



## "Exploration of nociceptive cortical processing with steady-state evoked potentials"

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### Abstract

The periodic presentation of a sensory stimulus induces, at certain frequencies of stimulation, a sustained electroencephalographic response known as steady-state evoked potentials (SS-EP). SS-EPs are considered to reflect entrainment of cortical sensory networks resonating at the frequency of stimulation. In the present study we characterize and compare SS-EPs elicited by the selective electrical activation of nociceptive A $\delta$ -fibers and non-nociceptive A $\beta$ -fibers. Nine subjects took part in the experiment. Ten second trains of nociceptive (intra-epidermal electrical stimulation) and non-nociceptive (transcutaneous electrical stimulation) stimuli were applied to the left and right hand in separate blocks. Trains consisted of 0.5 ms constant-current pulses modulated at 3, 7, 13, 23 and 43 Hz. Consistent nociceptive and non-nociceptive SS-EPs were recorded at all stimulation frequencies. Whereas non-nociceptive SS-EPs were maximal over the parietal region contralateral to the stimulate...

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## Référence bibliographique

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## Introduction

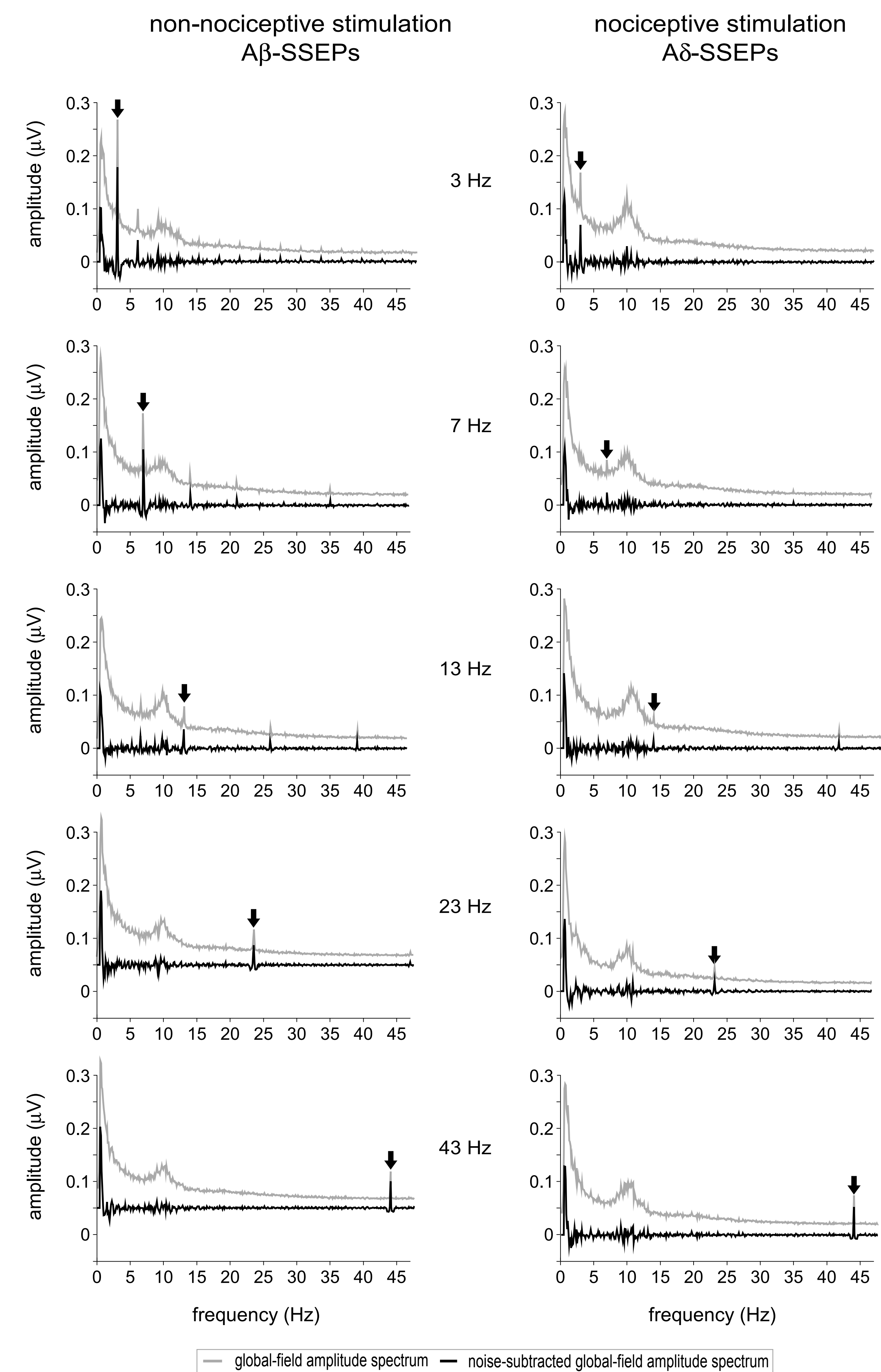
Studies have shown that the periodic repetition of a stimulus induces, at certain stimulation frequencies, a sustained electro-cortical response of corresponding frequency, referred to as steady-state evoked potentials (SSEPs)<sup>1</sup>. Using infrared laser stimulation, we recently showed that SSEPs can be used to explore nociceptive cortical processing<sup>2</sup>. Here, we implemented a novel approach to elicit such responses, using a periodic intra-epidermal electrical stimulation of cutaneous A $\delta$ -nociceptors (A $\delta$ -SSEPs). Using a wide range of frequencies (3, 7, 13, 23 vs. 43 Hz), we compared the scalp topographies and the temporal dynamics of these A $\delta$ -SSEPs to the A $\beta$ -SSEPs elicited by non-nociceptive transcutaneous electrical stimulation, as well as to the transient event-related potentials (A $\delta$ - and A $\beta$ -ERPs) elicited by the onset of the 10-s stimulation trains, which were applied to the left and right hand.

## Methods

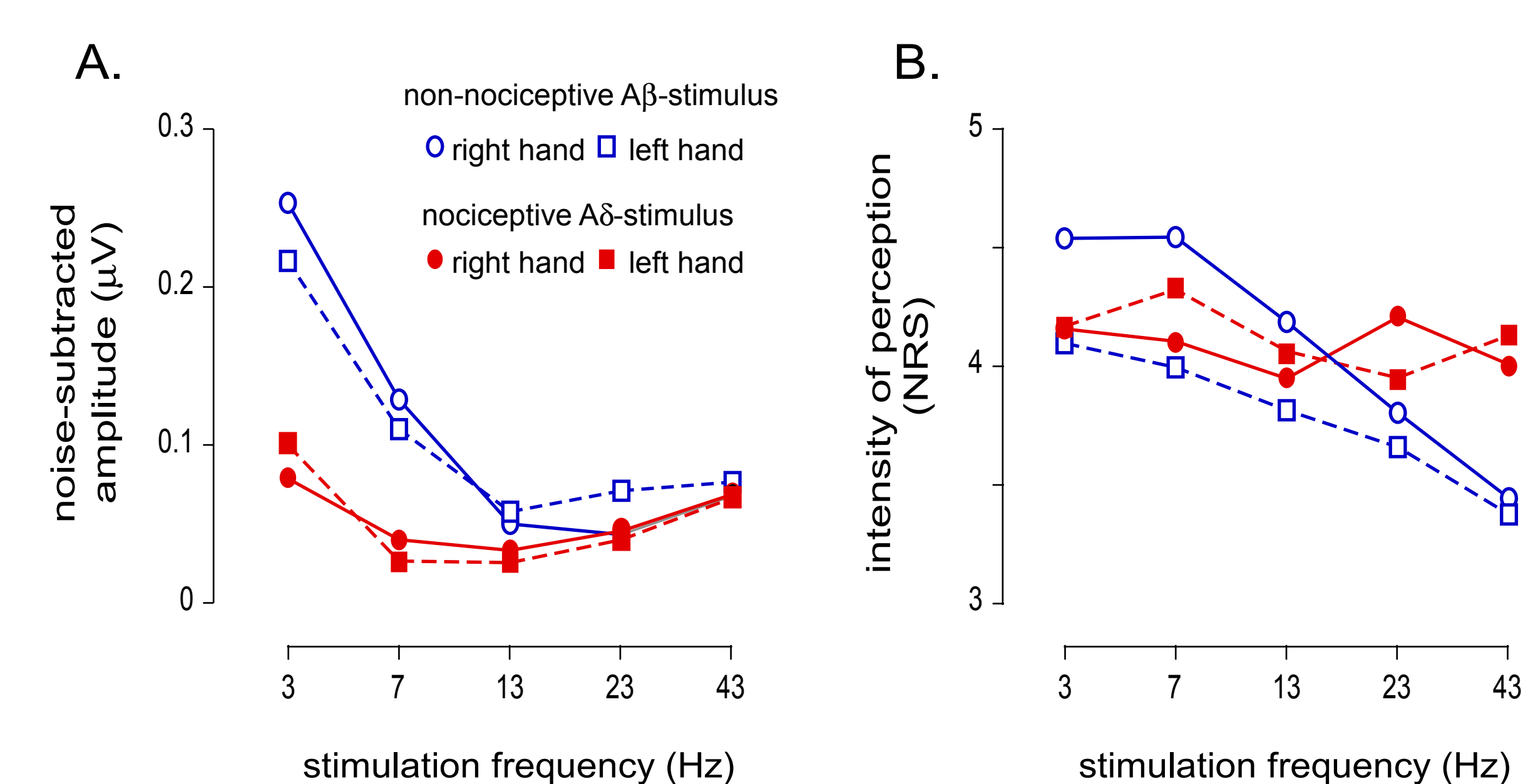
- EEG: 64 scalp electrodes, 1,000 Hz sampling-rate
- 9 participants
- Two types of stimulation: A $\delta$  stimulus vs. A $\beta$  stimulus
  - **A $\delta$  stimulus:** nociceptive intra-epidermal electrical stimulation of the hand dorsum (sensory territory of the superficial radial nerve)<sup>3,4</sup>.
  - **A $\beta$  stimulus:** non-nociceptive transcutaneous electrical stimulation of the superficial radial nerve at the level of the wrist.
- Stimulus intensity : A $\delta$  stimulus: 0.24  $\pm$  0.03 mA  
A $\beta$  stimulus: 1.13  $\pm$  0.41 mA  
(2x detection threshold to a single 0.5 ms pulse)<sup>4</sup>
- Two sites of stimulation: right hand vs. left hand.
- Five stimulation frequencies: 3, 7, 13, 23 and 43 Hz.
- Five stimulation blocks  
Each block consisted in 10 trains of electrical pulses lasting 10 s, modulated at the corresponding stimulation frequency, and separated by a 10 s ITI.
- After each stimulation train  
Subjects were asked to report the intensity of perception using a numerical rating scale (NRS: 0-10).

## Results

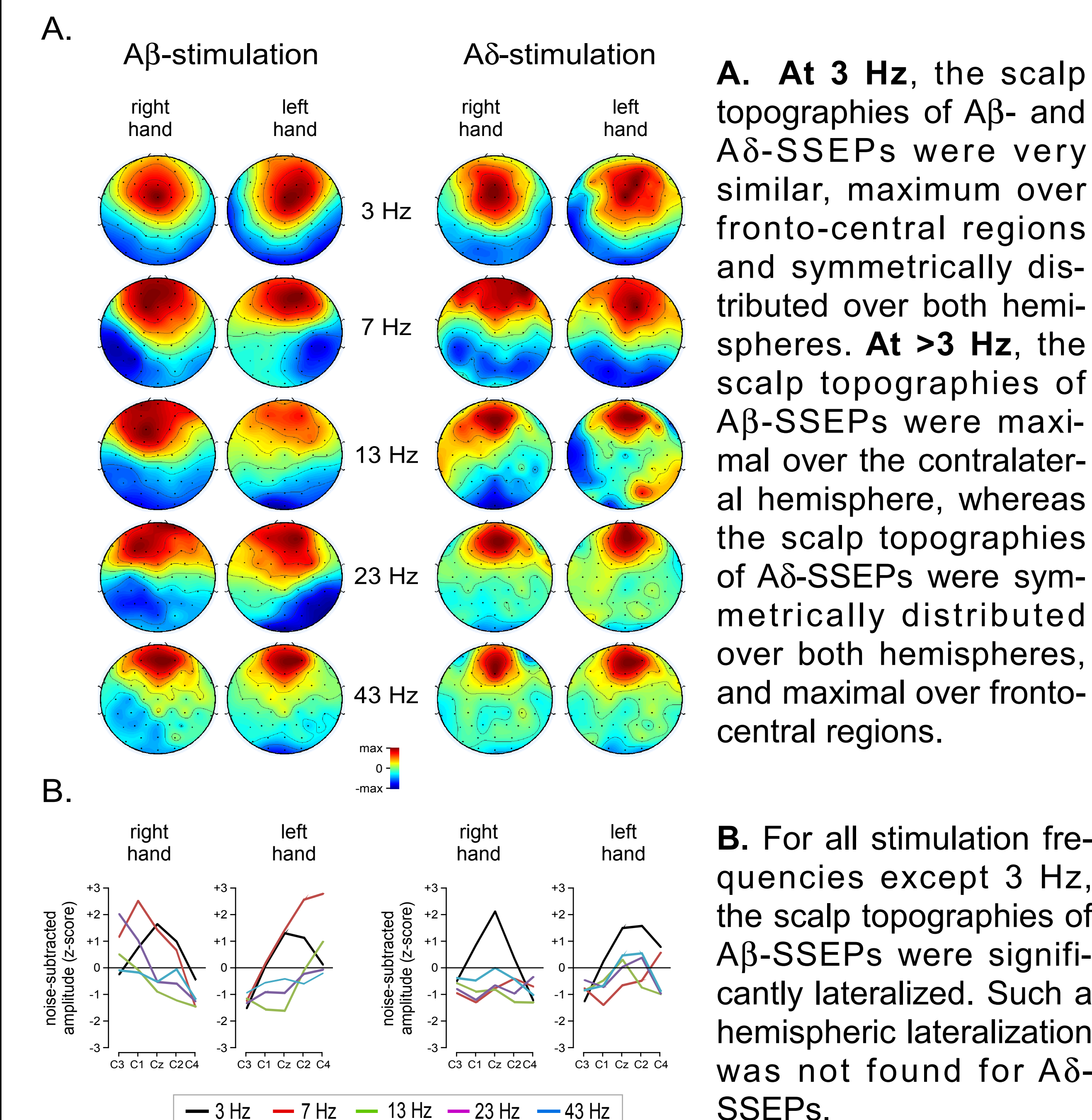
### Steady-state evoked potentials (SSEPs)



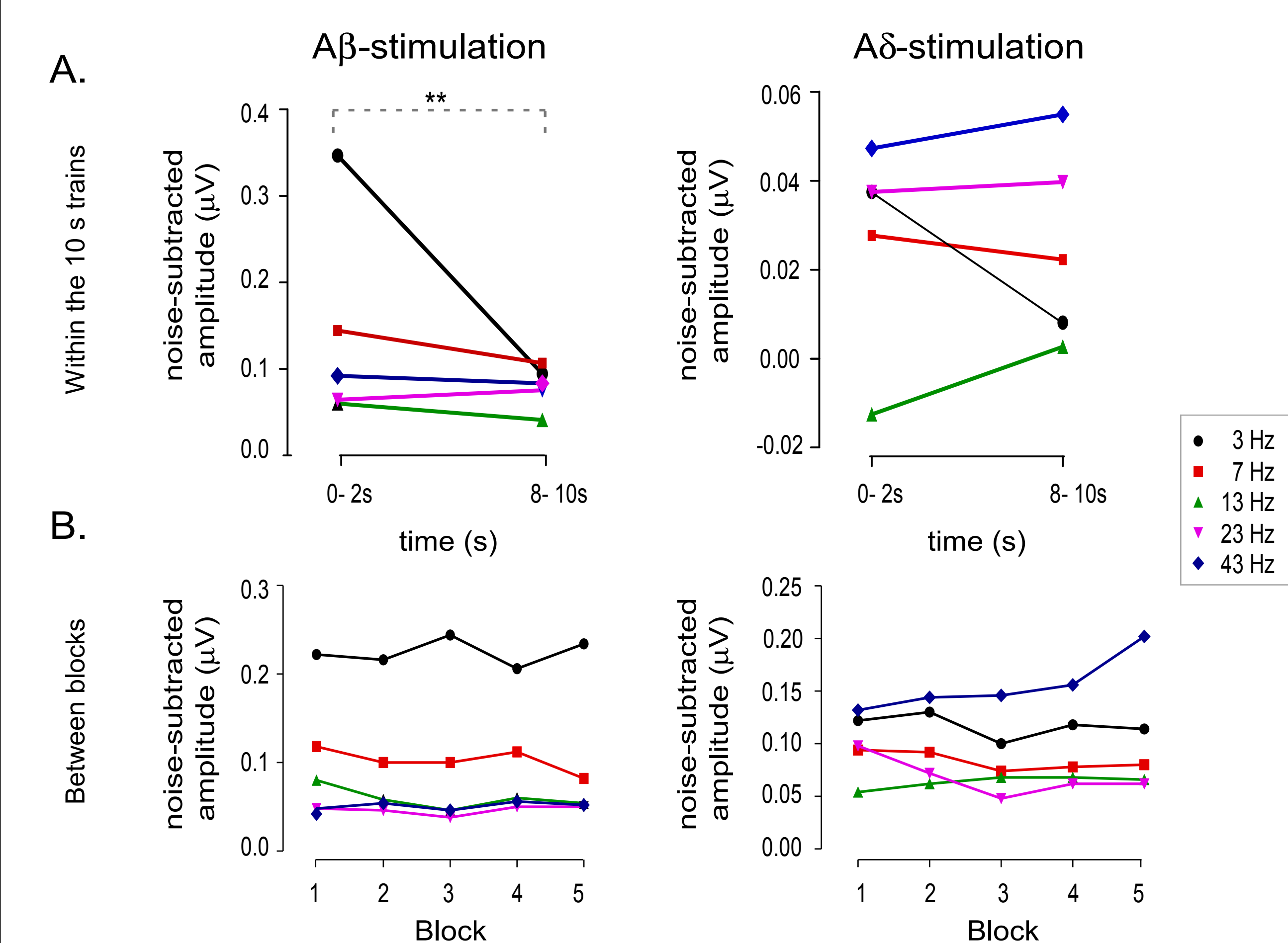
### Effect of stimulation frequency



### Scalp topographies of A $\beta$ - and A $\delta$ -SSEPs



### Temporal dynamics of A $\beta$ - and A $\delta$ -SSEPs

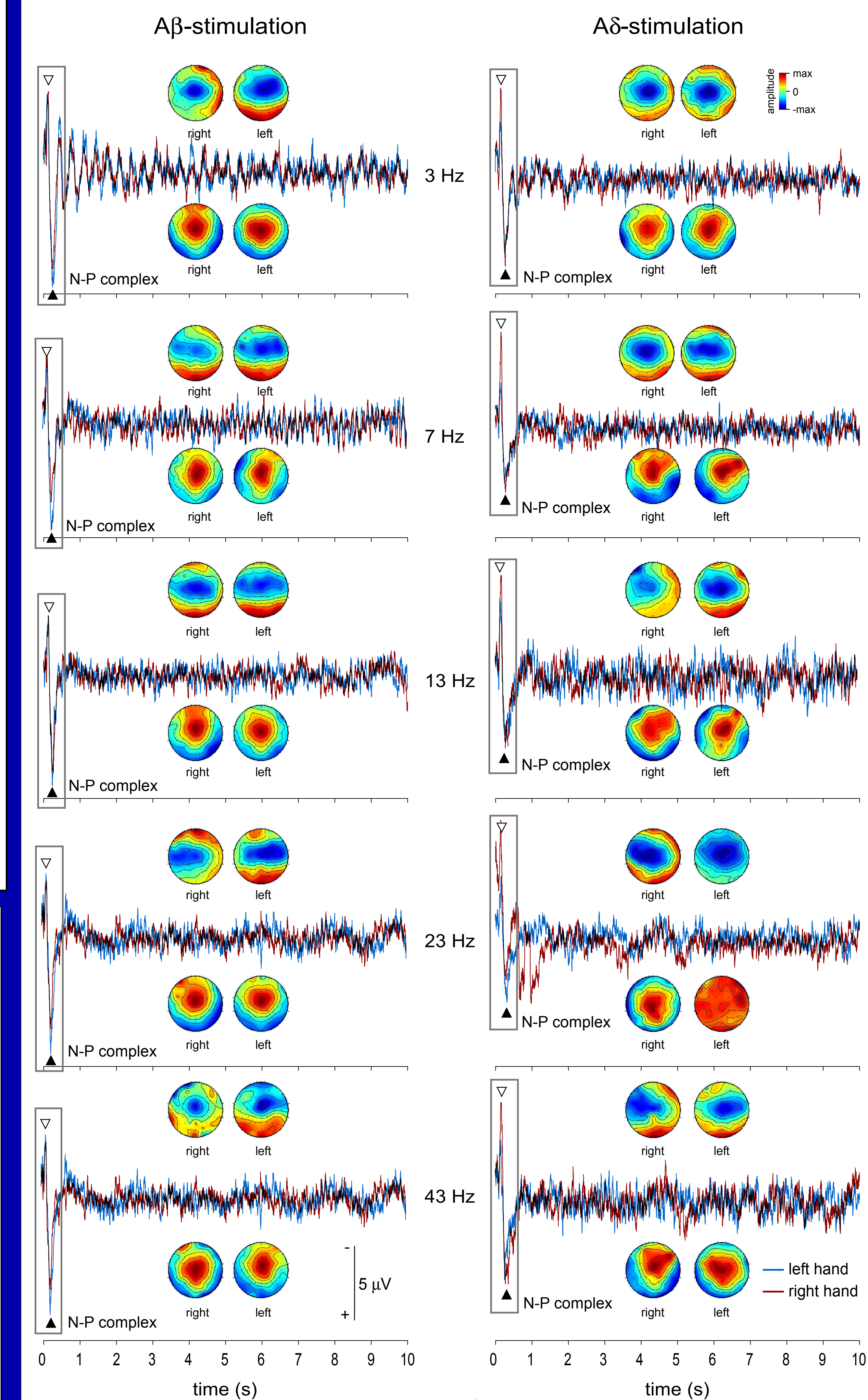


**A.** For all stimulation frequencies, the magnitude of A $\delta$ -SSEPs remained constant throughout the 10-s train. The magnitude of A $\beta$ -SSEPs remained also constant, except when stimulating at 3 Hz. **B.** The magnitude of both A $\delta$  and A $\beta$ -SSEPs was largely unaffected by stimulus repetition across blocks.

## Conclusion

Our result show that **consistent nociceptive SSEPs** can be obtained by the selective, rapid and periodic **intra-epidermal electrical stimulation** of nociceptive free nerve endings, using a wide range of frequencies (3-43 Hz). **At 3 Hz**, the topographies of A $\beta$ - and A $\delta$ -SSEPs were both maximal at the vertex, and resembled that of the late P2 wave of transient ERPs, suggesting activity originating from the **same neuronal populations**. The magnitude of 3 Hz A $\beta$ -SSEPs also show marked habituation, suggesting that these responses were mainly related to unspecific, attention-related processes. In contrast, **at frequencies  $> 3$  Hz**, the topographies of A $\beta$ - and A $\delta$ -SSEPs were markedly different. A $\beta$ -SSEPs were maximal over the contralateral parietal region, while A $\delta$ -SSEPs were maximal over midline frontal regions, thus indicating an **entrainment of distinct neuronal populations**. Furthermore, the responses showed no habituation, suggesting more obligatory and specific stages of sensory processing.

### Event-related potentials (ERPs)



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