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Sections
Abstract
Introduction
Methods
Results
Discussion
Tables
Appendix
References
Supplementary Information
Funding
Further Information
Article Metrics
Additional Information
Supplementary Information
Rights and permissions

Supplementary Information

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A longitudinal, randomized experimental pilot study to investigate the effects of airborne infrasound on human mental health, cognition, and brain structure

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Abstract

Airborne infrasound (20 Hz) emitted by e.g., large machinery, wind farms is ubiquitous in technological environments. Health hazards are controversially discussed at present. This study investigated effects of airborne infrasound on human mental health, cognition, and brain structure in humans. Specifically, infrasound stimulation (6 Hz, 90 dB SPL at ear) or sham exposure were installed in participants' (N = 36) bedrooms and active for 28 nights. Somatic and psychiatric symptoms, sound sensitivity, sleep quality, cognitive performance, and structural MRI were assessed pre-post. Post-findings were arranged for all behavioral variables. Exploratory correlations between changes in brain structure and behavioral changes were also tested. Severe scores of and trait (p = 0.04) State-Anxiety (STAI) were significantly reduced in ICBE increases, but there were decreases within clusters in the cerebellum (Vermis) and left angular gyrus (BA39) in sham-exposed participants. Sham-exposed participants showed a global scale, however, future sham should consider more fine-grained specific effects, particularly in cognitive and emotional domains. Infrasound exposure had no effect on hypertension and symptoms. As in such behavior tests could be established. Sham-exposed grey matter decline cannot be interpreted in terms of potential beneficial/adverse, no improvement through IR exposure. Parameters that may interfere/attain changes as established in the present study include motor function, sensory processing/ hearing/ and motor perceptions, and/or cognitive/ higher auditory processing (i.e., language-related tasks), which are focus potential target variables for future research.

Introduction

In the wake of industrial and technological innovations of the twentieth century, an emerging question is whether sound waves below the human hearing threshold (< 20 Hz, termed infrasound (IS), can affect human behavior and brain structure. It shall be noted that the hearing threshold, principal high sound pressure levels (SPL), is variable, and a hearing sensation can be perceived at infrasonic frequencies. For example, it has been demonstrated that 2.5 Hz sinusoidal stimuli at 90 dB SPL (at ear) can be heard by some participants (Salt & Hullar[1]). Concerning adverse effects, symptoms like nausea, tinnitus, vertigo, and headaches are non-specific, yet, sleep disturbances, or annoyance have been documented for IS, mainly in occupational settings (Leventhall[2]). Although, occupational exposure to IS is mostly attributed to industrial sources, such as machinery, or wind turbines (Leventhall[2]). Review of evidence concerning these adverse effects suggested that instruments, and machinery components were usually inaudible, presumably causing a distinct sense of adverse effects were attributable to inaudible IS or merely an effect of auditory noise. Most research notes that adverse effects are not attributable to inaudible IS (Leventhall[2]). Nevertheless, the effect of these stimuli suggested that psychological and social mechanisms may contribute to annoyance, which explains the observed adverse health effects better than exposure to sole low frequency noise per se[2]. According to another review, annoyance reported by about 10% of individuals living in proximity to relevant infrasonic or low-frequency sources[3]. Both reviews concluded that call for methodologically well-designed long-term studies, which are lacking at present.

Concerning potential hard effects of IS, not to mention inaudible IS, the literature is extremely scarce. In a first ground breaking study by Gomelsky and colleagues[4], exposure to low frequency (7 Hz) and high intensity (100 dB) IS induced a decrease in blood pressure, heart rate and superior temporal gyrus (an area largely responsible for higher order auditory processing, such as language comprehension). The signal was evident at SPL between 80 and 110 dB for audible infrasound and low frequencies between 2 and 20 Hz[4]. Another pilot study conducted by our research group found that 28 Hz generated brain activities within the cerebellum and the left angular gyrus (BA39) in healthy participants (Weichenberger et al.[5]). Moreover, it further study investigated resting state brain activity and found to be significantly altered by near-threshold (hence inaudible) IS at a frequency of 12 Hz. Higher-level connectivity in the right superior temporal gyrus (primary auditory cortex), the insula, cingulate cortex, and the right amygdala, was identified. This speaks for the possibility of subcortical and cortical processing of inaudible IS, which could be mediated by bone conduction. Somewhat contradicting the idea of IS inducing adverse effects, in the aviation sector, our research team also found a trend-level improvement in working memory performance under the influence of perceivable 12 Hz IS[6]. Yet, slightly contradictory, there was a trend for investigating the interaction of IS with audible sound. While IS does not alter hearing thresholds for pure tones, it seems to reduce the hearing threshold for tones of 16 Hz leading to reduce the loud of IS as humans in an equation of loudness[7].

Despite some prime-facie evidence of potential effects of IS on human (mental health and) cognition, there are virtually no studies that directly investigated the effect of IS on brain structure in a randomized controlled design, and there is so far no study of its effects on brain structure. There is plenty of evidence for, now, showing that our environment and lifestyle can have a profound impact on the brains' morphology, and IS could be a potential candidate environmental factor. Recent studies have shown that a few plain traffic, large ventilation systems, public transportation, and heavy machinery, are large mechanic[8]. So far, all designed laboratory studies investigated the effects on global which do not match the real situation of exposure in IS source in the public and all day life. The present study is the first and conducted randomized long-term exposure that (one month) to airborne infrasound (IS) in healthy participants. Our study aimed to investigate potential adverse effects of inaudible IS on human health and cognition. We included symptoms in general, anxiety, depression, stress, somatic symptoms (i.e., sleep disturbances, somatic symptoms), cognitive attention (i.e., alertness, vigilance, cognitive flexibility, divided attention, attention shifting, inhibition), and brain structure have never been studied previous research. Hypothesis, which is the intention of the present study.

Methods

Recruitment and in- and exclusion criteria

The study was approved by the Ethics Committee of Health Care Institute (Ref.Vote protocol available here: https://doi.org/10.48550/arXiv.2202.12334[9]) and was deemed NO INTERVENTION IS (protocol#1, registration date: 09/03/2018). In all procedures, we adhered to the declaration of Helsinki, and the study was approved by a local ethics committee in the year around 2016 (Kommission der Ärztekammer Hamburg, approval number: PV5072). Active and sham exposure was installed in the participants' bedrooms. The study was active for 28 nights. The obtained infrasound curves from all sources which are used in this study. The sound curves were recorded in a quiet room, and the sound curves were recorded using an ear-like microphone (Brüel & Kjær, Type 4190, Nærum, Denmark). The recorded sound curves were analysed in group assignment design. Participants were assigned to the conditions based on their bedroom's location (i.e., neighbourhood). Participants were recruited through flyers, concerned people who actively expressed their interest, and were recruited by the study team. Participants were assigned to 12 sets per condition (taking into account potential drop-out). Included participants were separately assigned to the most available for position and unseen of their assignment until the end of the trial. The experimenter was aware of the group assignment, but participants were blind to their assignment. Participants were informed about the purpose of the study, the study's aim, the study's duration, and the procedure. Participants were informed that the study team first evaluated everyone's study information and a fine for an online screening to check for and exclusion criteria. The screening took about 45 min, and included socio-demographic assessments, including sex, age (inquired to be between 18 and 45 years), handedness, and BMI (inclusion: 18.5–30 kg/m²), and questions about exclusion criteria. Exclusion criteria were: (1) use of the bedroom, number of windows and doors in the bedroom, city district, and closeness to main roads; (2) Hobbies: sleeping in the bedroom was an exclusion criterion for safety reasons. In addition, pet owners were asked to keep animals outside the room for the time of the exposure. Main exclusion criteria were counter-indications for magnetic resonance imaging (MRI), such as metal in the body, claustrophobia, pacemaker, body, or implants, chronic intervention, acupuncture, or other severe disease (e.g., cancer), as well as central nervous system diseases, Similarly, indicating any anomalies concerning hearing (e.g., diarrhoea, pain ear surgery, chronic information of the ear canal, chronic tinnitus, anxiety, anomalies) were exclusion. Central nervous rehabilitation clinic/hospital, and/or psychiatric/psychotherapy treatment, and/or, and/or, and/or

wind turbine noise[36].

Conclusion

Our study broadly suggests that inaudible (6 Hz) IS does not affect human behavior per se, including a range of health-related and psychological variables (i.e., self-reports of sound sensitivity, sleep, psychiatric symptoms, or stress) and cognitive functions (i.e., alertness, sustained attention, cognitive flexibility, divided attention, shift of attention, inhibition). Based on our brain structural analyses, it seems that IS exposure relates to grey matter decline in brain areas that are associated with somatomotor- and cognitive functions such as working memory (bilateral cerebellum VIIIa) and higher auditory processing (angular gyrus, BA39), comprising functions such as speech intelligibility/production or semantic/lexical processing and reading. The overall pattern of results, including exploratory findings of changed body perception (increased perceived weakness), makes a plausible case for assessing bodily sensations at a level of greater detail, adding physiological assessments such as electromyography, and to focus on tasks related to language processing and complex (verbal) working memory in future trials.

Data availability

We hereby declare that our data, code and syntaxes (including a documentation of all analyses that were undertaken) are available upon request.

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Ethics declarations

Competing interests

The authors declare no competing interests.

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