A PRELIMINARY STUDY OF THE SHORT-TERM AND LONG-TERM NEURAL ADAPTATION OF THE AUDITORY BRAINSTEM RESPONSE BY THE USE OF RANDOMIZED STIMULATION

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1 - INTRODUCTION

Brainstem auditory evoked response (BAER) signals represent the electrical activity of the auditory brainstem associated with a stimulus. The study of BAER at high stimulation rates is of great interest in the field of audiology since it presents several advantages: the reduction of the recording time, an earlier diagnosis of certain neural diseases, and the study of adaptation, which consists on a variation of the auditory response during a constant stimulus condition. This preliminary study is based in BAER recorded at fast stimulation rates using the Randomized Stimulation technique to check wether adaptation is a short-term or a long-term process.

2 - RANDOMIZED STIMULATION & SPLIT

The Randomized Stimulation technique consist of the average of auditory responses whose corresponding inter-stimulus interval (ISI) vary randomly between two values according to a predefined probability distribution (Figure 1.B, 1.C). This methodology can be used to obtain auditory evoked potentials at very fast stimulation rates (Figure 1.D). This stimulation technique allows the categorization of auditory responses according to the ISI of the preceding stimulus (Figure 2).

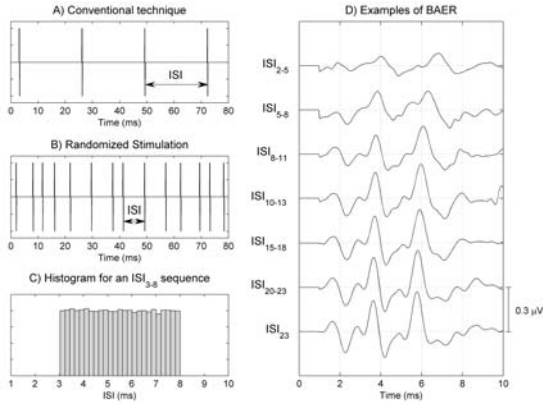

Figure 1. A) Stimulation sequence in the conventional technique. B) $ISI_{3\text{-}8}$ Randomized Stimulation sequence. C) Histogram for an $ISI_{3\text{-}8}$ Stimulation sequence. D) Examples of BAER recorded using the Randomized Stimulation technique at different stimulation rates.

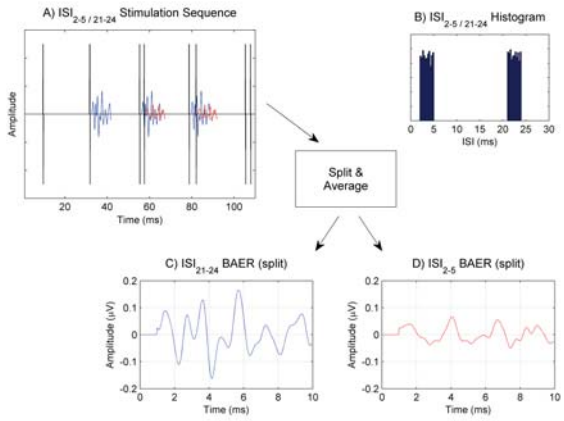

Figure 2. Split & Average process explanation. A) $ISI_{2\text{-}5/21\text{-}24}$ stimulation sequence. ISI of stimuli vary uniformly random between 2 - 5 and 21 - 24 ms. Auditory responses whose previous ISI is between 2 - 5 and 21 - 24 ms are highlighted in blue and red respectively. B) Histogram for a $ISI_{2\text{-}5/21\text{-}24}$ stimulation sequence. C-D) Average of auditory responses whose previous ISI is between 21 - 24 ms (C) and between 2 - 5 (D).

3 - EXPERIMENT

BAER from six normally hearing subjects were recorded using the Randomized Stimulation technique at the stimulation rates $ISI_{21\text{-}24}$ (rec), $ISI_{2\text{-}5/21\text{-}24}$ (rec), and $ISI_{2\text{-}5}$ (rec) (Figure 3). Auditory responses corresponding to $ISI_{2\text{-}5}$ and $ISI_{21\text{-}24}$ were retrieved from the $ISI_{2\text{-}5/21\text{-}24}$ stimulation sequence, obtaining the $ISI_{2\text{-}5}$ (split) and $ISI_{21\text{-}24}$ (split) signals (Figure 3). Two scenarios were considered: (a) $ISI_{21\text{-}24}$ (rec) and $ISI_{2\text{-}5}$ (rec) signals are similar to $ISI_{21\text{-}24}$ (split) and $ISI_{2\text{-}5}$ (split) signals respectively; and (b) $ISI_{21\text{-}24}$ (split) and $ISI_{2\text{-}5}$ (split) are similar signals. The similarity of signals is analyzed in terms of amplitudes and latencies of the waves. On one hand, scenario (a) would suggest that adaptation is a short-term process since the morphology of the response is strongly influenced by the previous ISI. On the other hand, scenario (b) would indicate that adaptation is a long-term process in which the morphology of BAER depends on the stimulation rate of several previous stimuli.

The results of this experiment show that amplitudes of the waves in $ISI_{2\text{-}5}$ (split) signals are considerably smaller than those in $ISI_{21\text{-}24}$ (split) signals in the six subjects. In contrast, the differences of Latency V between $ISI_{2\text{-}5}$ (split) and $ISI_{21\text{-}24}$ (split) signals vary among subjects: subjects 5 and 6 show a high difference, subjects 2 and 4 show a very small difference, and subjects 1 and 3 are in between.

This findings suggest (1) that the mechanisms of adaptation that influence amplitudes and latencies in BAER are different; (2) that short-term and long-term adaptation mechanisms are involved in the hearing process; and (3) that subjects present a high dispersion according to their tendency towards a short-term or a long-term adaptation process.

Understand the biological mechanisms or the possible hearing diseases that influence such dispersion may have important repercussions in the field of audiology. Although a study with more subjects would be necessary to reach more solid conclusions, these preliminary results let open a new research line that may lead to a better understanding of the adaptation phenomenon.

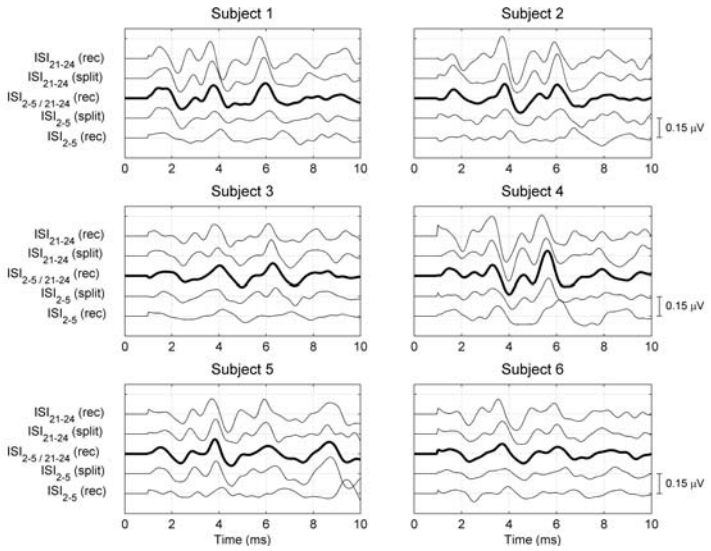

Figure 3. BAER recorded from six subjects at the stimulation rates $ISI_{21\text{-}24}$ (rec), $ISI_{2\text{-}5/21\text{-}24}$ (rec), and $ISI_{2\text{-}5}$ (rec); and BAER retrieved from the $ISI_{2\text{-}5/21\text{-}24}$ sequence: $ISI_{21\text{-}24}$ (split) and $ISI_{2\text{-}5}$ (split). The number of sweeps recorded to obtain each signal is: $ISI_{21\text{-}24}$ (rec) → 3000 sweeps; $ISI_{2\text{-}5/21\text{-}24}$ (rec) → 10.000 sweeps; $ISI_{21\text{-}24}$ (split) and $ISI_{2\text{-}5}$ (split) → 5.000 sweeps; and $ISI_{2\text{-}5}$ (rec) → 20.000 sweeps.

4 - CONCLUSIONS

- ✓ The proposed methodology can be used to explore the adaptation process.
- ✓ The mechanisms of adaptation that influence amplitudes and latencies in BAER are different.
- ✓ Both long-term and short-term adaptation mechanisms are involved in the hearing process.
- ✓ Subjects present a high dispersion in their tendency towards to a short-term or a long-term adaptation process.

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