Auditory Middle Latency Responses recorded at High Stimulation Rates using Randomized Stimulation and Averaging (RSA)

Joaquin T. Valderrama*, Angel de la Torre, Isaac Alvarez, Jose C. Segura,
A. Roger D. Thornton, Manuel Sainz, and Jose L. Vargas

ugr | Universidad de Granada

*E-mail us to jvalderrama@ugr.es

New Orleans (EEUU), 9-13 June 2013

International Evoked Response Audiometry Study Group

- Hi again. This time I will present some results regarding the use of the RSA technique recording MLR at high rates. I will also talk about the influence of the amount of jitter in the stimulation sequence to obtain reliable auditory evoked potentials.

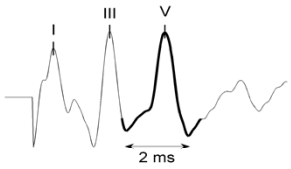
Structure

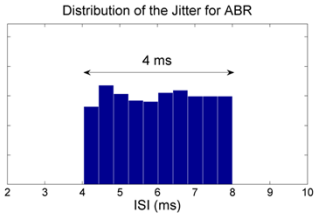
- Introduction. RSA and RSD methods.
- Influence of the jitter.
- MLR recorded with RSA and RSD.
- Conclusions.

- This work is structured with a brief introduction of the RSA and RSD techniques, an analysis of the influence of the jitter, and results of MLR obtained with both RSA and RSD techniques. Finally, I will summarize the content of this work and present the main conclusions.

Introduction. RSA and RSD methods.

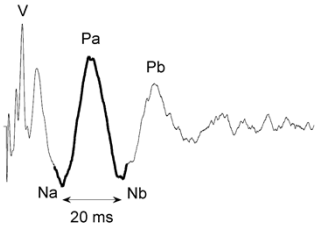
- In ABR: High jitter relative to the peak width

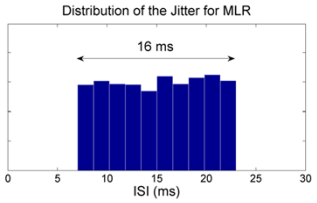




RSA ≈ RSD

- In MLR: Low jitter relative to the peak width





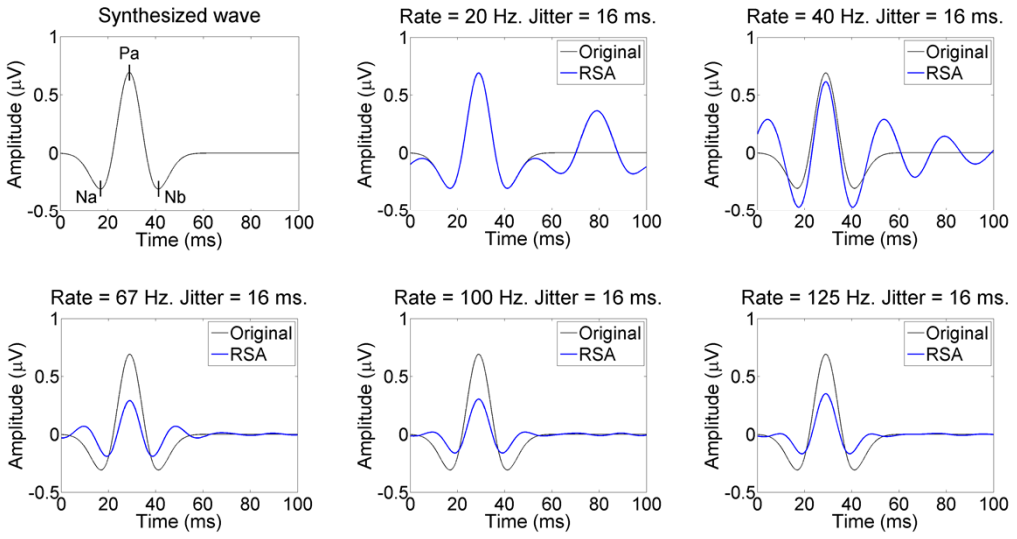
RSA *vs* RSD?

3 / 13

New Orleans (EEUU), 9-13 June 2013

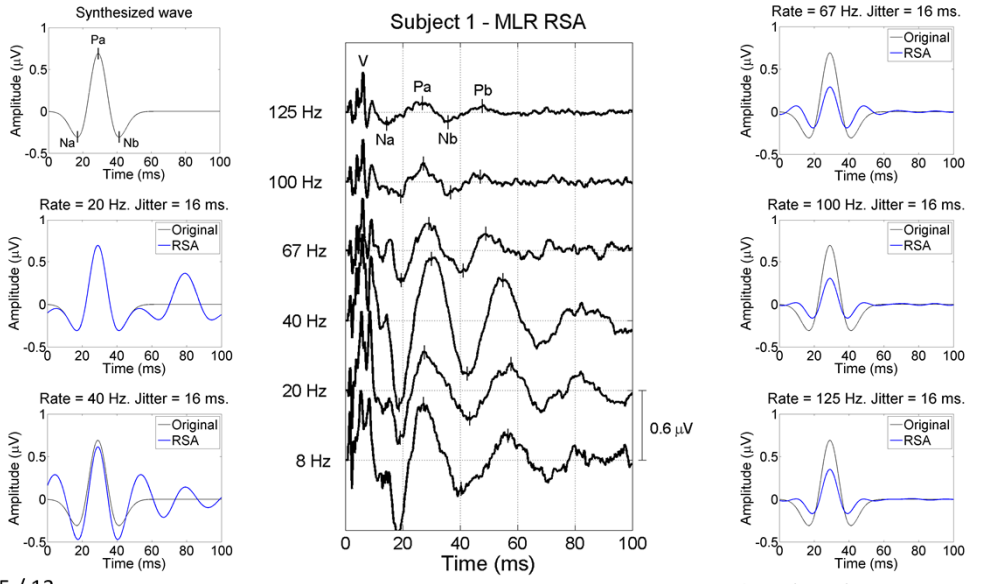
- On the preceding speech we recorded ABR using the RSA with stimulation sequences of a fixed jitter of 4 ms. In this case, the amount jitter relative to the width of the peak was high, and we concluded that the performance of the RSA technique was similar to RSD.
- In this work, we will obtain MLR with stimulation sequences of a jitter of 16 ms. This time, the amount of jitter relative to the width of the peak is much lower: 16 ms in comparison to 20 ms. In this work, we will analyse the performance of RSA in comparison with its version that includes deconvolution.

Influence of the jitter in RSA. Simulations.



- For this purpose, we have implemented a simulation with a synthesized wave similar in shape to a Pa peak. We have recovered this wave with the RSA technique at different stimulation rates using stimulation sequences of a jitter of 16 ms.
- According to this simulation, when we have an averaged stimulation rate of 20 Hz and a jitter of 16 ms, RSA generates an additional peak around 80 ms that is not part of the original wave.
- With a rate of 40 Hz, RSA generates a resonance that could artificially enhance the Pb component and generate additional peaks at other latencies.
- At very high stimulation rates (higher than 50 Hz), RSA does not obtain accurate measures of the amplitudes, but does not generate additional peaks.
- It is remarkable that in this simulation scenario, RSA obtains accurately the latency of the peak, but the amplitude that provides is not reliable.

Influence of the jitter in RSA. Real MLR.

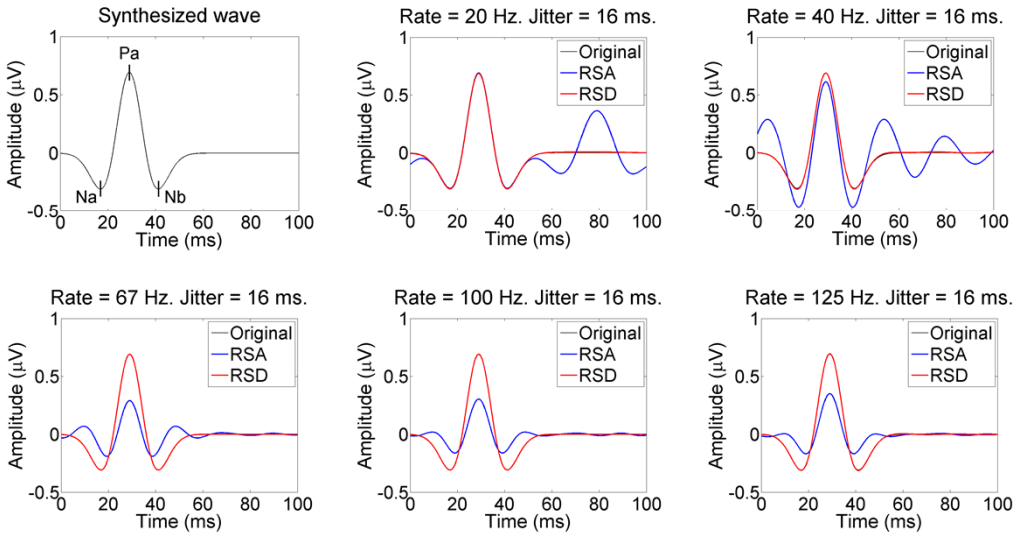


5 / 13

New Orleans (EEUU), 9-13 June 2013

- We can check these described effects on a real MLR. This figure shows MLR signals from one subject at different stimulation rates.
- In this figure we can observe the additional peak generated by the RSA technique in 80 ms at 20 Hz, and the resonance at 40 Hz.
- At very high stimulation rates the waves can be identified, but the amplitude is not high.

Influence of the jitter in RSD. Simulations.



6 / 13

New Orleans (EEUU), 9-13 June 2013

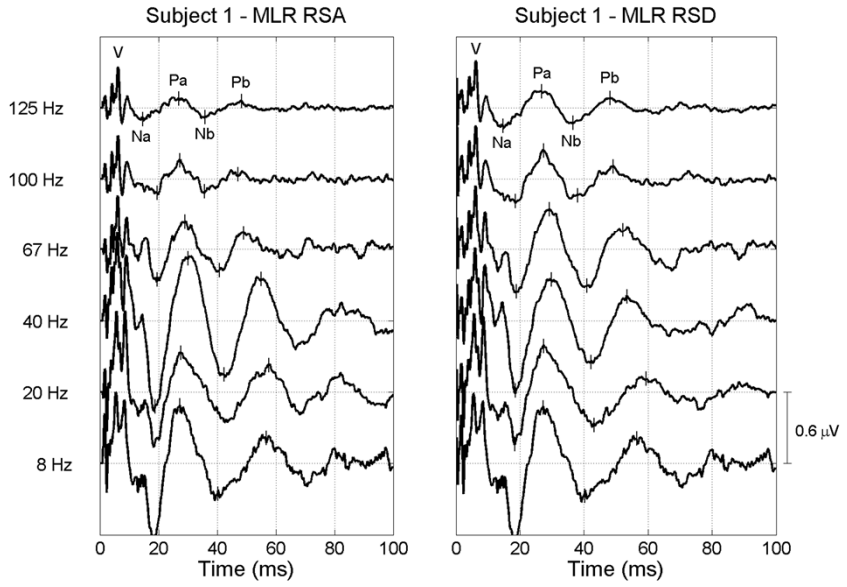
- What happens when we use a technique based in deconvolution such as RSD?
- When we use the RSD technique, the peaks are well estimated in all scenarios. The undesired effects of RSA are not present with RSD. The red line (RSD) fits perfectly the synthesized wave.

MLR recorded with RSA and RSD

- Parameters of the study
  - 4 normal hearing subjects
  - Ipsilateral stimulation at 70 dBnHL
  - RSD processing with blocks of 20 responses
  - Analog filter settings: 2^{th} order, BW [5 - 2000] Hz
  - Digital filter settings: 4^{th} order, BW [10 - 1500] Hz
  - Averaged sweeps varied from 2.000 (8 Hz) to 40.000 (125 Hz)
  - 16 ms jitter uniformly random distributed along with the averaged stimulation rates of 8 Hz, 20 Hz, 40 Hz, 67 Hz, 100 Hz, and 125 Hz.

- Next, we will analyze the performance of the RSA and RSA techniques with real MLR recorded on the following conditions.
- We have obtained MLR from a group of 4 normal hearing subjects, using ipsilateral stimulation at 70 dBnHL.
- The processing of RSD was done with blocks of 20 responses.
- We used both analog and digital filters with a bandwidth around 10 to 1500 Hz.
- The number of averaged sweeps varied from 2000 to 40.000, maintaining a fixed recording time of about 4 to 5 minutes.
- We used stimulation sequences of a jitter of 16 ms at averaged stimulation rates of 8, 20, 40, 67, 100 and 125 Hz.

MLR recorded with RSA and RSD

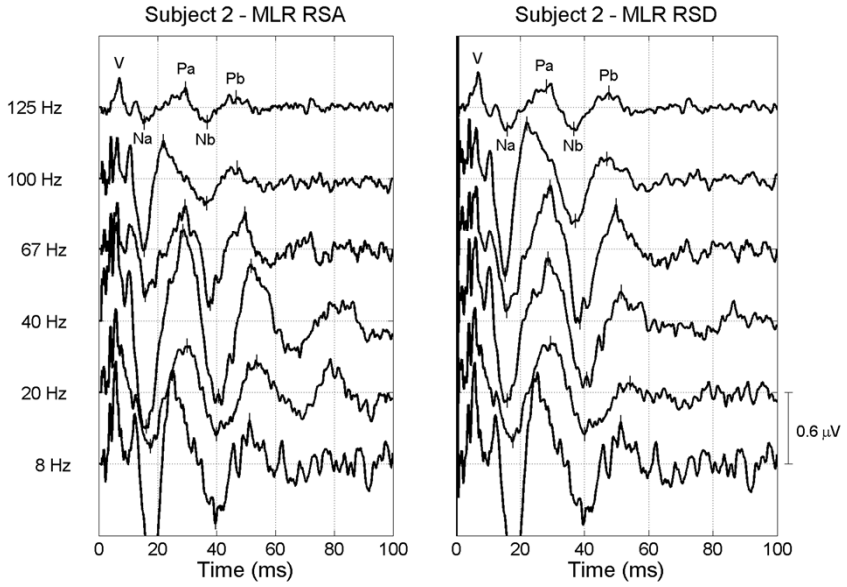


8 / 13

New Orleans (EEUU), 9-13 June 2013

- This figure shows MLR from subject 1 obtained with the RSA and RSD technique.
- In this figure, we can appreciate how the resonance presence on RSA is attenuated on RSD.
- And the waves that are underestimated with RSA, are properly obtained with RSD. Its amplitude is higher.

MLR recorded with RSA and RSD

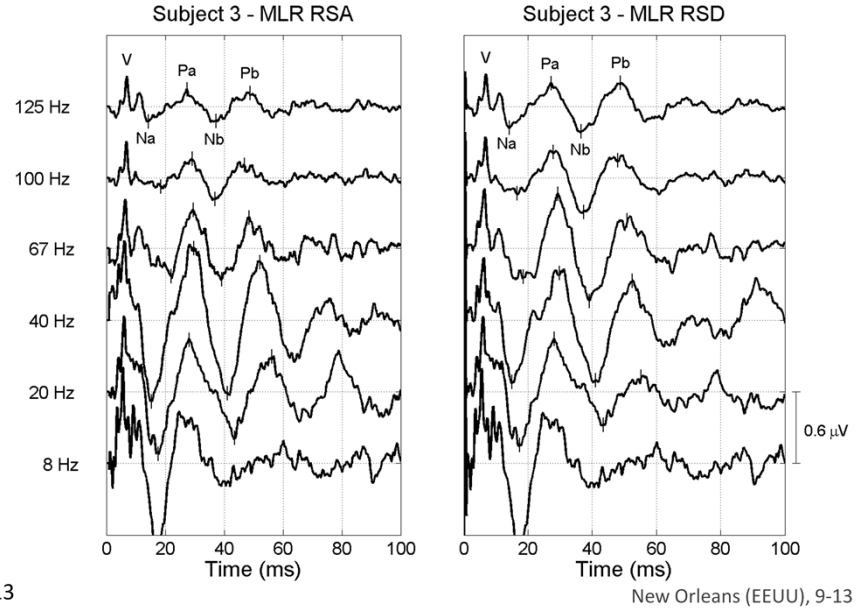


9 / 13

New Orleans (EEUU), 9-13 June 2013

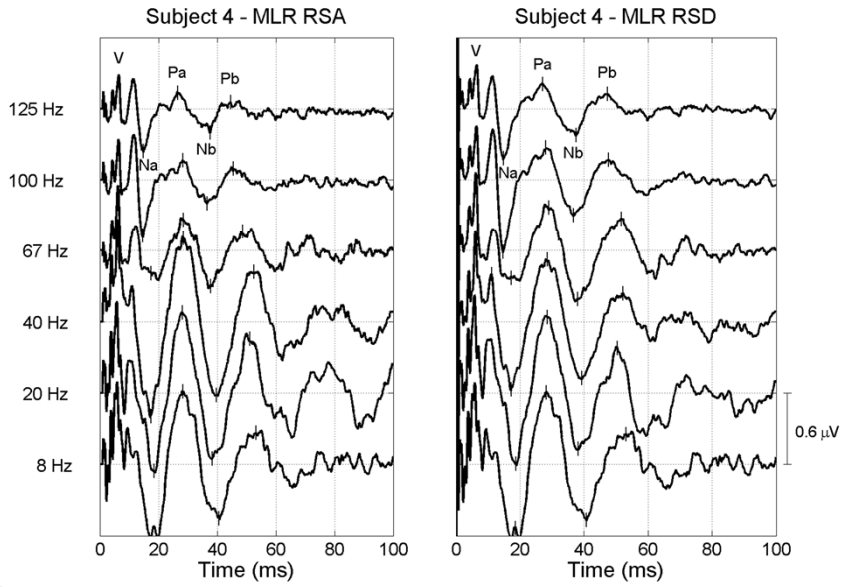
- This is definitely a noisier recording, but in this subject we can appreciate how the "generated wave" at 80 ms in RSA at 20 Hz is not present with RSD.
- The resonance at 40 Hz is attenuated and the waves are better recorded at very high stimulation rates with RSD.

MLR recorded with RSA and RSD



- Again, lower resonance, better peaks estimated with RSD.

MLR recorded with RSA and RSD



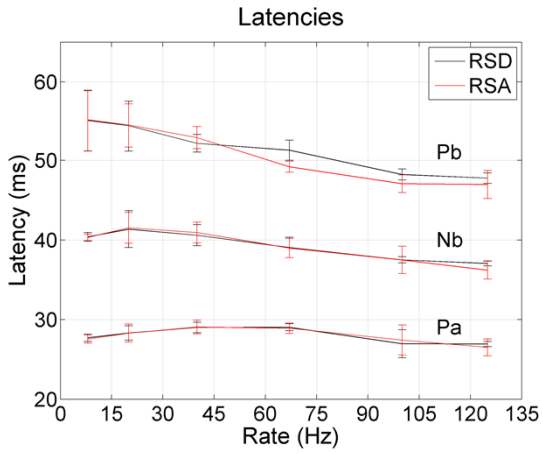
11 / 13

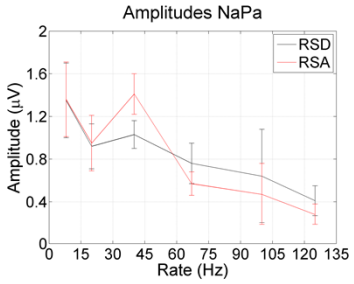
New Orleans (EEUU), 9-13 June 2013

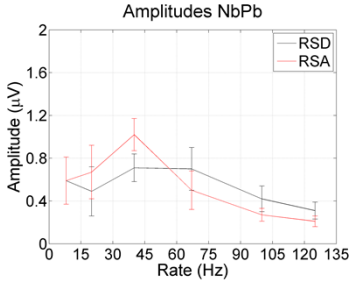
- And finally, these effects are also present on the last subject explored.

MLR recorded with RSA and RSD. Analysis.

- Study of amplitudes and latencies







12 / 13

New Orleans (EEUU), 9-13 June 2013

- These graphics show an analysis of the latencies and amplitudes of the recorded MLR.
- This study shows that the estimation of the latencies with the RSA and the RSD technique is very similar. There may be some divergence at 67 Hz for the Pb component, but in general terms, both techniques present similar measures of latencies.
- However, this analysis shows significant differences between the amplitudes measured with RSA and RSD in both Pa and Pb components. RSD presents lower amplitudes around 40 Hz since it attenuates the resonance, and higher amplitudes at very high stimulation rates because the peaks are better estimated.

Summary

- This work analyses the influence of the jitter on the performance of the RSA and RSD techniques.
- Presents auditory MLR signals obtained with the RSA and RSD techniques at high stimulation rates.

Conclusions

- RSA presents limitations when the jitter is low compared to the width of the peak.
  - In this situation, it is recommended the use of a technique based in deconvolution.
- The RSD technique allows the recording of auditory MLR signals at rates up to 125 Hz.

- To summarize, in this work we have presented a study of the influence of the jitter on the RSA and RSD techniques, and presents an analysis of the amplitudes and latencies on MLR obtained at high stimulation rates.
- The main conclusions of this work are, on one hand, that RSA presents limitations when the jitter of the stimulation sequence is low compared to the width of the peak. In this situation, a technique based in deconvolution such as RSD is recommended.
- The other main conclusion of this work, is that RSD seems to be an efficient method for obtaining MLR at very high stimulation rates. In this work, we have successfully measured MLR at rates up to 125 Hz, which can be useful to explore the neural adaptation effects or test an hypothetic reduction on the recording time.

- Thanks for your attention.