

## Strengthening sleep–autonomic interaction via acoustic enhancement of slow oscillations

Daniela Grimaldi, Nelly A Papalambros, Kathryn J Reid, Sabra M Abbott, Roneil G Malkani, Maged Gendy, Marta Iwanaszko, Rosemary I Braun, Daniel J Sanchez, Ken A Paller ... [Show more](#)

*Sleep*, Volume 42, Issue 5, May 2019, zsz036, <https://doi.org/10.1093/sleep/zsz036>

**Published:** 06 February 2019 **Article history** ▼

[Views](#) ▼ [Cite](#) [Permissions](#) [Share](#) ▼

### Abstract

Slow-wave sleep (SWS) is important for overall health since it affects many physiological processes including cardio-metabolic function. Sleep and autonomic nervous system (ANS) activity are closely coupled at anatomical and physiological levels. Sleep-related changes in autonomic function are likely the main pathway through which SWS affects many systems within the body. There are characteristic changes in ANS activity across sleep stages. Notably, in non-rapid eye-movement sleep, the progression into SWS is characterized by increased parasympathetic activity, an important measure of cardiovascular health.

Experimental manipulations that enhance slow-wave activity (SWA, 0.5–4 Hz) can improve sleep-mediated memory and immune function. However, effects of SWA enhancement on autonomic regulation have not been investigated. Here, we employed an adaptive algorithm to deliver 50 ms sounds phase-locked to slow-waves, with regular pauses in stimulation (~5 s ON/~5 s OFF), in healthy young adults. We sought to determine whether acoustic enhancement of SWA altered parasympathetic activity during SWS assessed with heart rate variability (HRV), and evening-to-morning changes in HRV, plasma cortisol, and blood pressure.

Stimulation, compared with a sham condition, increased SWA during ON versus OFF intervals. This ON/OFF SWA enhancement was associated with a reduction in evening-to-morning change of cortisol levels and indices of sympathetic activity. Furthermore, the enhancement of SWA in ON intervals during sleep cycles 2–3 was accompanied by an increase in parasympathetic activity (high-frequency, HRV). Together these findings suggest that acoustic enhancement of SWA has a positive effect on autonomic function in sleep. Approaches to strengthen brain–heart interaction during sleep could have important implications for cardiovascular health.

[slow wave activity](#), [parasympathetic activity](#), [acoustic stimulation](#), [sleep](#), [autonomic nervous system](#)

© Sleep Research Society 2019. Published by Oxford University Press on behalf of the Sleep Research Society. All rights reserved. For permissions, please e-mail [journals.permissions@oup.com](mailto:journals.permissions@oup.com).

This article is published and distributed under the terms of the Oxford University Press, Standard Journals Publication Model ([https://academic.oup.com/journals/pages/open\\_access/funder\\_policies/chorus/standard\\_publication\\_model](https://academic.oup.com/journals/pages/open_access/funder_policies/chorus/standard_publication_model))

Topic:

[heart rate variability](#)

[autonomic nervous system](#)

[sleep](#)

[acoustic stimulation](#)

[acoustics](#)

**Issue Section:** [Sleep, Health and Disease](#)

You do not currently have access to this article.

## Sign in

Don't already have an Oxford Academic account? [Register](#)

### Oxford Academic account

Email address / Username [?](#)

Password

[Sign In](#)

[Forgot password?](#)

[Don't have an account?](#)

### Sleep Research Society members



[Sign in via society site](#)

### American Academy of Sleep Medicine members



[Sign in via society site](#)

### Sign in via your Institution

[Sign in](#)

### Purchase

## Short-term Access

To purchase short term access, please sign in to your Oxford Academic account above.

Don't already have an Oxford Academic account? [Register](#)

Strengthening sleep–autonomic interaction via acoustic enhancement of slow oscillations - 24 Hours access

EUR €36.00

GBP £28.00

USD \$45.00

## Rental



This article is also available for rental through DeepDyve.

[View Metrics](#)

### Email alerts

[New issue alert](#)

[Advance article alerts](#)

[Article activity alert](#)

[Subject alert](#)

---

[Receive exclusive offers and updates from Oxford Academic](#)

## More on this topic

Cardiac Autonomic Nervous Activity in Sleep-Related Painful Erections

Middle Ear Muscle Activity (MEMA) in Schizophrenia Using a Noninvasive Technique

Autonomic Arousals Related to Traffic Noise during Sleep

Sleep Perception and Misperception in Chronic Cocaine Users During Abstinence

## Related articles in

## Related articles in PubMed

[MASK (Mobile Airways Sentinel Network), a mobile App with ARIA's comprehensive solution in Spanish-speaking countries].

Associations between ambient particle radioactivity and lung function.

Pharmacokinetics of ambrisentan in a patient with Pulmonary Arterial Hypertension and a total gastrectomy.

Resting Heart Rate Variability is Negatively Associated with Mirror Neuron and Limbic Response to Emotional Faces.

## Citing articles via

Google Scholar

CrossRef

**Latest** | **Most Read** | **Most Cited**

Characterization of the sleep disorder of anti-IgLON5 disease

Actigraphic detection of periodic limb movements: development and validation of a potential device-independent algorithm. A proof of concept study

Simultaneous tonic and phasic REM sleep without atonia best predicts early phenoconversion to neurodegenerative disease in idiopathic REM sleep behavior disorder

Residual symptoms after natural remission of insomnia: associations with relapse over 4 years

Sleep duration and fragmentation in relation to leukocyte DNA methylation in adolescents

**Looking for your next opportunity?**

Chair of Pain Research  
Boston, Massachusetts

---

PEDIATRIC EMERGENCY PHYSICIAN  
Saskatoon Shines, Saskatchewan

---

Endowed Chair of Occupational  
Health/Medicine  
Saint John, New Brunswick

---

CHIEF OF THE DIVISION OF ALLERGY,  
IMMUNOLOGY AND INFECTIOUS  
DISEASE  
New Brunswick, New Jersey

[View all jobs](#)

**OXFORD**  
UNIVERSITY PRESS

[About SLEEP](#)

[Editorial Board](#)

[Author Guidelines](#)

[Facebook](#)

[Twitter](#)

[Contact Us](#)

[Purchase](#)

[Recommend to your Library](#)

[Advertising and Corporate Services](#)

[Journals Career Network](#)

Online ISSN 1550-9109

Print ISSN 0161-8105

Copyright © 2019 Sleep Research Society

[About Us](#)

[Contact Us](#)

[Careers](#)

[Help](#)

[Access & Purchase](#)

[Rights & Permissions](#)

[Open Access](#)

## Resources

[Authors](#)

[Librarians](#)

[Societies](#)

[Sponsors & Advertisers](#)

[Press & Media](#)

[Agents](#)

## Connect

[Join Our Mailing List](#)

[OUPblog](#)

[Twitter](#)

[Facebook](#)

[YouTube](#)

[Tumblr](#)

## Explore

[Shop OUP Academic](#)

[Oxford Dictionaries](#)

[Oxford Index](#)

[Epigeum](#)

[OUP Worldwide](#)

[University of Oxford](#)

*further the University's objective of excellence in research, scholarship,  
and education by publishing worldwide*

Copyright © 2019 Oxford University Press  
Accessibility

[Get Adobe Reader](#)

[Cookie Policy](#)

[Privacy Policy](#)

[Legal Notice](#)

[Site Map](#)