Characteristics of the N1-P2 On-Off Evoked Response Using Broadband Stimuli

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Introduction

The N1-P2 auditory evoked response has been studied extensively using brief tonal and click stimuli. Therefore, much is known about the auditory cortex's response to stimulus onset with regard to intensity effects on response latency and amplitude.

Few studies have examined the auditory cortex's off-response to sustained stimuli. Of the studies that have been done, many have used tonal stimuli (1000 Hz) presented at the same intensity to all participants in an effort to explain generators of the response.[1]

Purpose:

- To determine if the on-off and sustained response can be recorded consistently
- To examine characteristics of the on-off response using a stimulus other than 1000 Hz - specifically broadband noise
- To determine effects of intensity and duration on waveform morphology, latency, and amplitude
- To examine the possibility of common vs. independent physiological generators of the response

Methods

Subjects:

13 young adult participants, all undergraduate and graduate students at the University of Connecticut, with no history of learning disabilities, auditory processing disorders, or otologic/neurological problems. All participants met the following criteria to ensure hearing function within normal limits bilaterally:

- Normal otoscopy
- Jerger type A tympanograms [2]
- Peripheral hearing within normal limits for interoctave frequencies from 250-8000 Hz, as determined by pure-tone audiometry using the modified Hughson-Westlake procedure
- Dichotic Digit Test scores of 90% or better at 50 dB SL to screen for central auditory dysfunction [3]

Stimuli:

4 broadband noise conditions were presented to each participant and routed through 10Ω ER-2 insert earphones.

800 ms duration 70 dB SL	**2000 ms duration 70 dB SL**
800 ms duration 40 dB SL	**2000 ms duration 40 dB SL**

- Each stimulus duration includes a 40 ms rise/fall time
- Each individual stimulus followed by a 4500 ms ISI

Procedure:

Test stimulus behavioral thresholds and electrophysiologic N1-P2 measurements were obtained in a double-walled sound proof booth using the NeuroScan Stim^2 evoked potential system.

Participants were seated in a reclining chair and instructed to relax quietly with their eyes fixated on a point at eye level or with their eyes closed while remaining awake.[A]

Electrode placement

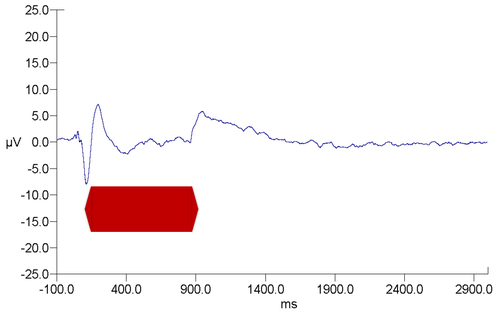
- Cz (active), A1/A2 (reference), the non-reference earlobe (ground), and at the outer canthus of the eye (eyeblink rejection)
- Electrode impedances $\leq$ 5.4 kOhms

2 waveforms of 100 accepted trials for each condition were obtained, averaged, and filtered from 0.3-30 Hz.

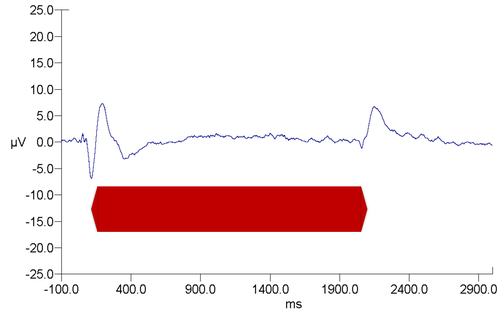
Results

Grand Averages

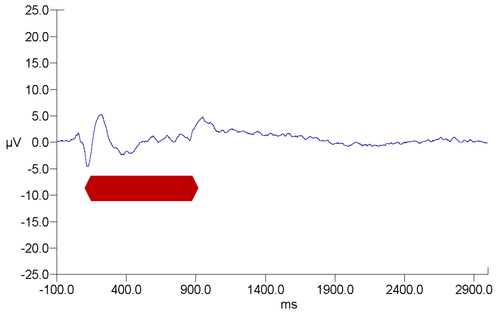
800 ms – 70 dB SL



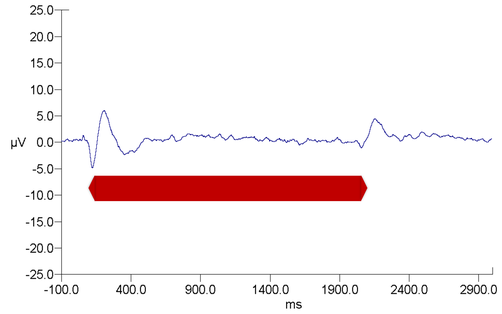
2000 ms – 70 dB SL



800 ms – 40 dB SL



2000 ms – 40 dB SL



800 ms – 70 dB SL	Onset	Offset
N1 Latency	112 ms *	**857 ms**
P2 Latency	196 ms *	**949 ms**

800 ms – 40 dB SL	Onset	Offset
N1 Latency	119 ms *	**855 ms**
P2 Latency	220 ms *	**948 ms**

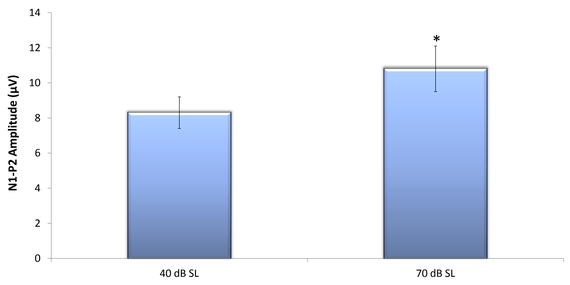
Asterisks indicate latency changes reaching statistical significance (<0.05) as a function of intensity changes

2000 ms – 70 dB SL	Onset	Offset
N1 Latency	114 ms *	**2059 ms**
P2 Latency	192 ms *	**2150 ms**

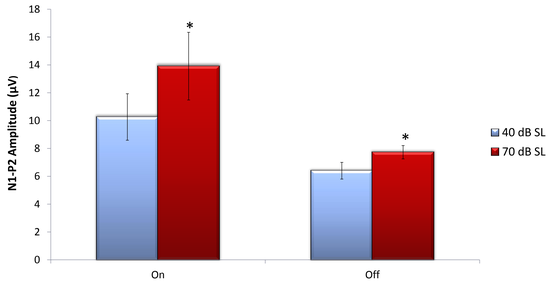
2000 ms – 40 dB SL	Onset	Offset
N1 Latency	121 ms *	**2056 ms**
P2 Latency	206 ms *	**2157 ms**

Asterisks indicate latency changes reaching statistical significance (<0.05) as a function of intensity changes

Mean N1-P2 Amplitudes – On-Off & Durations Collapsed



Mean N1-P2 Amplitudes – Durations Collapsed



Results & Discussion

A 2x2 factorial repeated measures ANOVA was used to analyze data:

- Intensity effects were seen for onset N1 and P2 latencies resulting in shorter latencies for the 70 dB SL conditions that were statistically significant from their 40 dB SL counterparts.
- Stimulus duration had no effect on onset and offset response amplitude and latency.
- Intensity did not seem to affect offset N1 and P2 latency in either of the stimulus durations.
- N1-off shows a definite trend of smaller amplitude when compared to N1-on.

Offset N1 and P2 latencies occurred on average about 40 ms earlier than expected when using onset N1-P2 latency criteria. In the present study, a 40 ms rise/fall time was utilized, suggesting that the on-response occurs sometime during the rise of the stimulus, while the off-response occurs at the moment when stimulus plateau turns to stimulus fall, which was held constant in all stimulus conditions.

Using 1000 Hz stimuli with 10 ms rise/fall times, Pantev et al. noted off-responses occurring 13 ms earlier than the on-response on average, although they did not elaborate on the phenomenon.[4]

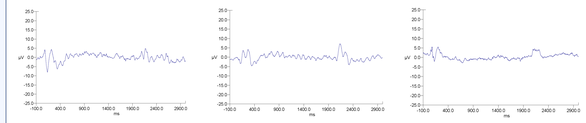
Conclusions & Future Directions

The off-response seemed to respond acutely overall to the decay of the stimulus envelope from plateau to the initial part of the fall ramp.

This lack of intensity effect on offset latency, coupled with the rapid response to envelope decay, argues for the consideration of different underlying physiological mechanisms for the on- and off-response in this study.

We entertain the possibility that a distinct group of neuronal cells within the auditory cortex may be responding to stimulus onset while a separate group of cells may be responding to the stimulus offset, creating this physiological difference. This hypothesis is consistent with previous research.[5] Studies focusing on isolating the off-response from the on-off response should be explored.

Waveforms of 3 separate individuals with tinnitus were obtained and are shown below for the 2000 ms - 70 dB SL condition.



Preliminary data from these individuals were excluded from the present study.

We entertain the possibility that waveform morphology may suggest that the on-off N1-P2 responses in those with tinnitus could differ from those without tinnitus. Characteristics of the N1-P2 on-off potential should be explored in this population.

References

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2. Jerger, J. (1970). Clinical experience with impedance audiometry. *Archives of Otolaryngology, 92*(4), 311-324.
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