Early Auditory Novelty Processing in Humans: Auditory Brainstem and Middle-Latency Responses

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Introduction

The detection of unexpected events in the auditory environment is crucial for survival, as preparing the organism for rapidly changing surrounding conditions. The neural correlates of change detection are commonly studied through the oddball paradigm that elicits a negative potential approximately 100-200 ms after the stimulus onset called Mismatch Negativity (MMN) response (Näätänen et al, 1978). In contrast to the large amount of research in humans focusing on this mechanism, few animal studies reported a MMN- like response in the primary auditory cortex (Ulanovsky et al., 2004), non-primary thalamus (Kraus et al., 1994; Anderson et al., 2009) and inferior colliculus (Pérez-González et al., 2005, Malimierca et al., 2007).

Main question: Is there any effect of auditory frequency change detection in humans in the time range of the Auditory Brainstem (ABR) and Middle Latency (MLR) Responses?

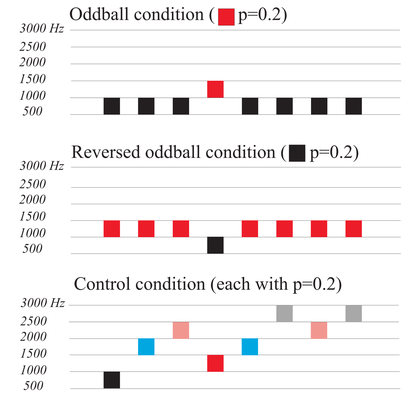
Methods

Participants: 18 normal-hearing subjects (18-29 years, 15 females, 3 left handed)

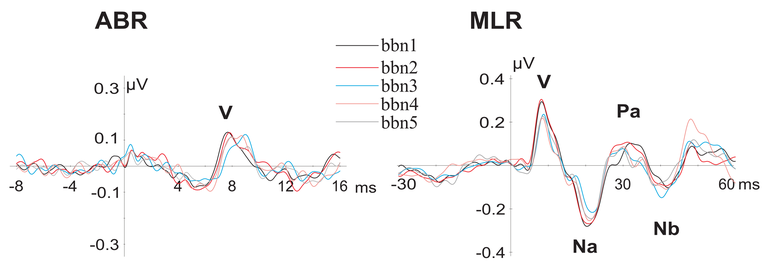
Stimuli: Bursts of 40 ms broadband noise bandpass-filtered from 500 to 3000 Hz in steps of 500 Hz (termed bbn1, bbn2, bbn3, bbn4, and bbn5) were delivered to the right ear at an intensity of 80 dB SPL with a stimulus onset asynchrony of 96 ms. The left ear was masked with white noise.

Electrophysiological measurement: ABRs and MLRs were both extracted from the same continuous EEG recording from the Cz electrode. An electrode placed at the left ear lobe served as reference. Sampling rate = 20000 Hz, On-line filter: 0.05-1500 Hz, Off-line filter: 100-1500 Hz (ABR); 15-250 Hz (MLR).

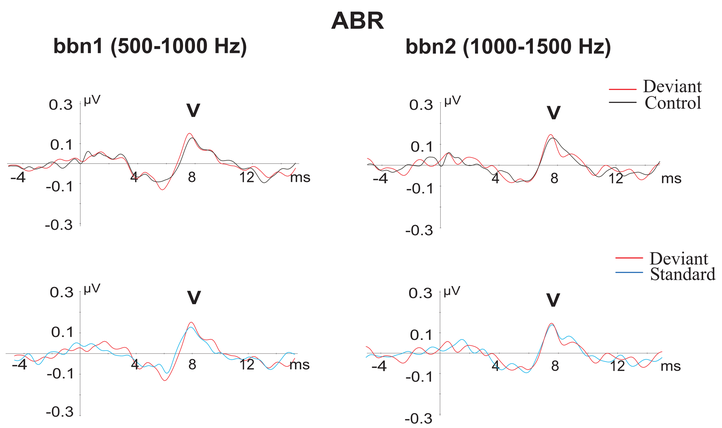
Design:

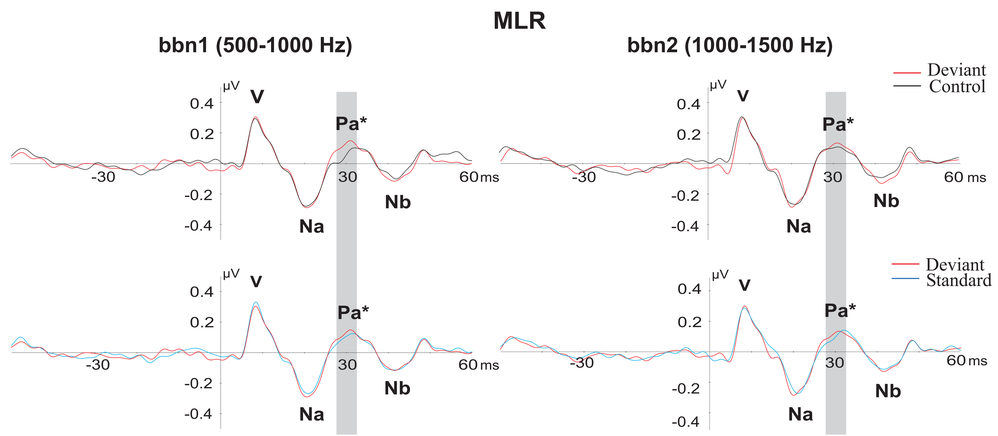


Results



The control stimuli elicited robust ABR and MLR responses for the five different band-pass filtered broadband noises used in the experiment, with similar waveforms elicited by the control stimuli for the frequency bands of interest, bbn1 and bbn2.





The data were analyzed by means of repeated-measures analyses of variance (ANOVA) on the mean amplitudes of the V (ABR), and Na, Pa, Nb (MLR) waveforms separately, including the factors Frequency (bbn1, bbn2) and Stimulus Type (deviant, standard, control). Stimulus Type effect was observed for the time window (29-33 ms) of the Pa component ($F(2,34) = 4.79$, $p = 0.01$). Post-hoc repeated-measures contrasts confirmed statistical significant differences between deviant and standard AEPs ($F(1,17) = 5.31$, $p = 0.03$) and between deviant and control AEPs ($F(1,17) = 7.29$, $p = 0.01$) in the Pa latency window.

Conclusions

The results of the present study have revealed that auditory novelty (deviance) detection can take place in humans as early as 30 ms from the onset of the stimulus feature that is novel compared to a repetitive background. This was supported by the fact that the Pa component of the MLR, peaking at 30 ms from change onset, was larger for the deviant stimulus than for the responses elicited both to the standard and to the control stimulus. Our findings support the idea of a new electrophysiological marker of auditory novelty detection that indicates the auditory response to novel stimuli in the Pa latency range, supposedly originating in the primary auditory cortex (Yvert et al., 2001). More generally, the results support the notion that novelty detection is a basic property of the functional organization of the auditory system that acts at different levels along the auditory pathway.

References

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