Frequency Discrimination:
Difference Limen
Or
Auditory steady State Response?
Freq. Discrimination is a fundamental auditory process underlying more complex auditory tasks, such as sp. comprehension & understanding (Nagle, 2009).

**Theories of frequency perception:**
- Phase-Locked theory:
- Place theory: (Schukentch, 1993).

Freq. Discrimination can be measured subjectively by two methods:

- Difference limen for frequency.
- Frequency Modulation Difference limens (FMDLs) (Moore B.C., 1993).

DL is the smallest change in frequency that can be detected subjectively (Durrrant & Lovrinic, 1995).

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ASSR is an electrophysiological response to repeated sound stimuli presented at a high repetition rate (Beck et al., 2007).

Modulated stimuli used for eliciting ASSR are useful in assessing how the brain can detect changes in frequency and amplitude (Picton, 2003).

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FM Difference Limen

Versus

Auditory Steady State Response

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Is there a difference between subjective FD (using FMDL) and objective FD (using ASSR)?

Is there a relation &/or a correlation between these two tests since they both measure frequency discrimination?

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Aims

➢ To compare FD in normal H. subjects using FM stimuli in subjective and objective methods.

➢ To correlate between these two procedures.

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Subjects & Method

Thirty normal hearing adults.
They were 16 females & 14 males.
The inclusion criteria:

- HT = or < 25dBHL from 250: 8KHz.
- Normal ME function

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1- FMDL

- Measured at: 500, 1000, 2000, 4000Hz.
- Mono. signals at 40dB SL.

FMDL was defined as the smallest detectable difference in frequency modulation (Krishnamurti, 2000).
2- ASSR

Four frequencies were tested separately in each ear.
Frequencies were: 500, 1K, 2K, 4K Hz.
Modulation rate was:

<table>
<thead>
<tr>
<th>77</th>
<th>85</th>
<th>93</th>
<th>101</th>
<th>→ Rt</th>
</tr>
</thead>
<tbody>
<tr>
<td>79</td>
<td>87</td>
<td>95</td>
<td>103</td>
<td>→ Lt</td>
</tr>
</tbody>
</table>

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Results

- FMDL increased as the carrier freq. increased from 500:4KHz.

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ASSR Results

- ASSR response amplitude increased as the carrier freq. increased from 500:4000Hz.
- This result agrees with John et al., 2003 & John et al., 2002.

Table (1): T-test for comparing FMDL & ASSR

<table>
<thead>
<tr>
<th>Freq. In Hz</th>
<th>FMDL Mean (SD)</th>
<th>ASSR Mean (SD)</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>6.1 (2.20)</td>
<td>0.113 (0.96)</td>
<td>-14.874</td>
<td>0.000</td>
</tr>
<tr>
<td>1000</td>
<td>9.6 (0.81)</td>
<td>0.115 (0.1)</td>
<td>-63.37</td>
<td>0.000</td>
</tr>
<tr>
<td>2000</td>
<td>18.26 (2.50)</td>
<td>0.111 (0.12)</td>
<td>-39.66</td>
<td>0.000</td>
</tr>
<tr>
<td>4000</td>
<td>34.66 (5.69)</td>
<td>0.144 (0.19)</td>
<td>-33.217</td>
<td>0.000</td>
</tr>
</tbody>
</table>
### Table (2): ANOVA of the FMDL.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
<th>p- value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Freq.</td>
<td>14615.56</td>
<td>4871.86</td>
<td>441.36</td>
<td>0.000</td>
</tr>
<tr>
<td>Within Freq.</td>
<td>1280.43</td>
<td>11.04</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Multiple Comparisons

Dependent Variable: MFDL
Scheffe

<table>
<thead>
<tr>
<th>(I) TYPE</th>
<th>(J) TYPE</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sig.</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>500</td>
<td>1000</td>
<td>-3.5000*</td>
<td>.85784</td>
<td>.001</td>
<td>-5.9337</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>-12.1667*</td>
<td>.85784</td>
<td>.000</td>
<td>-14.6003</td>
</tr>
<tr>
<td></td>
<td>4000</td>
<td>-28.5667*</td>
<td>.85784</td>
<td>.000</td>
<td>-31.0003</td>
</tr>
<tr>
<td>1000</td>
<td>500</td>
<td>3.5000*</td>
<td>.85784</td>
<td>.001</td>
<td>1.0663</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>-8.6667*</td>
<td>.85784</td>
<td>.000</td>
<td>-11.1003</td>
</tr>
<tr>
<td></td>
<td>4000</td>
<td>-25.0667*</td>
<td>.85784</td>
<td>.000</td>
<td>-27.5003</td>
</tr>
<tr>
<td>2000</td>
<td>500</td>
<td>12.1667*</td>
<td>.85784</td>
<td>.000</td>
<td>9.7330</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>8.6667*</td>
<td>.85784</td>
<td>.000</td>
<td>6.2330</td>
</tr>
<tr>
<td></td>
<td>4000</td>
<td>-16.4000*</td>
<td>.85784</td>
<td>.000</td>
<td>-18.8337</td>
</tr>
<tr>
<td>4000</td>
<td>500</td>
<td>28.5667*</td>
<td>.85784</td>
<td>.000</td>
<td>26.1330</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>25.0667*</td>
<td>.85784</td>
<td>.000</td>
<td>22.6330</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>16.4000*</td>
<td>.85784</td>
<td>.000</td>
<td>13.9663</td>
</tr>
</tbody>
</table>

* The mean difference is significant at the .05 level.
### Table (3): ANOVA of the ASSR

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Freq.</td>
<td>0.022</td>
<td>0.007</td>
<td>0.428</td>
<td>0.723</td>
</tr>
<tr>
<td>Within Freq.</td>
<td>2.008</td>
<td>0.017</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### Table (5): ANOVA of FMDL & ASSR

<table>
<thead>
<tr>
<th>Variable</th>
<th>Type III sum of squares</th>
<th>Mean square</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>45.36</td>
<td>45.361</td>
<td>1161.4</td>
<td>0.000</td>
</tr>
<tr>
<td>Freq.</td>
<td>0.677</td>
<td>0.226</td>
<td>5.774</td>
<td>0.001</td>
</tr>
<tr>
<td>Error</td>
<td>9.178</td>
<td>3.906E</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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In order to drop the measure of units, standardizing the values of both tests results was done.

Results showed NO Intersection between the two tests.

The absence of significant correlation between FMDL & ASSR in normal hearing subjects, does not mean that we are chasing irrelevant information.

This correlation may need certain methodology to be apparent, or it may be more evident in subjects with HL.

In fact, this finding stimulated us to continue to the second phase of this work.

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**Conclusions**

- FMDL & ASSR amplitude increased significantly with increasing the carrier frequency.
- There was no significant correlation between FMDL & ASSR in normal hearing subjects.

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**Recommendations**

- The use different methodologies for subjects with hearing loss.
- ASSR can then, be used as an objective test for frequency discrimination.

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Thank You For Your Attention