

Low Gamma-Range Auditory Response: A Reliable Marker for Loss of Consciousness During General Anesthesia

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BACKGROUND

Objective: To assess the attenuation of gamma-range responses to auditory stimulation during loss of consciousness under general anesthesia.

Prior Research: Studies have demonstrated^{1,2} that 40 Hz constant frequency stimulation — a measure sensitive to alterations in the thalamocortical loops essential for consciousness — is significantly attenuated during anesthesia.

Innovation: Building on these findings, our study explores Envelope Following Responses (EFR) to wide-band chirp-modulated stimulation, examining both low and high gamma frequencies to identify potential new markers for unconsciousness during anesthesia.

METHODS

Participants: 26 patients undergoing propofol-remifentanyl total intravenous anesthesia (TIVA TCI)^{3,4}.

Stimulation Protocols:

- Constant frequency 40-Hz stimulation, click-based
- Wide-band chirp-modulated stimulation in the range 30-100 Hz, click-based

Data Recording: EEG data were collected using a 64-channel amplifier system before anesthesia, during maintenance, and approximately 30 minutes post-awakening.

Monitoring: Standard monitoring, predicted effect-site concentrations of anesthetic agents (target-controlled infusion systems) and depth of anesthesia (bispectral index - BIS).

Analysis: EEG analysis focused on inter-trial phase clustering (ITPC) from 7 fronto-central channels employing a non-parametric cluster-based permutation procedure⁵

RESULTS

40-Hz Stimulation

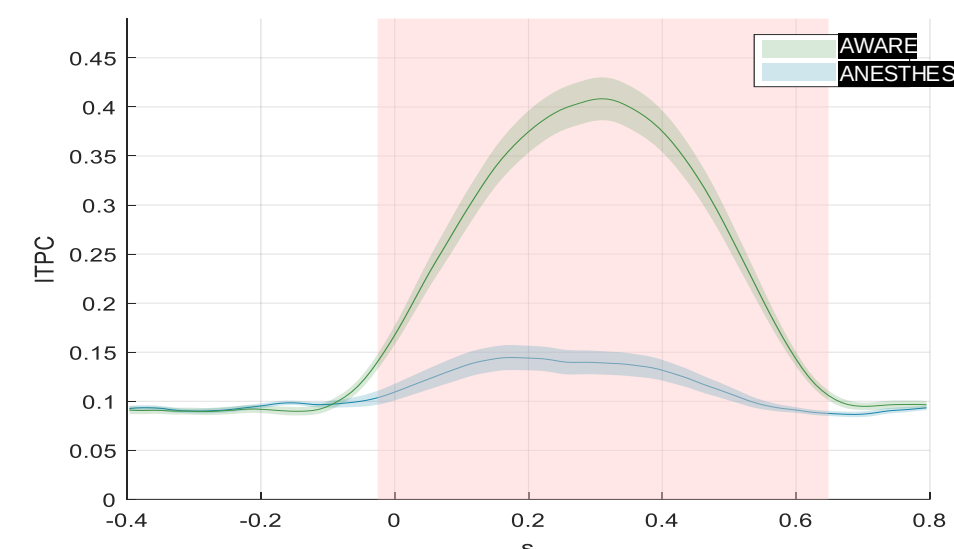
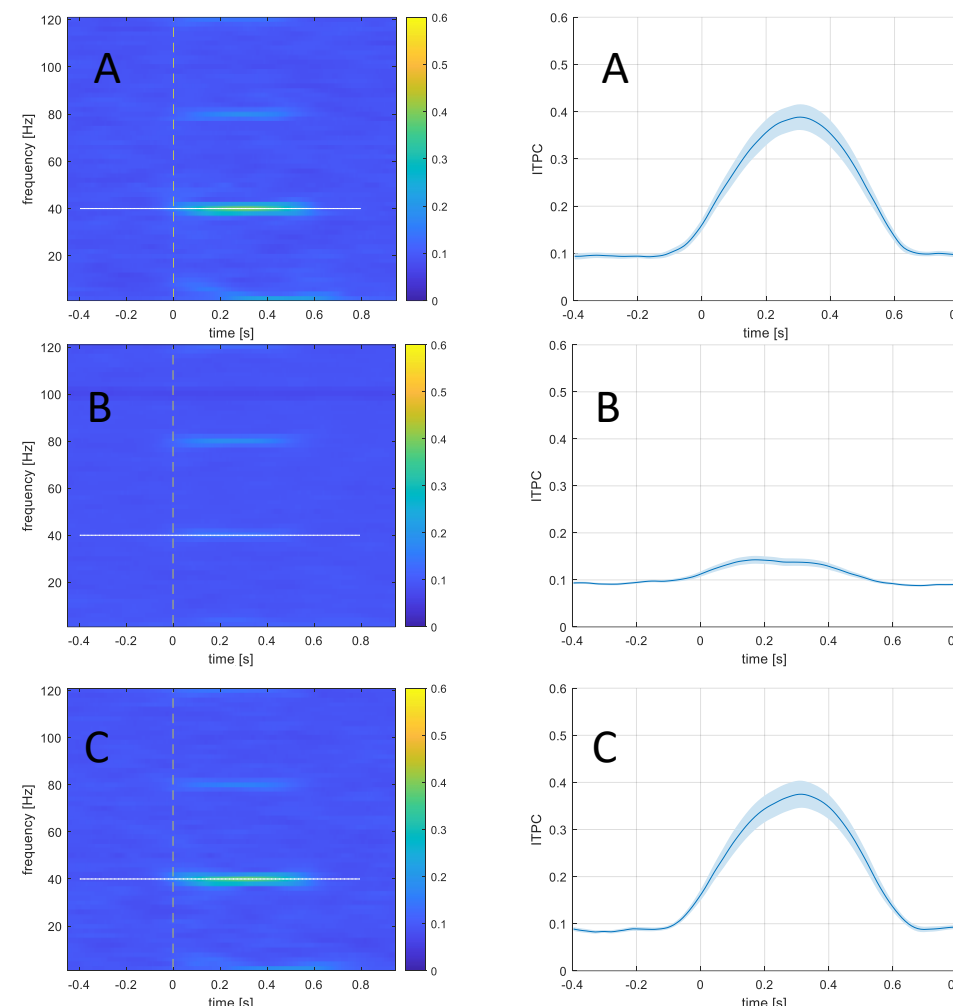


Figure 1. Grand average time-frequency responses (left panel) and 40-Hz ASSR responses (middle panel) under three conditions: A. pre-anesthesia, B. anesthesia maintenance, and C. post-anesthesia. The right panel shows the results of a non-parametric cluster-level statistical analysis comparing AWARE condition (average of pre-anesthesia and post-anesthesia responses) with ANESTHESIA maintenance condition. The pink box highlights the significant suprathreshold cluster from -0.03 to 0.65 s (cluster statistic = 602.2, $p < .001$). Ribbons on the middle and right panels indicate the standard error of the mean.

Wide-Band Stimulation

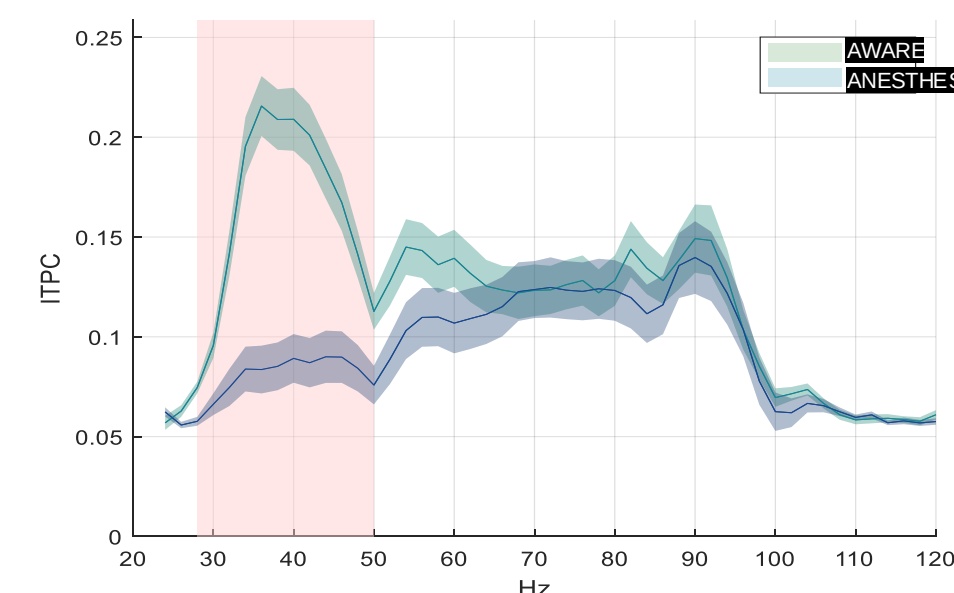
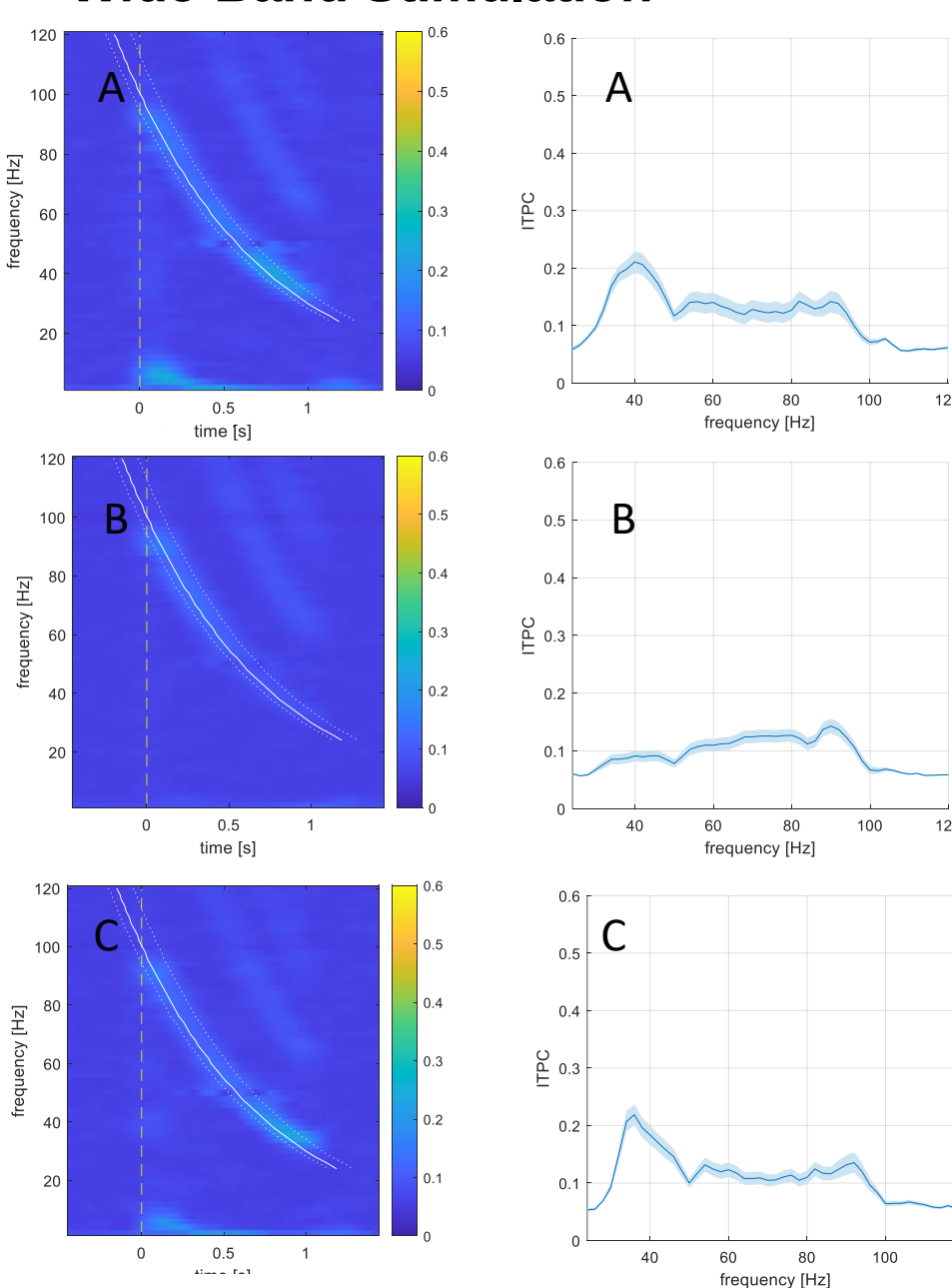


Figure 2. Grand average time-frequency responses (left panel) and envelope following responses (middle panel) under three conditions: A. pre-anesthesia, B. anesthesia maintenance, and C. post-anesthesia. The right panel displays the results of a non-parametric cluster-level statistical analysis comparing AWARE condition (average of pre-anesthesia and post-anesthesia responses) with ANESTHESIA maintenance condition. The pink box indicates the significant suprathreshold cluster in the 28-50 Hz range (cluster statistic = 64.28, $p < .001$). Ribbons on the middle and right panels indicate the standard error of the mean.

CONCLUSION

Findings

- **40-Hz ASSR:** Consistent attenuation was confirmed during loss of consciousness under general anesthesia.
- **Wide-Band Stimulation:** Low-gamma range (28-50 Hz) produced the most distinctive response, highlighting its potential for selectively detecting loss of consciousness

Implications

- **Depth of Anesthesia Monitoring:** No significant differences were observed in BIS index levels or propofol effect-site concentrations, indicating limited utility of 40-Hz ASSR and low-gamma EFR for anesthesia titration and monitoring during maintenance. This may be due to an already marked reduction in ITPC at loss of consciousness.
- **Neural Mechanisms of General Anesthesia:** Attenuation of low-gamma frequencies during propofol anesthesia may result from direct effects on GABAergic interneurons and pyramidal excitatory neurons, along with indirect effects on the cholinergic system.

References

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