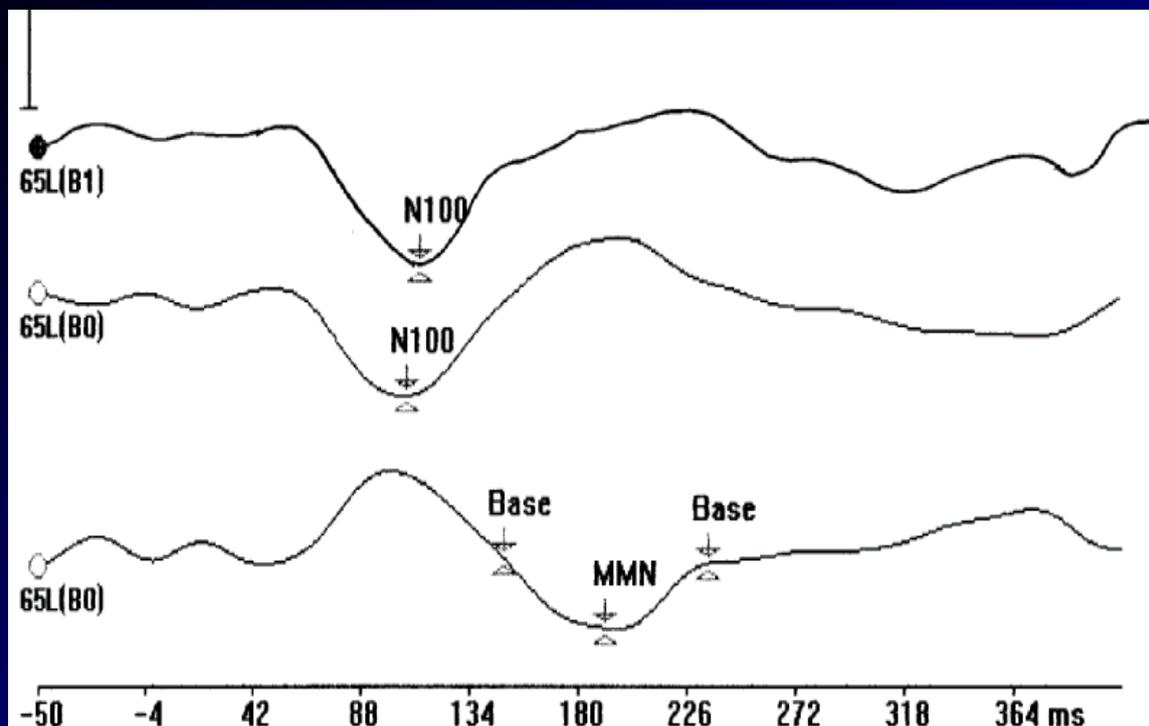
□ In the control group:

On using speech stimuli, there was only significant increase in MMN amplitude in the REC ($P < 0.05$).

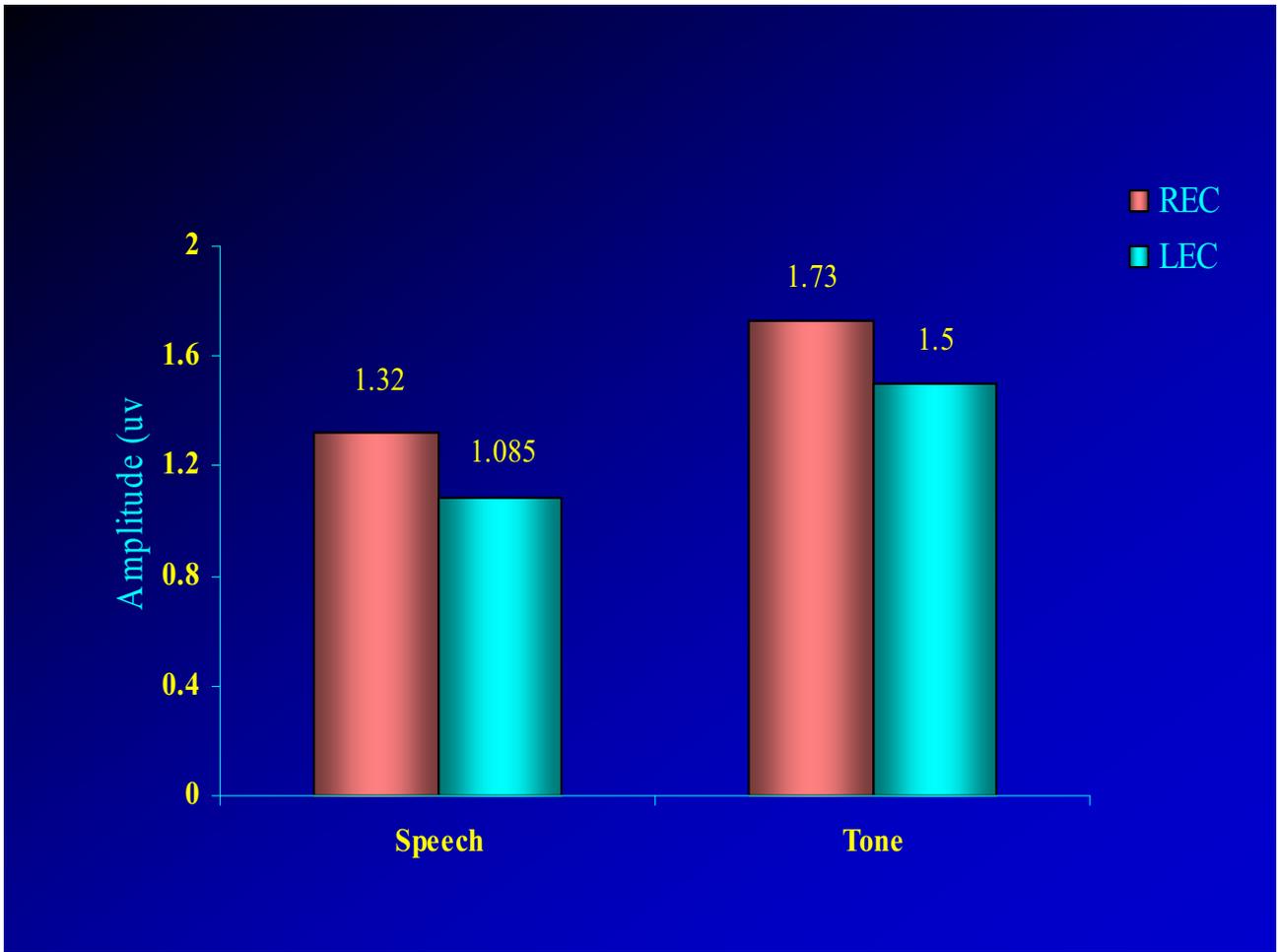
This could be explained by using the contralateral pathway to carry speech stimuli to the left hemisphere. This is consistent with the work of Alho et al., (1998).

On using tone stimuli, there was no significant difference between REC & LEC ($P > 0.05$).

This is consistent with Belin et al., (1998) who reported that non-speech materials of longer transitions (> 40 ms) elicit bilateral symmetrical hemispheric activation.



MMN in the left ear of a subject with bilateral normal peripheral hearing on using speech stimuli.



□ In RES subgroup:

On using speech stimuli:

MMN was present in 62.8% of cases.

MMN had significantly delayed latency when compared to (REC).

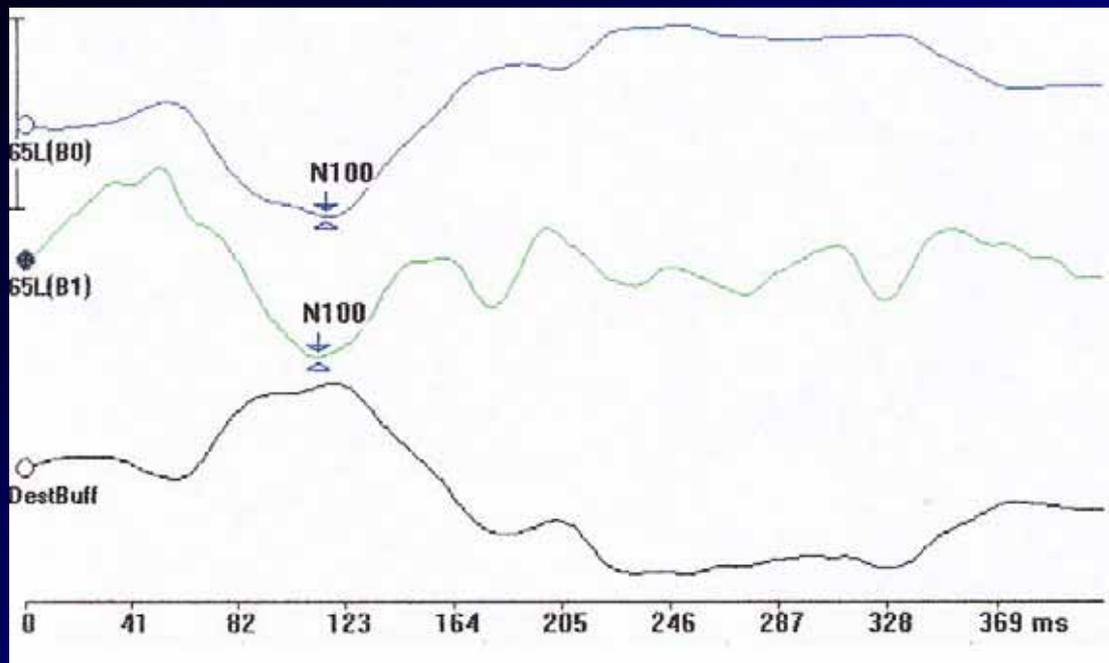
Mean delay was about 16ms which was the interhemispheric transfer time reported in the work of Bjorkhund and Lian (1993).

□ In LES subgroup:

- Only MMN latency was significantly delayed when compared to LEC ($P < 0.05$).
- This is consistent with of Kholsa et al., (2003).

□ Comparing RES with LES:

- RES subgroup showed absent MMN in some cases & delayed latency in the others when compared with LES subgroup.
- This is consistent with Kholsa et al (2003) who reported more symmetric activation of ipsilateral (earlier latency) & contralateral (degradation through inter-hemispheric transfer) pathways in cases with left UHL (RES).



Absent MMN response in a subject with left UHL (RES) on using speech stimuli.

On using tone stimuli:

□ In RES subgroup:

There was no significant difference between RES subgroup & REC ($P > 0.05$).

□ In LES subgroup:

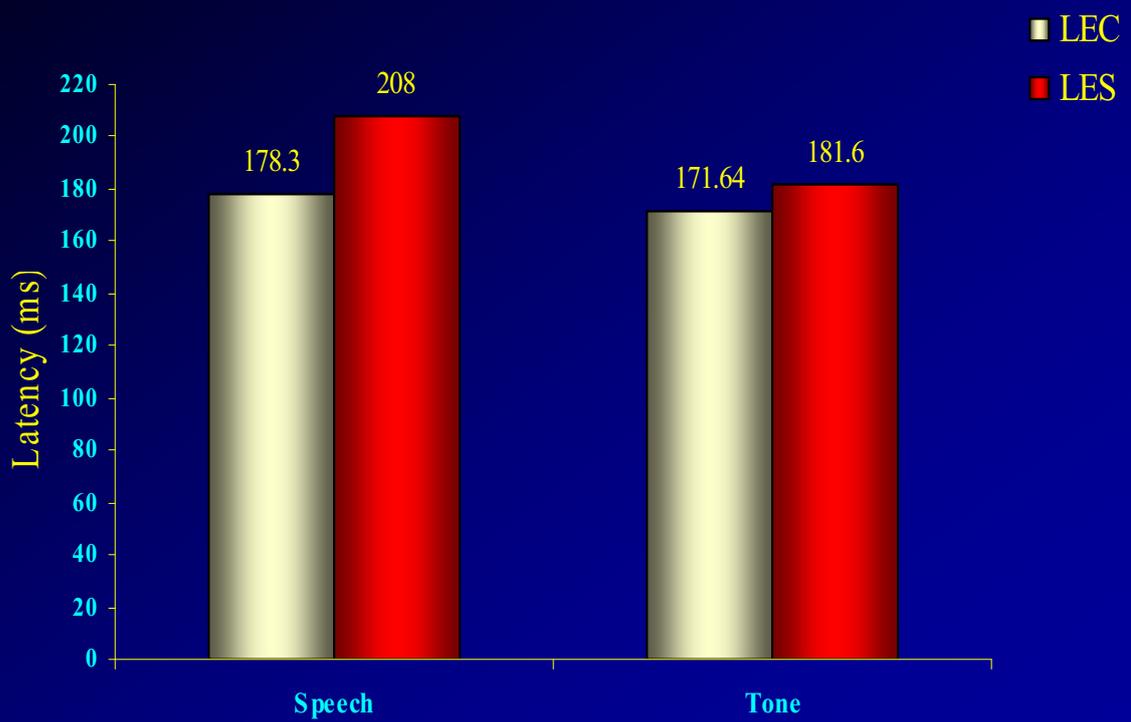
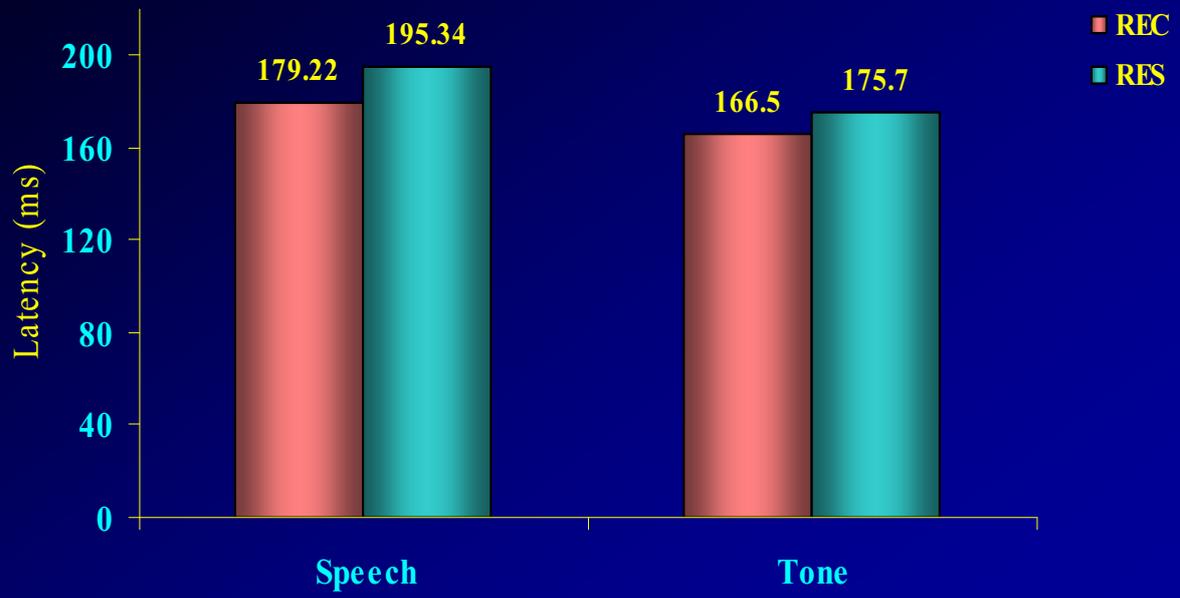
There was no significant difference between LES subgroup & LEC ($P > 0.05$).

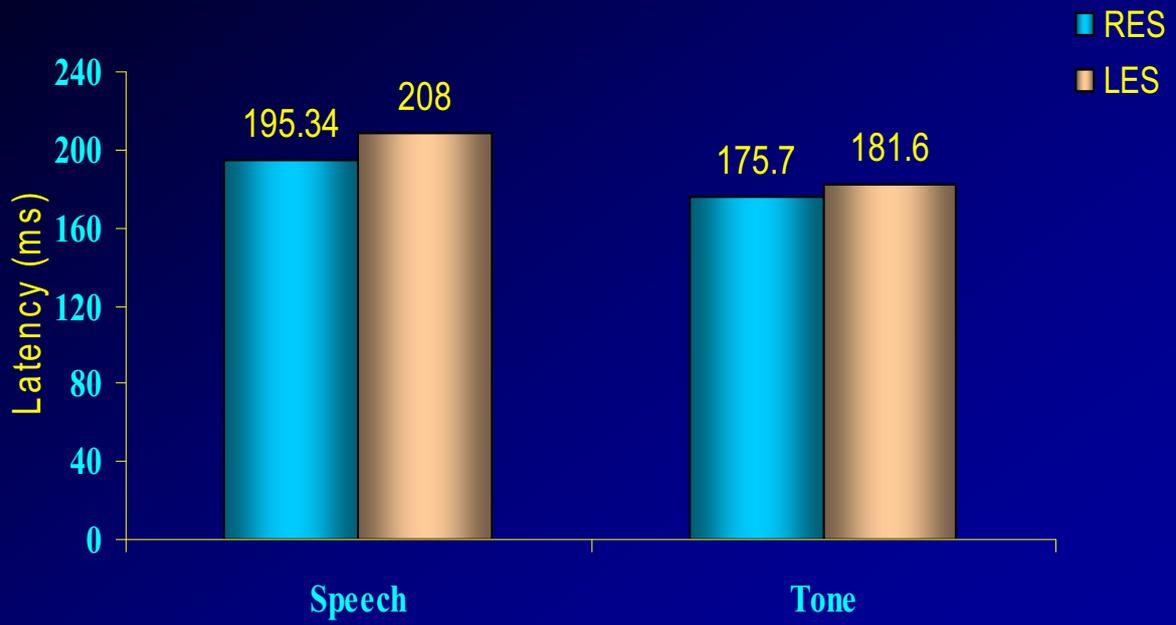
- These results are not in accordance with Scheffler et al., (1998) who reported that patients with UHL have stronger and earlier responses at the ipsilateral hemisphere.

□ Comparing RES & LES subgroups:

- ✿ LES subgroup had significantly delayed MMN latency ($P < 0.05$).
- ✿ Smaller MMN amplitude, duration and area, were recorded, however, the differences did not reach the significant level ($P > 0.05$).
- ✿ These results are consistent with Fujiki et al., (1998).

- ✿ On the other hand, these findings disagree with Kholsa et al., (2003) who reported the use of the ipsilateral pathway in RES subgroup and the contralateral pathway in LES subgroup.





Effect of Age of Onset of UHL

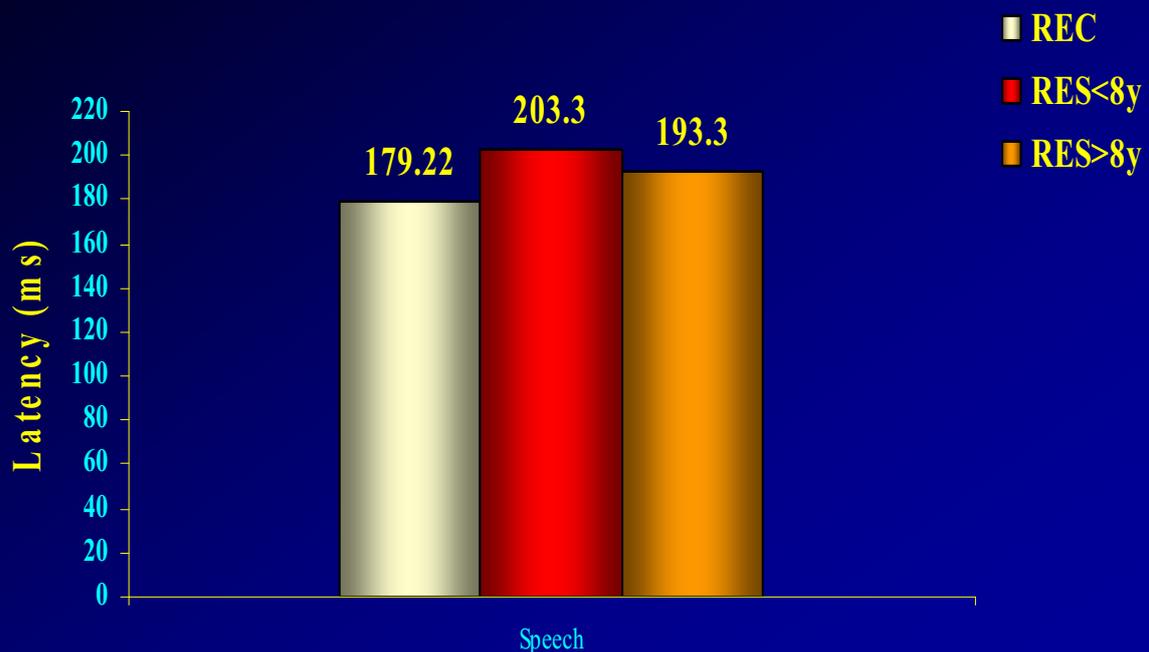
On using Speech:

□ In the right ear:

- **MMN was present in 47.6% of cases with left UHL before 8yrs with significant delayed latency ($P < 0.05$).**
- **This could be explained by degradation of speech stimuli in the ipsilateral pathway or through the interhemispheric connection in their way to the left hemisphere (Muller-Gass et al., 2001).**

- **MMN was elicited in 68.4% after the age of 8yrs with no significant difference from control ($P > 0.05$).**
- **This indicates that compensatory mechanisms still present in cases with delayed onset of UHL.**
- **This agreed with Ponton et al (2001) who reported that human cortex may alter its organization if it is deprived of its input for more than two decades.**

- **The increased number of cases with absent MMN in RES<8y (52.4%) indicated that the earlier the age of onset of UHL, the more drastic the effect on speech processing. This is consistent with Willott (1996).**



□ In the left ear:

- MMN was elicited in the left ears in cases with right UHL (before & after 8 years) with significantly delayed latency when compared with control ($P < 0.05$).**
- There was no significant effect of age of onset of UHL ($P > 0.05$).**

- This is consistent with Lieu (2004) who found that cases with right UHL are at risk for speech processing abnormalities whether it occurred early or late in life.**

❑ **Comparing the right and left ears:**

▪ ***Before the age of 8 years:***

MMN latency was affected whatever the side of affection.

▪ ***After the age of 8 years:***

Only cases with right UHL had significantly delayed latency.

- **This is not consistent with Musiek (2002) who reported that even the mature brain is capable of undergoing reorganization at the cortical level.**

On using tone stimuli:

- There was no significant difference between the subgroups and control group ($P > 0.05$).**
- There was no significant effect of the age of onset of UHL in either right or left ears ($P > 0.05$).**

- This indicated that tone processing may be independent on the side or age of onset of UHL.**
- This reflects early maturation of tone processing mechanism.**
- This is consistent with Durrant and Lovring (1995) who reported that simple tone discrimination does not need full cortical maturation.**

Comparing Speech vs tone in the study subgroups:

□ In the right ear:

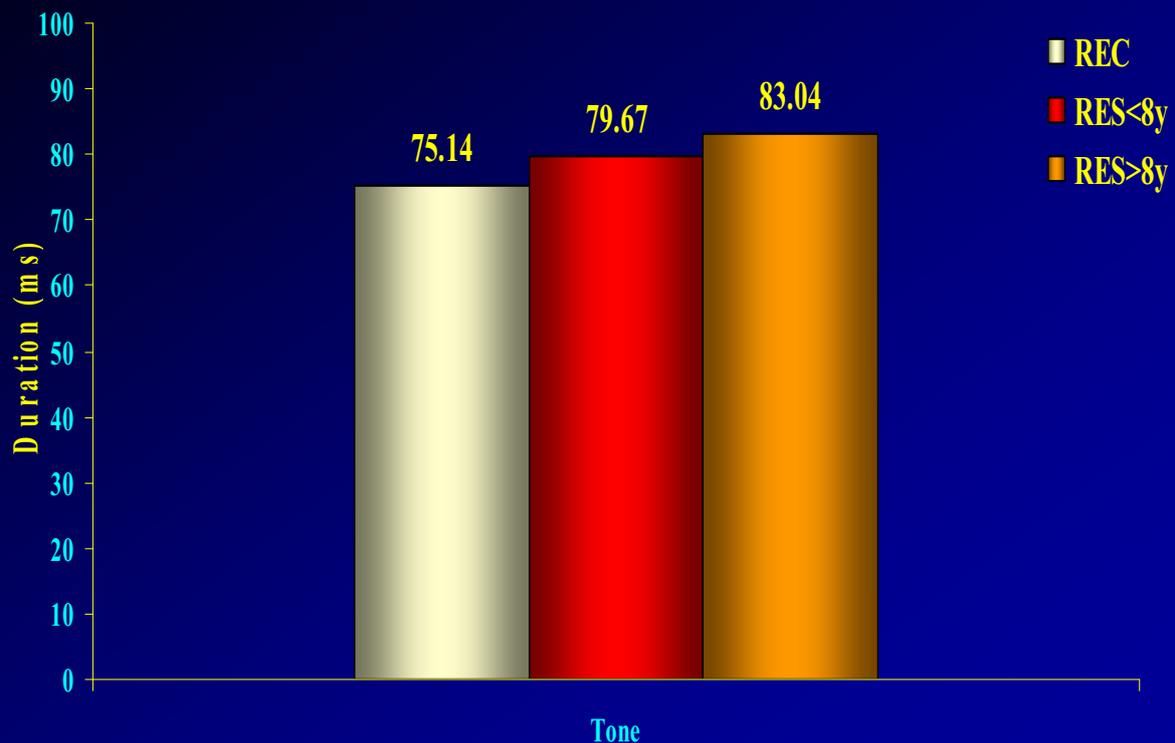
MMN latency was significantly delayed on using speech whether UHL occurred before or after age of 8yrs ($P > 0.05$).

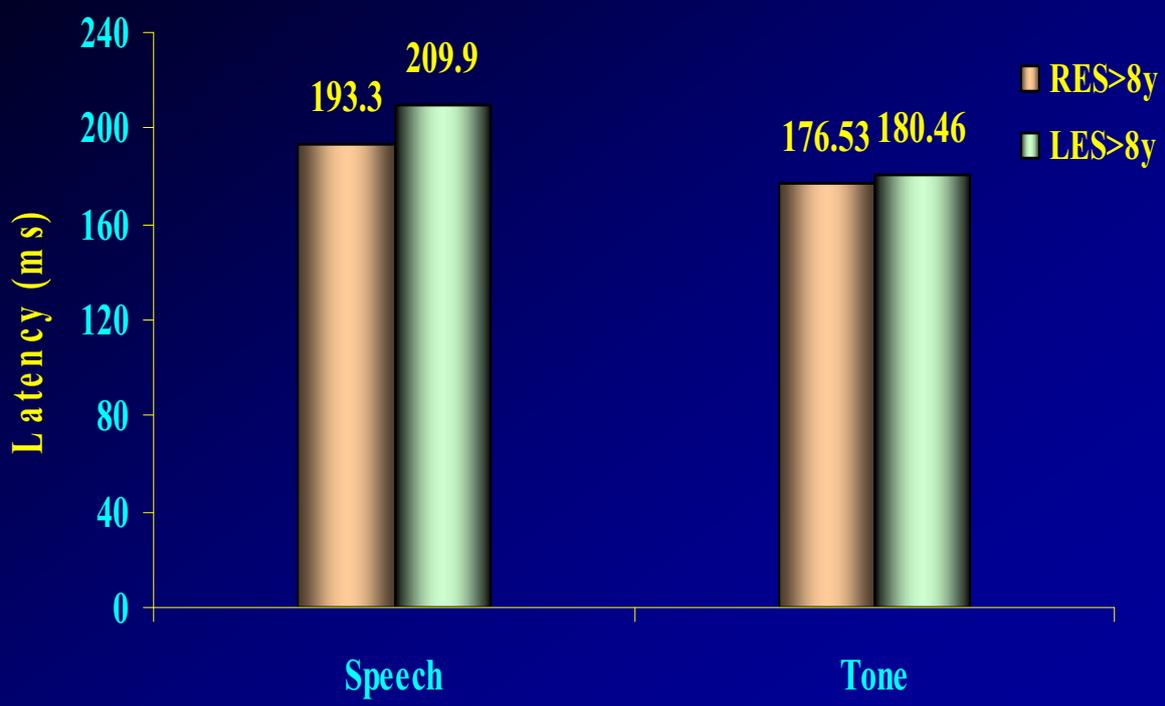
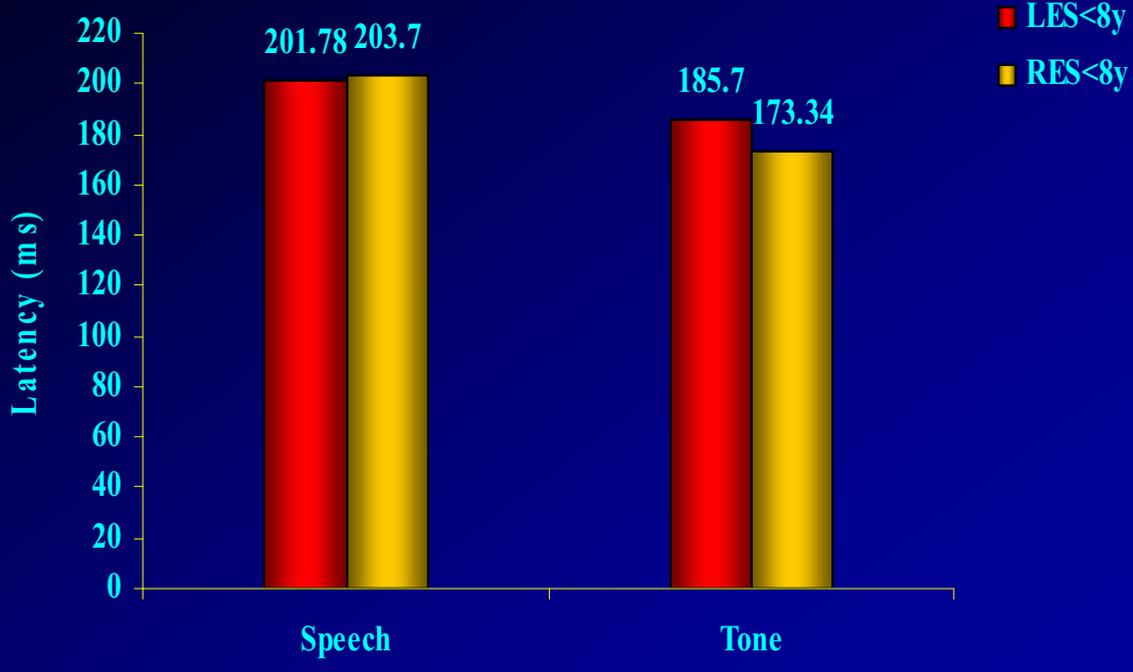
□ In the left ear:

MMN latency was significantly delayed on using speech stimuli when UHL occurred after 8 yrs ($P < 0.05$).

- This indicates that the age of onset of UHL has no effect on MMN response to pure tone.**

- **MMN response to pure tone were not affected by the age of onset of UHL. This is consistent with Durrant and Lovring (1995) who reported that frequency discrimination is most likely determined by the 1ry auditory neurons.**







- ✿ **Speculative mechanisms of plasticity are proposed to be responsible for reorganization in auditory system following UHL.**
- ✿ **The first mechanism could be an increase in the strength of the ipsilateral pathway due to:**
 1. Loss of inhibitory processes.
 2. Emergence of new projections in that pathway.
 3. The presence of kinetic process.

● The MOC system may be involved in plasticity following UHL.

■ Plasticity depends on several factors:

1. side of UHL (right vs left UHL)
2. age of onset of UHL
3. age of the subject .
4. duration of UHL
5. and the type and complexity of the stimulus.



On using speech stimuli:

1. **MMN response was larger in amplitude in REC.**

2. **In left UHL (RES):**

- ✿ **MMN was absent in some cases (37.2%) & delayed in the rest.**
- ✿ **MMN response was affected whether UHL occurred before or after the age of full language acquisition.**

- ✿ **UHL has more effect below the age of 8 yrs.**

3. **In right UHL (LES):**

- ✿ **MMN latency was delayed.**
- ✿ **MMN latency is affected whether UHL occurred before or after the age of full language acquisition.**

4. Comparing RES with LES:

LES subgroup had significantly delayed MMN latency when compared with RES subgroup ($P < 0.05$).

5. Speech processing is affected whatever the side of UHL.

On using tone stimuli:

1. There was no significant difference between REC & LEC ($P > 0.05$).

2. In left UHL (RES):

■ No significant difference with control.

■ No significant effect of age of onset of UHL.

3. In right UHL (LES):

■ No significant difference with control.

4. Comparing RES with LES:

■ There was no significant difference.

Comparing speech and tone responses:

- Shorter MMN latency, duration, amplitude and area were obtained in study subgroups on using tone stimuli.

Recommendations



- **Results of the current work revealed that subjects with UHL are at risk for speech processing abnormalities.**
- **These findings were found whether UHL occurred in right or left ear, before or after the age of full language acquisition.**
- **So, specially designed rehabilitation programs could be used with those subjects in order to enhance their speech processing capabilities.**

- **Various speech stimuli are recommended to study the effect of stimulus complexity in UHL.**
- **Comparing left-handed with right-handed subjects to study the lateralization effect of speech & non speech stimuli.**
- **Studying adults & children with UHL.**
- **Studying the effect of UHL in males & females for addressing the issue of gender effect on the cortical plasticity.**

