Automatic Quality Assessment and Response Detection of Auditory Evoked Potentials based on Response Tracking

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New Orleans (EEUU), 9-13 June 2013

International Evoked Response Audiometry Study Group

- Good morning. My name is Joaquín Valderrama, I am with the University of Granada, in the south of Spain.
- This is the first time I am attending this conference, and I am very happy to be here with you.
- During the following 10 minutes I will present the work entitled "…"

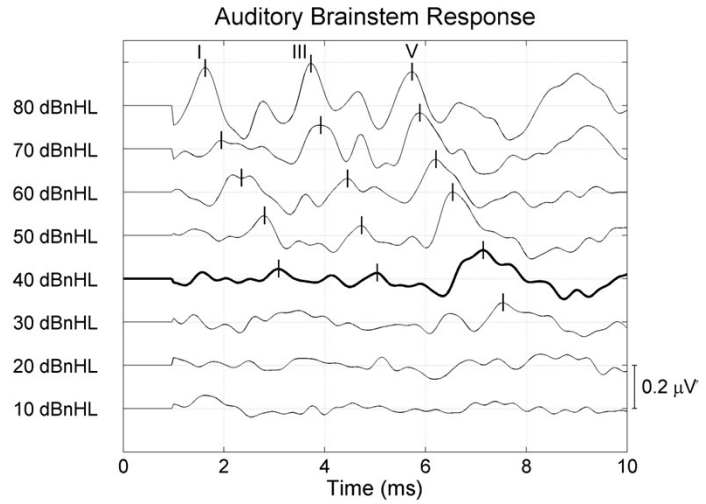
Structure

- Introduction. Response detection.
- Description of the methodology.
- Test of the methodology based on real ABR.
- Summary & Conclusions.

- I have organized this exposition with (1) a brief introduction about response detection, (2) a description of the proposed methodology for automatic quality assessment and response detection, (3) I will present some results about the performance of this method, and (4) finally, I will summarize the content of this speech and give the main conclusions.

Introduction. Response detection.

- Is this signal an auditory brainstem evoked potential?



3 / 9

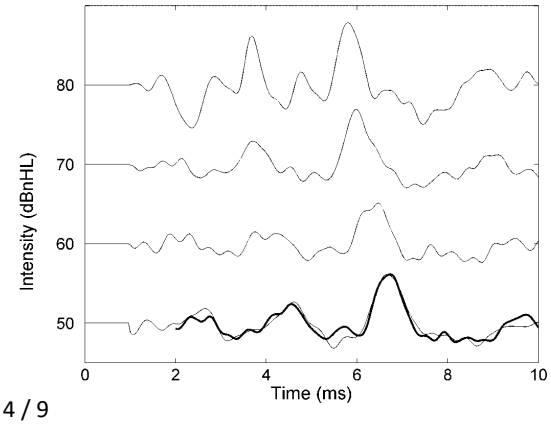
New Orleans (EEUU), 9-13 June 2013

- I would like to start this conference with a question: Is this signal an auditory brainstem evoked potential?
- It could be, the intensity of stimulation is not very high and with that latency, this peak could be a wave V.
- But how sure can we be about that? You may agree with me that it wouldn't be wiser to base a clinical decision only on that recording.
- This study changes completely when we analyze the same recording in a series of responses obtained in different conditions.
- In this new graph, we could confirm the detection of auditory brainstem response based on the replication of the signals and its natural change on the morphology when the intensity of stimulation changes.
- This method for response detection is used worldwide subjectively by many experts.

- In this work, we have developed a method that approaches this methodology for response detection.

Methodology

- Objective: Analyze changes on the morphology as a stimulation parameter varies
  - The changes on the morphology are analyzed by transformations made to a reference signal that fits the auditory response.



- Steps of the method
  1. Obtain a reference signal
  2. Do 3D transformations
     - Expand & Compress
     - Time translation
     - Amplitude adjustment
  3. Obtain best approximation
  4. Update reference signal

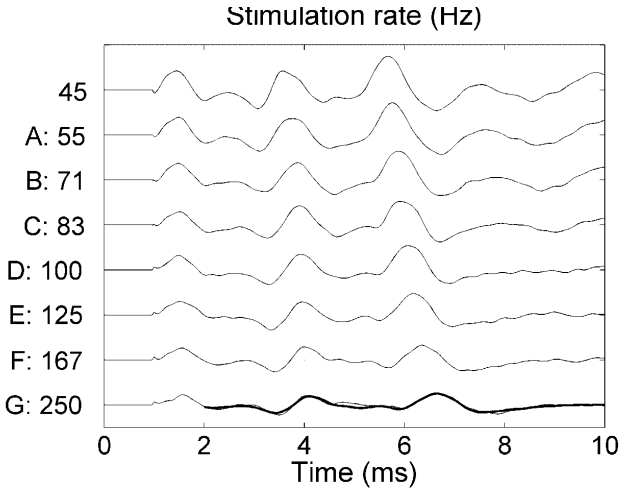
- Basically, the objective of the proposed methodology consists on analyzing the changes on the morphology of the recordings as a stimulation parameter varies (for example, the intensity or the stimulation rate), and check if the described changes on the morphology are in accordance with the physiological model.
- The changes on the morphology are analyzed by transformations made to a reference signal that fits the auditory responses.
- I will describe the methodology with a scheme.
- The first step is to obtain a reference signal. To start, we will use the first recording as reference.
- This recording will be transformed in 3 dimensions: compressing and expanding the signal, doing a time translation, and adjusting the amplitude of the signal.
- This method search the best approximation of the reference signal to the test signal. The best approximation is the one that maximizes the coefficient of determination between the reference and the test signal.
- Once the reference signal is fitted to the test signal, the reference signal is updated by doing the mean of the adjusted reference signal and the test signal to accommodate the changes on the morphology of the response.
- This process is repeated along all test recordings.

Test of the methodology. ABR study.

- Evaluation of the methodology with ABR obtained:
  A. Varying the stimulation rate
  B. Varying the intensity of stimulation
  C. No-stimulation (No ABR present on the recording)

- This methodology has been evaluated with real ABR obtained in 3 conditions:
  - With ABR obtained varying the intensity of stimulation
  - With ABR obtained varying the stimulation rate
  - With no stimulation provided, therefore, no ABR could be identified in the signal.

Test of the methodology. Stimulation rate.



	Exp.	Trans.	Ampl	R^2
A	1 %	0,04	0,92	0,98
B	1 %	0,04	0,84	0,97
C	0 %	0,08	0,75	0,94
D	4 %	-0,12	0,66	0,93
E	3 %	-0,08	0,59	0,92
F	4 %	-0,08	0,47	0,88
G	9 %	-0,28	0,34	0,90

Response Detected

6 / 9

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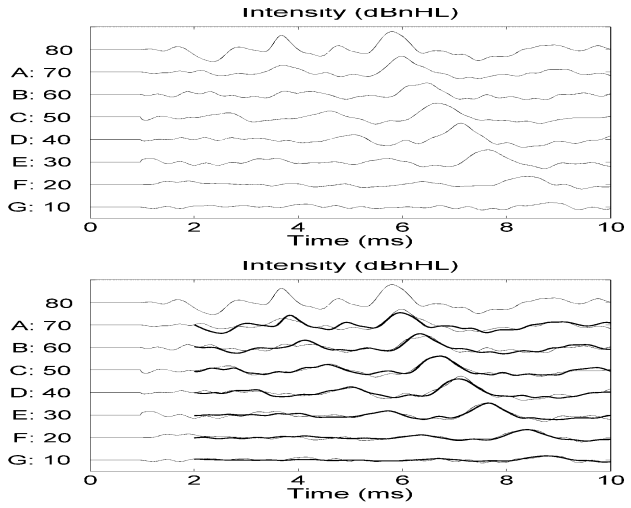
- This graphic shows ABR signals recorded on one normal hearing subject at different stimulation rates using the RSA technique.
- The process of evaluation is as described before:
    - Obtain a reference signal
    - Make adjustments to this signal to fit the auditory response
    - Update the reference signal
    - And repeat the process all along the set of responses.
- This table shows the transformations made to the reference signal along this process.
- In this table:
    - We can observe a systematic positive expansion factor, which explains that the wave III shifts less than the wave V.
    - A negative time translation to compensate the expansion of the reference signal.
    - And an amplitude factor which decreases as stimulation rate increases.
    - A coefficient of determination greater than 0.7 in all recordings makes this analysis confident.

Test of the methodology. Intensity.

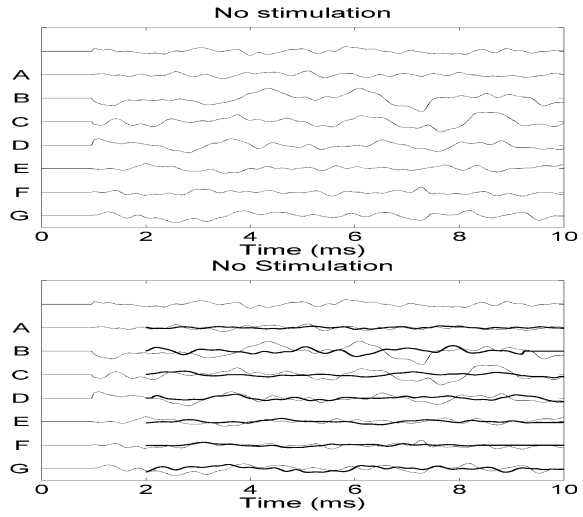


	Exp.	Trans.	Ampl	R^2
A	0 %	0,16	0,57	0,71
B	2 %	0,24	0,59	0,75
C	-3 %	0,52	0,78	0,89
D	-2 %	0,52	0,76	0,85
E	-4 %	1,04	0,67	0,80
F	5 %	0,36	0,44	0,79
G	3 %	0,12	0,23	0,59

Response Detected

- When we have an intensity varying recordings, like this set of responses. We obtain the following transformations.
  - The compression factor is not determinative. It alternates with small compressions and expansions.
  - There is a systematic positive time translation.
  - The amplitude factor decreases as the intensity of stimulation decreases.
  - The coefficient of determination greater than 0.7 suggest that the experimental data can be modeled by the reference signals.

Test of the methodology. No stimulation.



	Exp.	Trans.	Ampl	R^2
A	-13 %	0,28	0,32	0,21
B	13 %	-0,8	0,95	0,13
C	-7 %	0,64	0,61	0,20
D	-10 %	1,24	0,68	0,28
E	-10 %	0,52	0,59	0,47
F	5 %	-1,72	0,50	0,29
G	7 %	0,16	0,72	0,41

No Response Detected

8 / 9

New Orleans (EEUU), 9-13 June 2013

- Finally, when no ABR is present on the recordings, the coefficient of determination is lower than 0.7 in all recordings and that means that the model does not represent the experimental data. In other words, there is not a relationship between the signals and that could lead to evaluate the set of signals with no response detected.

Summary & Conclusions

- Method for automatic quality assessment and response detection based on response tracking.
- These preliminary results suggest that this method could be used to discriminate sets of auditory responses with a varying stimulation parameter.
- This method could provide additional information that can be taken into account along with other automatic methodologies to improve the accuracy in automatic response detection.
- Automatic methods should help the operator interpretation, but never replace it.

- In this work, we have described a methodology that could be used to automatic quality assessment and response detection based on response tracking by analyzing the transformations made to a reference signal that fits the auditory responses.
- The preliminary results of this work suggest that this methodology could discriminate sets of auditory responses from sets without respones. I would like to remark that these are very preliminary results.
- This method could provide additional information that can be taken into account along with other related automatic methodologies such as Fsp or the correlation coefficient in order to improve the accuracy in automatic response detection.
- Moreover, we believe that automatic methods should never replace the operator interpretation, but should help.
- Thank you very much for your attention.

- RESPUESTAS COMODÍN
- We are currently on the first stage of developing this technique and we hope we can soon present more consistent results.
- With this work we would like to describe the idea of an automatic method that analyses the transformations made to a reference signal that fits the auditory responses and check if these transformations are in accordance with the physiological model.
- How this method works with noisy recordings or how to implement the methodology in a hospital protocol is out of the scope of this work.
- The quality measure of this method is related to the coefficient of determination, that indicates how well the experimental data is modeled by the reference signal.