Project 017 Pilot Study on Aircraft Noise and Sleep Disturbance

University of Pennsylvania

Project Lead Investigator

Mathias Basner
Associate Professor of Sleep and Chronobiology
Department of Psychiatry
University of Pennsylvania
1019 Blockley Hall, 423 Guardian Dr.
Philadelphia, PA 19104-6021
215-573-5866
basner@mail.med.upenn.edu

University Participants

University of Pennsylvania

- P.I.: Mathias Basner, Associate Professor
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- Period of Performance: October 1, 2015 to September 30, 2016
- Task(s):
  (1) Philadelphia Sleep Study: Data analysis
  (2) Second Pilot Sleep Study: Data acquisition

Project Funding Level

The funding amount for this period was $343,498.00. The cost sharing requirement for this project was met by our international collaborators at the German Aerospace Center (DLR).

Investigation Team

- Principal Investigator: Mathias Basner
- Co-Investigator: Sarah McGuire
- Research Assistants: Anjana Kallarackal, Maryam Witte

Project Overview

The long-term goal of this line of research is to derive exposure-response relationships for aircraft noise-induced sleep disturbance that are representative of the exposed U.S. population. As studies will have to investigate samples around multiple airports it will not be possible to use polysomnography (i.e., simultaneous recording of the electroencephalogram, electromyogram, and electrooculogram) to monitor sleep, as this method requires trained personnel at the measurement site in the evening and in the morning and is thus too costly. An alternative methodology of using a single channel electrocardiogram (ECG) and actigraphy to monitor sleep has been examined. This methodology allows the investigation of larger subject samples at lower cost as individuals can be taught how to apply the electrodes themselves. Also unlike polysomnography, awakenings can be identified automatically. As part of previous research, an algorithm for identifying EEG arousals (Basner, Griefahn, Müller et al., 2007) based on increases in heart rate was refined in order to only identify those arousals greater than or equal to 15 seconds in duration, which is the most agreed upon indicator of noise-induced sleep disturbance. High agreement between EEG visually scored arousals and arousals identified using the refined ECG based algorithm was obtained. The methodology of using ECG and actigraphy to monitor sleep has been implemented in two pilot field studies to evaluate the quality of data that can be obtained for unattended physiological and noise measurements. Based on lessons learned, the study protocol is being refined in order to inform the design and cost of a potential multi-airport study on the effects of noise on sleep.

Task1- Philadelphia Sleep Study: Data analysis

Objectives

(1) Evaluate the completeness and quality of data obtained through unattended sleep measurements.
(2) Compare the degree of sleep fragmentation, subjective sleep ratings, and subjective health ratings between participants that lived near the airport and those that lived in a control region.
(3) Develop models relating awakenings to indoor noise levels and compare results to models derived from similar studies conducted by DLR in Germany.
(4) Further refine study protocol and methodology based on lessons learned.

Research Approach

A pilot sleep study was conducted around Philadelphia International Airport. This airport was selected as it was in close proximity to the study team and had relevant amounts of nighttime air traffic. Measurements took place between July 2014 and July 2015. Forty participants who lived near the airport and 40 participants from a control region in Philadelphia County were enrolled in the study. Participants were recruited primarily through mailed flyers. Each participant completed 3 nights/4 days of unattended measurements. Staff went to the participant's home on the first day of the study to explain the protocol and setup the equipment and after the third night to collect the equipment. Baseline sleep and health characteristics were obtained subjectively on the first day. Each night participants completed ECG and actigraphy measurement with concurrent indoor noise recordings. Each morning participants completed blood pressure measurements and self-report assessments of their previous night's sleep. The methodology, analysis, and results are described in detail in a separate ASCENT project report.

There were several limitations of the Philadelpia sleep study methodology. First, while the target enrollment of the study was met, the response rate was low with 3700 flyers mailed. This low response rate could affect the generalizability of the results. One potential reason for the low response rate could be that individuals were reluctant to allow unknown staff members enter their homes to setup the equipment. Another limitation was the methodological expense as trained staff was in the field 2 to 4 days per week. These limitations have been addressed in the refined methodology implemented in the second pilot sleep study.

Task 2-Second Pilot Sleep Study: Data acquisition

Objectives

(1) Complete acquisition of survey and acoustical and physiological data
(2) Refine and to the extent possible, automatize the methodology to identify aircraft noise events and maximum sound pressure levels in complex acoustical signals
(3) Inform the design and cost of a potential multiple airport study based on lessons learned

Research Approach

Based on lessons learned in the Philadelphia Sleep study, the methodology has been refined and a second pilot study is being conducted to evaluate its feasibility. The airport for this study was selected in consultation with the FAA and has relevant amounts of nighttime air traffic and a sufficient population to sample from. To determine the sample regions around the airport, L_{Night} noise contours were provided by the FAA. Additionally we calculated L_{Night} contours for 84 weekdays based on flight track data. For the study we have 10 sampling regions, 5 east and west of the airport of the following noise categories: < 40 dB (control region), 40-45 dB, 45-50 dB, 50-55 dB, and > 55 dB L_{Night}.

To recruit participants for the study a brief survey is mailed to randomly selected households within each of the 10 sampling frames. The primary purpose of the survey is determining the eligibility of individuals to take part in an in-home sleep study. The survey contains questions on the individual's health, sleep, and noise sensitivity. For completing the survey participants receive an Amazon gift card. The amount of the gift card is$2.00, $5.00, or $10.00 which is randomly assigned. The purpose of varying the gift card amount is to examine the difference in response rate received. The target number of completed surveys is 200 per 5dB noise category.

In the survey, participants indicate their interest in taking part in the in-home sleep study which consists of 5 nights of unattended ECG and actigraphy measurements and indoor sound recordings. The equipment is mailed to the participant's homes and instruction manuals and videos on how to setup and use the equipment are provided. Mailing the equipment eliminates the need for staff in the field which significantly reduces the study cost. In addition, by mailing the equipment the response rate may increase as staff does not enter the participant's homes. The target enrollment for the in-home study is 40 per 5 dB noise category. The outcomes for this study are to determine the response rates for both the mail and in-home study, assess the feasibility of mailing equipment, and evaluate the quality of data that can be obtained.

Data collection is ongoing.

Milestones

The following are milestones that were achieved during the past 12 months:
(1) Data analysis for the Philadelphia Sleep Study was completed 8/2016
(2) Data collection for the second pilot sleep study began 9/2016.

Major Accomplishments

Task 1: The primary objective of the Philadelphia Sleep Study was to evaluate the feasibility of conducting a study with unattended acoustical and physiological measurements. For this study 79 out of 80 participants enrolled completed the measurements, and all but 1 completed all three nights of the study. In addition, for all measurements there was less than 10% of data loss. This result suggests that participants are able to follow protocol and complete unattended measurements.

Task 2: All preparations for the study were completed during the last period including; preparing the survey, purchasing and testing physiological and noise measurement equipment, and obtaining addresses. As part of the preparations, low cost sound recording equipment was identified, which includes a class 1 microphone and small recorder. The identification of this noise monitoring equipment has reduced the methodological cost and enabled more sites to be studied concurrently.

Publications

ASCENT Project Report

Basner M, McGuire S, and Witte M. Pilot sleep study near Philadelphia International Airport: ASCENT Project 17 Report, 2016.

Conference Proceedings

McGuire S, Witte M, and Basner M. Evaluation and refinement of a methodology for examining the effects of aircraft noise on sleep in communities in the US. Internoise, Hamburg, Germany, 2016.

Outreach Efforts

None

Awards

None

Student Involvement

None

Plans for Next Period

Task 1: We will continue to compare the results from the Philadelphia Sleep Study to the results from German field studies conducted around Cologne-Bonn and Frankfurt Airport and publish the findings as part of continued collaboration with colleagues at the German Aerospace Center (DLR).

Task 2: Concurrently with the data collection, we will analyze the sound recordings. For this analysis we will refine and automatize the methodology of identifying aircraft noise events and maximum sound pressure levels in the recordings.

The identification of aircraft noise events can be challenging based on indoor sound measurements only due to masking of other noise events (e.g., air conditioning system, snoring). A methodology will be developed that automatically identifies aircraft noise events based on flight track data provided by FAA and estimates indoor noise levels based on outdoor noise predictions and an established relationship of outdoor/indoor noise attenuation in cases were the aircraft noise event is masked by other noise sources.

References

Basner M, Griefahn B, Müller U, Plath G, Samel A. An ECG-based algorithm for the automatic identification of autonomic activations associated with cortical arousal. Sleep 2007; 30(10):1349-61.