

# Impact of Sleep on Extracellular Volume in Human Brains: A Study with Simultaneous Sodium ( $^{23}\text{Na}$ ) MRI and EEG

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## Abstract

**Background:** Alzheimer's disease is associated with neurotoxic amyloid-beta ( $A\beta$ ) plaques. Studies in mice demonstrated that cerebrospinal fluid (CSF) clearance, if impaired, reduces  $A\beta$  clearance by 70% and that sleep enhances CSF clearance via expanding extracellular space by 60%. However, the impact of sleep on extracellular volume in human remains unclear due to lack of non-invasive technology. In this study, we use unique sodium ( $^{23}\text{Na}$ ) magnetic resonance imaging (MRI) to measure extracellular volume fraction (ECVF) in healthy subjects while monitoring their sleep stage with MRI-compatible electroencephalography (EEG).

**Method:** With IRB approval, we studied 16 cognitively-healthy subjects (age  $52.9 \pm 17.6$  years, ranging 27–77 years, 7 males and 9 females). The study lasted 1.5 hours, including four repeated 16-min sodium MRIs on a clinical scanner at 3T (Prisma, Siemens), and continuous EEG recording (Brain Vision, 32-channel, Garner, NC). The subjects were instructed to relax and fall asleep. Sleep was scored to five stages (wake, N1, N2, N3, and REM), based on American Academy of Sleep Medicine (AASM) Manual (v2.6, 2020). Sodium MRI was performed with a dual-tuned ( $^1\text{H}$ - $^{23}\text{Na}$ ) birdcage coil (QED, Cleveland, OH) and a custom-developed pulse sequence, twisted projection imaging (TP0), with parameters: FOV=220mm, matrix size=64, 3D isotropic, TE/TR = 0.5/100ms, flip angle=90°, averages=6, and TA=16min. ECVF,  $\sigma_{\text{ECVF}}$ , was calculated on the sodium images voxel-by-voxel, i.e.,  $s = \Delta V (a_w C_w + a_g C_g) = \Delta V (145 a_w + 15 a_g)$ , with  $a_w + a_g = 1$ .

**Result:** In panel P1 is the set-up of the study, including the MRI, EEG, sodium images, and hardware set-up. In P2 are typical EEG waveforms and spectra of sleep stages. In P3 is a representative of ECVF maps from a subject (43 years old, female). In P4 are outcomes of the study. Surprisingly, we observed a decrease in ECVF with sleep stage in the gray matter ( $P=0.036$ ) and in the white matter ( $P=0.085$ , nearly significant).

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# Sleep Research Volume 20

**Alan F. Stokes, Kirsten Kite**



## **Sleep Research Volume 20:**

**Ontketen je brein** Theo Compennolle, 2015-01-06 Een absolute mustread voor iedereen die meer uit zijn brein wil halen Altijd online en bereikbaar zijn multitasken negatieve stress slaapgebrek open kantoren waar iedereen elkaar kan horen Ons denkende brein staat meer dan ooit onder druk met nefaste gevolgen voor onze productiviteit creativiteit en gezondheid Doordat ze hun brein onvoldoende kennen doen slimme mensen domme dingen zo stelt neuropsychiater Theo Compennolle In dit baanbrekende boek ontsluit hij in zijn bekende glasheldere stijl de recentste kennis over ons denkende brein en toont hij aan welke breinboeien onze hersenen vandaag in een verstikkende klemgreep houden Maar hij laat ook zien hoe we ze kunnen ontketenen en reikt concrete tools en tips aan om het beste uit ons brein te halen Zijn vurige pleidooi voor meer slow thinking in een digitale wereld zal niemand onberoerd laten

**Flight Stress** Alan F. Stokes, Kirsten Kite, 2017-03-02 While stress and fatigue are often dealt with in other books on aviation performance and human factors these realities of human vulnerability are now increasingly seen as central to the effective conduct of flight operations Flight Stress provides a comprehensive treatment and a better understanding of stress and fatigue as they relate to aviation It clarifies and distinguishes the concepts of stress and fatigue as they apply to flight and expounds sufficient theory to provide a principled basis for the consideration and amelioration of stress effects in aviation The authors examine what is known of the effects of stress from both laboratory and operational studies and detail the aspects of this knowledge to which aviation professionals should pay most attention They go on to discuss the implications of stress and fatigue for performance in a range of aviation contexts from air traffic control to aerial combat Physiological cognitive and medical sequel are explored The book locates aviation related work in its broader research context critically reviewing and illustrating the work with examples from accident and incident reports It is substantive but accessible since it both sets out the research base and provides plenty of real world examples to leaven and illustrate the narrative It thus provides an authoritative handbook for aviation professionals and a comprehensive source book and reference work for researchers The readership includes aviation professionals and researchers including medical personnel and registered Aviation Medical Examiners psychologists and Human Factors specialists training captains senior pilots and engineers air traffic controllers dispatchers and operations staff

**Sleep Disorders** Chris Idzikowski, 2012-03-14 For progress to be maintained in a clinical field like sleep medicine unimpeded unrestricted access to data and the advances in clinical practice should be available The reason why this book is exciting is that it breaks down the barriers to dissemination of information providing scientists physicians researchers and interested individuals with a valuable insight into the latest diverse developments within the study of sleep disorders This book is a collection of chapters which can be viewed as independent units dealing with different aspects and issues connected to sleep disorders having in common that they reflect leading edge ideas reflections and observations The authors take into account the medical and social aspects of sleep related disorders concentrating on different focus groups from

adults to pregnant women adolescents children and professional workers      Effects of Psychoactive Chemicals on Commercial Driver Health and Performance: Stimulants, Hypnotics, Nutritional, and Other Supplements Gerald P Krueger, Howard M Leaman, Gene Bergoffen, Daniel C Murray, Racquel Pickett, 2011 TRB's Commercial Truck and Bus Safety Synthesis Program CTBSSP Synthesis 19 Effects of Psychoactive Chemicals on Commercial Driver Health and Performance Stimulants Hypnotics Nutritional and Other Supplements identifies available information and research gaps relating to the use of chemical substances by commercial drivers and is intended to provide up to date information to inform decision makers about the near mid and long range planning needs for research and educational outreach programs      **Climate Change and Mental Health Equity** Rhonda J. Moore, 2024-07-18 Climate change is a driver of poverty poor mental health inequity and increased intersectional vulnerability with significant differential global impacts on individual and community health and well being For example people living in low resource settings in high income countries HICs and in low and middle income countries LMICs are at greater risk often experiencing fragile socioeconomic political and health infrastructures and conflict affected settings FCAS that place them at greater risk and vulnerabilities to climate change related mental health impacts The broad goal of this book is to place a social justice and inclusive lens on climate change and mental health equity focusing on these three key elements people place and community The book includes perspectives from the global North the global South and Indigenous perspectives to help provide greater insight into how we can better understand climate change and mental health equity across peoples place and community This book's three pronged approach will focus on certain trends in this emerging and growing field also bridging some of the more extensive gaps and is a tool for better understanding how mental health disparities might be addressed at this time      *An Investigation Into the Effects of Warming and Prostaglandin D2 on Sleep in Rats* Stephen Robert Morairty, 1996      **Artificial Intelligence in Mental Healthcare** Shivan Bhavnani, Ryan McKim, 2026-02-24 As the healthcare industry begins to digest recent advances in artificial intelligence AI this book unveils the potential impact of AI on mental and behavioral healthcare It covers existing and potential applications of AI in addition to its main subfields of machine learning generative AI included natural language processing NLP and predictive analytics This book navigates the intricacies of AI in all stages of the patient journey from diagnosis treatment and prevention offering a holistic view of the future of mental and behavioral healthcare It explores how AI is revolutionizing key therapeutic areas within mental health like substance misuse anxiety disorders and mood disorders It also assesses use cases in back office and non patient facing areas including reimbursement processes data collection and management and revenue cycle management Chapters are supplemented with a variety of real world case studies that highlight the practical implications of AI in clinical and non clinical settings This work is relevant for healthcare clinicians innovators researchers healthcare executives and students navigating the intersection of AI and mental and behavioral healthcare      **Annual Report** Brain Research Institute, University of California, Los Angeles, University of California, Los

Angeles. Brain Research Institute,1990      **Proceedings of the 20th Annual International Conference of the IEEE Engineering in Medicine and Biology Society** IEEE Engineering in Medicine and Biology Society. Conference,1998

Sleepless Annabel Abbs,2024-01-18 Sleepless has changed how I feel about sleep I was captivated The Times Book of the Week This book will inspire you to get up light a candle and experience your own Night Self Financial Times An antidote to sleep zealotry New Scientist THE NIGHT SELF IS CREATIVE CURIOUS VULNERABLE ENCHANTED COURAGEOUS In the winter of 2020 Annabel Abbs experienced a series of bereavements As she grieved she kept busy by day but at night sleep eluded her And yet her sleeplessness led to a profound and unexpected discovery her Night Self As the night transformed into a place of creativity and liberation Annabel found she wasn't alone From the radical fifteenth century philosopher Laura Cereta and subversive artist Louise Bourgeois to Virginia Woolf and the activist Peace Pilgrim women have long found sanctuary inspiration and courage in darkness Drawing on the latest science which shows we are more imaginative open minded and reflective at night Annabel set out to discover the potential of her Night Self Sleepless follows her journey from midnight hikes to starlit swims from Singapore the brightest city on Earth to the darkest corner of the Arctic Circle and finally to that most elusive of places sleep A moving revelatory voyage into the dark Sleepless invites us to feel less anxious about our sleep and to embrace the possibilities of the night      *Crew Factors in Flight Operations* ,1991      **Federation**

**Proceedings** Federation of American Societies for Experimental Biology,1979      **Optical Engineering Midwest '95** Rudolph P. Guzik,1995      **Sonic-boom Research: Selected Bibliography with Annotation** Harvey H. Hubbard,1986

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## **Table of Contents Sleep Research Volume 20**

1. Understanding the eBook Sleep Research Volume 20
  - The Rise of Digital Reading Sleep Research Volume 20
  - Advantages of eBooks Over Traditional Books
2. Identifying Sleep Research Volume 20
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Sleep Research Volume 20
  - User-Friendly Interface
4. Exploring eBook Recommendations from Sleep Research Volume 20
  - Personalized Recommendations
  - Sleep Research Volume 20 User Reviews and Ratings
  - Sleep Research Volume 20 and Bestseller Lists
5. Accessing Sleep Research Volume 20 Free and Paid eBooks
  - Sleep Research Volume 20 Public Domain eBooks

- Sleep Research Volume 20 eBook Subscription Services
- Sleep Research Volume 20 Budget-Friendly Options
- 6. Navigating Sleep Research Volume 20 eBook Formats
  - ePub, PDF, MOBI, and More
  - Sleep Research Volume 20 Compatibility with Devices
  - Sleep Research Volume 20 Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Sleep Research Volume 20
  - Highlighting and Note-Taking Sleep Research Volume 20
  - Interactive Elements Sleep Research Volume 20
- 8. Staying Engaged with Sleep Research Volume 20
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Sleep Research Volume 20
- 9. Balancing eBooks and Physical Books Sleep Research Volume 20
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Sleep Research Volume 20
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Sleep Research Volume 20
  - Setting Reading Goals Sleep Research Volume 20
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Sleep Research Volume 20
  - Fact-Checking eBook Content of Sleep Research Volume 20
  - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development
  - Exploring Educational eBooks

#### 14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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