A more efficient use of the recording time with randomized stimulation and averaging (RSA) in hearing screening applications

Joaquín T. Valderrama*, Ángel de la Torre, Isaac Alvarez, Jose C. Segura, Wafaa Kaf, Manuel Sainz, and Jose L. Vargas

ugr | Universidad de Granada

*E-mail us to jvalderrama@ugr.es

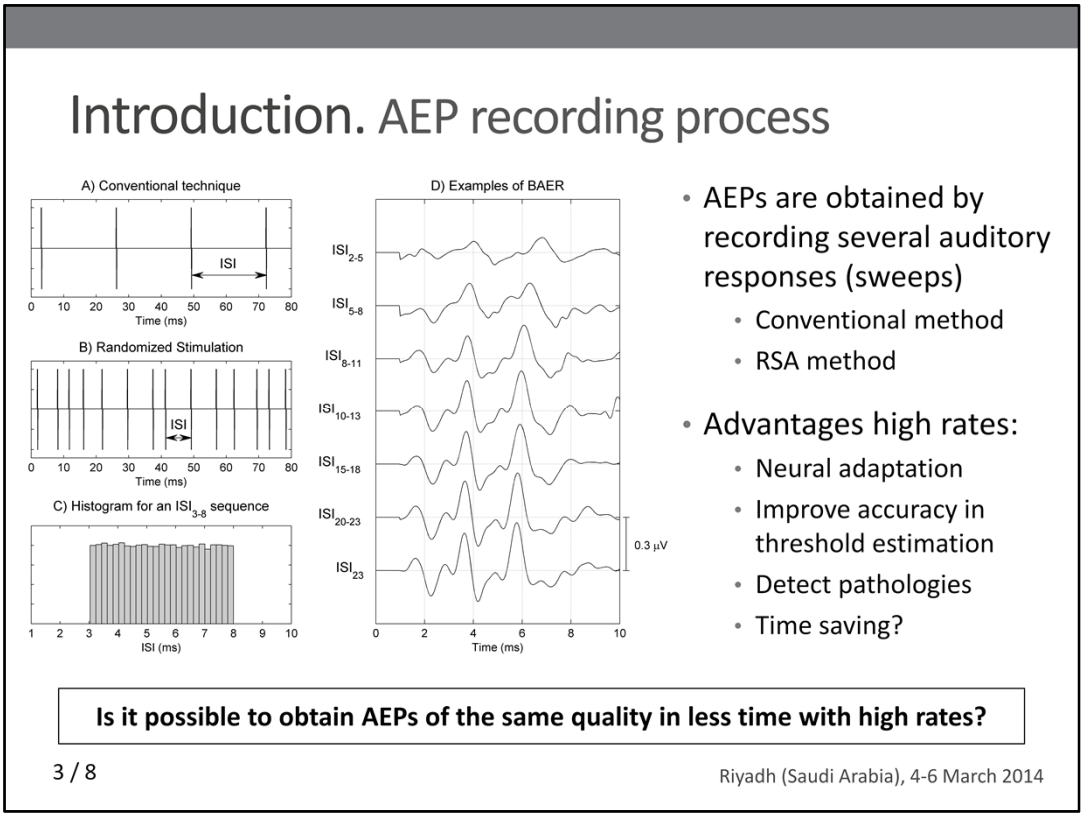
Riyadh (Saudi Arabia), 4-6 March 2014

9th International Conference of the Saudi Society of ORL & Head and Neck Surgery

Structure

- Introduction. Time saving with high stimulation rate.
- Description of the methodology.
- Results.
- Summary & Conclusions.

- I have organized this speech with:
    - (1) A brief introduction about the recording process of AEPs at high rates and whether or not high stimulation rates are appropriate for time saving.
    - (2) In this framework, we have prepared an experimental study to check if high stimulation rates with the RSA method could be used in clinical applications such as hearing screening in order to save recording time.
    - (3) I will provide details about the methods and present the results of this study.
    - (4) and finally, I will summarize the content of this speech and highlight the main contributions.



- I would like to **start** with a brief description of the recording process of AEPs.

- AEPs are **conventionally** obtained by the average of a large number of auditory responses, commonly called sweeps, corresponding to stimuli whose ISI are periodically distributed (with a fixed ISI).
    - Averaging reduces noise uncorrelated with the stimuli, and therefore, the more sweeps we average, the better quality would be the resulting AEP.
    - In this example (Figure A), this signal represents stimuli periodically presented with a fixed ISI of 23 ms.

- In contrast to the conventional method of stimulation, the **randomized stimulation and averaging (RSA)** method averages sweeps corresponding to a burst of stimuli whose ISI varies randomly according to predefined probability distribution.
    - In this example, Figure B shows a RSA stimulation signal, in which the ISIs of the stimuli vary randomly between 3 – 8 ms.
    - Figure C shows the probability distribution of the ISI, varying with a uniform distribution between 3 and 8 ms.
    - Figure D shows examples of high quality ABR signals obtained at different stimulation rates with the RSA method.
        - In this figure, the effects of neural adaptation are clearly seen:

amplitudes decrease, and latencies increase (especially in wave V) as stimulation rate increases.

- The conventional method of stimulation has the **limitation** that the Interstimulus interval (ISI) must be greater than the averaging window (typically 10 ms in ABR), otherwise the recordings would be systematically contaminated by the adjacent response. Therefore, ABR cannot be recorded at rates higher than 100 clicks per second. And this is a limitation, since the recording of AEPs at high rates present several advantages.

- The most relevant **advantages** of stimulating at high rates are:
    - (1) it allows the study of neural adaptation, as we can observe in this picture (D).
    - (2) some authors argue that high stimulation rates improves accuracy in estimating the hearing threshold
    - (3) other authors have presented evidences that high rates may help in the diagnosis of certain pathologies
    - (4) finally, some authors argue that since a required number of sweeps can be recorded faster with high rates, this could reduce recording time. However, as we can observe in figure D, the amplitudes of the waves decrease at high rates, decreasing therefore the SNR.

    - The reduction of the recording test time could have several benefits in certain clinical applications, such as exploring children or other non-cooperative subjects.

- So, the answer to the **scientific question** "…" is still very controversial.

- In **this study**, we have developed an experimental framework to analyze if whether or not high stimulation rates with RSA could be used to save time in recording ABR signals.

Methods

- 8 normal hearing subjects (males and females, 23-34 yr)
- ABR signals used as control:
  - Conventional method of stimulation
  - 33 clicks per second, 60 seconds = 2000 sw
  - Intensities: 30, 40, 50, 60, 70 dB nHL
- ABR signals used for test:
  - RSA method of stimulation, 125 clicks per second
  - Intensities: 30, 40, 50, 60, 70 dB nHL
  - Duration test: 5s (625 sw), 10s (1250 sw), …, 55s (6875 sw), 60s (7500 sw)
- Automatic quality estimation method:
  - Fsp = S/var(SP) Response validation: Fsp>2

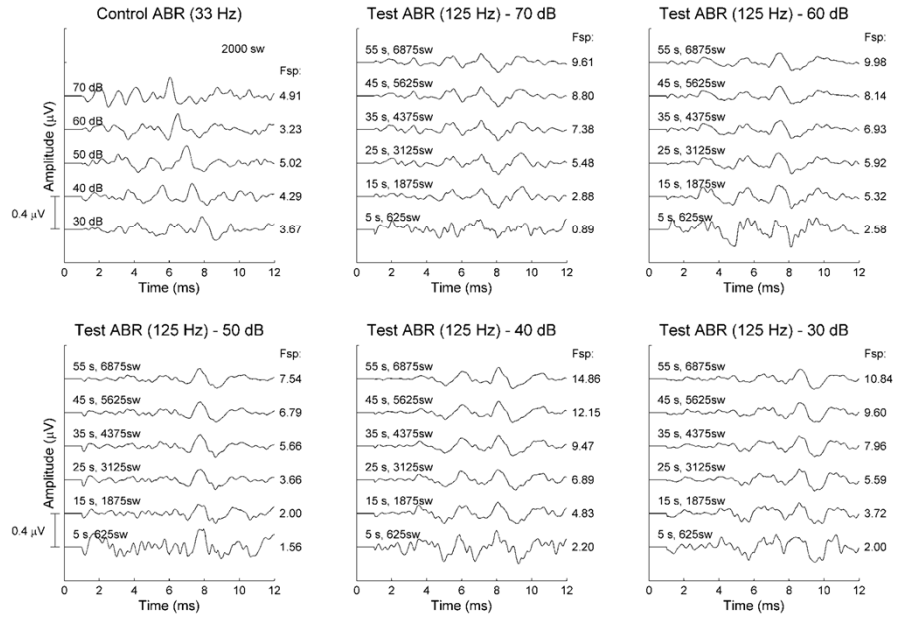
- In this study, we explored 8 normal hearing subjects.

- Basically, in this study we compare ABR signals obtained conventionally (2000 sw recorded at 33Hz, 1 minute recording) at different intensities, with ABR signals obtained with the RSA method at 125 clicks per second (about 4 times faster), at the same intensity levels, and obtained at a different number of sweeps.

- We compared the quality of the recordings through the automatic quality estimation method Fsp, which provides an estimation of the quality in terms of SNR by dividing the power of the signal and the variance of a single point across sweeps.

- Fsp evaluations greater than the threshold 2 are typically used to validate the presence of a response.

Results. ABRs subject S1



- I will show as examples the ABR signals from 2 subjects. These are from Subject 1.

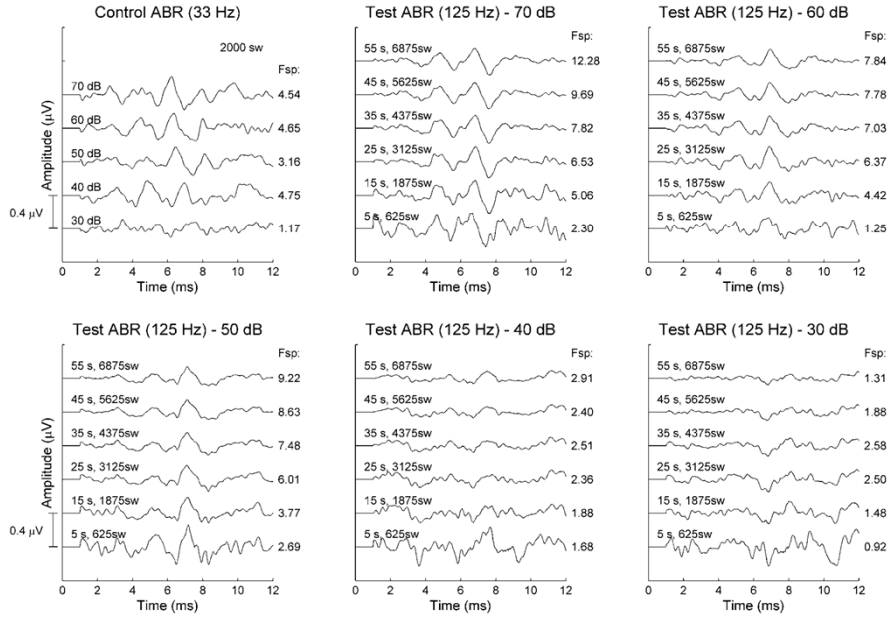
- The first figure shows the ABR signals used as control, recorded by the conventional method presenting 2000 stimuli periodically presented at 30 clicks per second (1 minute per recording). The quality estimation of each recording provided by the Fsp method is next to each recording.

- The rest of the figures show ABR signals obtained at different number of averaged sweeps at each intensity level. In this study, we compare the quality of these ABR signals used for test with the control.

- We can see that the quality of the responses systematically increases with the averaged number of sweeps

- In this example, high rates seems to be effective to reduce time at all intensity levels.

Results. ABRs subject S2

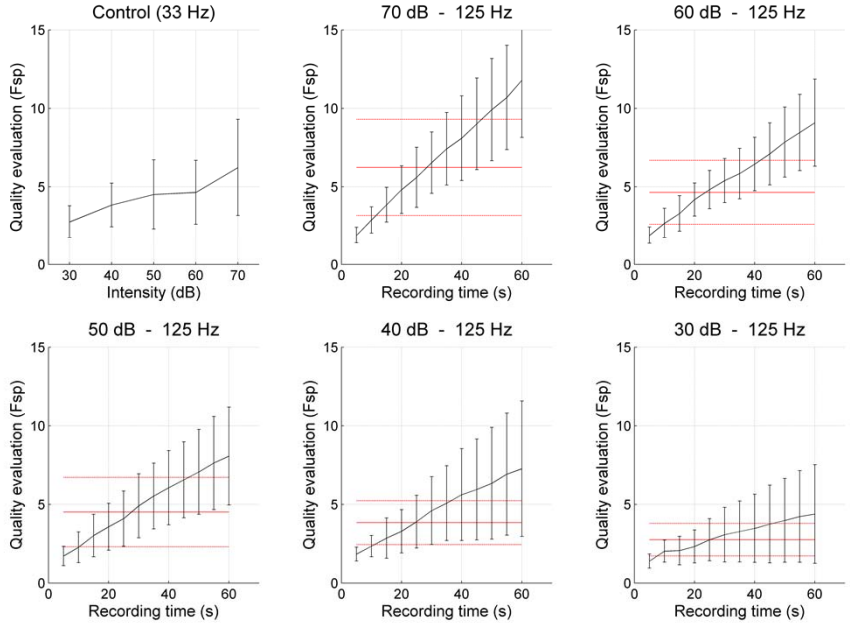


- However, it is quite common that in certain clinical applications such as hearing screening or threshold estimation, the identification of the response at low intensity levels is not as evident as at high levels.

- In these cases, high stimulation rates does not seem to help since the adaptation effects will make the response even of a lower amplitude, and therefore, the identification of the response would be more difficult.

- Although, at high levels the use of high rates could still save time. In this example, an ABR of the same quality as the control ABR could be obtained in less than 15 seconds, instead of 60 seconds, reducing considerably the recording test time.

Results. Quality evaluation



7 / 8

- These figures show the analysis of the data in terms of the mean and standard deviation of the quality estimations provided by the Fsp method.

- The first figure shows the quality estimation of the control ABR signals. The quality of the responses decreases as the intensity level decreases.

- The rest of the figures show

Summary & Conclusions

- **Methods**: The quality of ABR signals recorded at high rates with the RSA method at different recording times were compared to ABR signals recorded conventionally to test the reduction of the recording time.
- The **results** of this study show:
  - There is a significant reduction of the recording time at high levels, when the response is clear.
  - When the identification of the response is not evident (usually at low levels), high rates decrease the amplitude of the response and make the identification more difficult.
- **Conclusion**:
  - Time saving with RSA has promise in certain applications with high levels of stimulation
  - The benefits of high rates with RSA in hearing screening or threshold estimation are still unclear. A clinical study with more subjects would be necessary to reach more solid conclusions.

Riyadh (Saudi Arabia), 4-6 March 2014

- To summarize…

Thanks for your attention. Questions.

- The Alhambra, Granada (Spain)

Riyadh (Saudi Arabia), 4-6 March 2014

- These are a few photographs of the Alhambra monument in my city, an Islamic palace that we feel very proud of it.

- Thank you very much for your attention.