1. Environ Res. 2015 Oct;142:609-14. doi: 10.1016/j.envres.2015.08.016.

Framing sound: Using expectations to reduce environmental noise annoyance.

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BACKGROUND: Annoyance reactions to environmental noise, such as wind turbine sound, have public health implications given associations between annoyance and symptoms related to psychological distress. In the case of wind farms, factors contributing to noise annoyance have been theorised to include wind turbine sound characteristics, the noise sensitivity of residents, and contextual aspects, such as receiving information creating negative expectations about sound exposure.
OBJECTIVE: The experimental aim was to assess whether receiving positive or negative expectations about wind farm sound would differentially influence annoyance reactions during exposure to wind farm sound, and also influence associations between perceived noise sensitivity and noise annoyance.
METHOD: Sixty volunteers were randomly assigned to receive either negative or positive expectations about wind farm sound. Participants in the negative expectation group viewed a presentation which incorporated internet material indicating that exposure to wind turbine sound, particularly infrasound, might present a health risk. Positive expectation participants viewed a DVD which framed wind farm sound positively and included internet information about the health benefits of infrasound exposure. Participants were then simultaneously exposed to sub-audible infrasound and audible wind farm sound during two 7min exposure sessions, during which they assessed their experience of annoyance.
RESULTS: Positive expectation participants were significantly less annoyed than negative expectation participants, while noise sensitivity only predicted annoyance in the negative group.
CONCLUSION: Findings suggest accessing negative information about sound is likely to trigger annoyance, particularly in noise sensitive people and, importantly, portraying sound positively may reduce annoyance reactions, even in noise sensitive individuals.

PMID: 26313626 [PubMed - in process]

2. J Psychosom Res. 2015 Sep;79(3):185-9. doi: 10.1016/j.jpsychores.2015.04.014. Epub 2015 May 1.

Accentuate the positive: Counteracting psychogenic responses to media health messages in the age of the Internet.

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Comment in
J Psychosom Res. 2015 Sep;79(3):173-4.

OBJECTIVE: The Internet has expanded the scope for creating health scares and increased the risk of nocebo responding in individuals exposed to misinformation about threats to personal health posed by aspects of modern life, such as exposure to new technologies. It was the aim of this experiment to investigate whether the delivery of positive expectations might reduce or reverse symptoms triggered by negative expectations formed from such misinformation.
METHOD: In the context of a study investigating symptoms during exposure to windfarm sound, 64 volunteers assessed their symptomatic experiences during two

discrete sessions, throughout which they listened to wind turbine sound containing audible and sub-audible (infrasound) components. Participants were randomly assigned to watch either positive or negative information about the health effects of infrasound prior to their first infrasound exposure session. They were then shown the alternate information and exposed to infrasound during their second session.
RESULTS: Participants receiving negative expectations were less symptomatic during exposure if they had previously received positive expectations about infrasound. Further, participants given positive expectations after the earlier delivery of negative expectations exhibited a placebo response, reversing the nocebo response exhibited in their first exposure session.
CONCLUSION: Results suggest accessing positively framed health information may reverse or dilute the effect of negative expectations formed from exposure to media warnings about health risks posed by new technologies, such as wind turbines.

PMID: 25963037 [PubMed - in process]

3. Front Public Health. 2015 Apr 7;3:52. doi: 10.3389/fpubh.2015.00052. eCollection 2015.

Spectral discrete probability density function of measured wind turbine noise in the far field.

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Of interest is the spectral character of wind turbine noise at typical residential set-back distances. In this paper, a spectral statistical analysis has been applied to immission measurements conducted at three locations. This method provides discrete probability density functions for the Turbine ONLY component of the measured noise. This analysis is completed for one-third octave sound levels, at integer wind speeds, and is compared to existing metrics for measuring acoustic comfort as well as previous discussions on low-frequency noise sources.

PMCID: PMC4387936
PMID: 25905097 [PubMed]

4. J Acoust Soc Am. 2015 Mar;137(3):1356-65. doi: 10.1121/1.4913775.

A theory to explain some physiological effects of the infrasonic emissions at some wind farm sites.

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For at least four decades, there have been reports in scientific literature of people experiencing motion sickness-like symptoms attributed to low-frequency sound and infrasound. In the last several years, there have been an increasing number of such reports with respect to wind turbines; this corresponds to wind turbines becoming more prevalent. A study in Shirley, WI, has led to interesting findings that include: (1) To induce major effects, it appears that the source must be at a very low frequency, about 0.8 Hz and below with maximum effects at about 0.2 Hz; (2) the largest, newest wind turbines are moving down in frequency into this range; (3) the symptoms of motion sickness and wind turbine acoustic emissions "sickness" are very similar; (4) and it appears that the same organs in the inner ear, the otoliths may be central to both conditions. Given that the same organs may produce the same symptoms, one explanation is that the wind

turbine acoustic emissions may, in fact, induce motion sickness in those prone to this affliction.

PMID: 25786948 [PubMed]

5. J Acoust Soc Am. 2015 Mar;137(3):1265-73. doi: 10.1121/1.4908568.

Wind fence enclosures for infrasonic wind noise reduction.

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A large porous wind fence enclosure has been built and tested to optimize wind noise reduction at infrasonic frequencies between 0.01 and 10 Hz to develop a technology that is simple and cost effective and improves upon the limitations of spatial filter arrays for detecting nuclear explosions, wind turbine infrasound, and other sources of infrasound. Wind noise is reduced by minimizing the sum of the wind noise generated by the turbulence and velocity gradients inside the fence and by the area-averaging the decorrelated pressure fluctuations generated at the surface of the fence. The effects of varying the enclosure porosity, top condition, bottom gap, height, and diameter and adding a secondary windscreen were investigated. The wind fence enclosure achieved best reductions when the surface porosity was between 40% and 55% and was supplemented by a secondary windscreen. The most effective wind fence enclosure tested in this study achieved wind noise reductions of 20-27 dB over the 2-4 Hz frequency band, a minimum of 5 dB noise reduction for frequencies from 0.1 to 20 Hz, constant 3-6 dB noise reduction for frequencies with turbulence wavelengths larger than the fence, and sufficient wind noise reduction at high wind speeds (3-6 m/s) to detect microbaroms.

PMID: 25786940 [PubMed]

6. Front Public Health. 2015 Feb 24;3:31. doi: 10.3389/fpubh.2015.00031. eCollection 2015.

Health-based audible noise guidelines account for infrasound and low-frequency noise produced by wind turbines.

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Setbacks for wind turbines have been established in many jurisdictions to address potential health concerns associated with audible noise. However, in recent years, it has been suggested that infrasound (IS) and low-frequency noise (LFN) could be responsible for the onset of adverse health effects self-reported by some individuals living in proximity to wind turbines, even when audible noise limits are met. The purpose of this paper was to investigate whether current audible noise-based guidelines for wind turbines account for the protection of human health, given the levels of IS and LFN typically produced by wind turbines. New field measurements of indoor IS and outdoor LFN at locations between 400 and 900 m from the nearest turbine, which were previously underrepresented in the scientific literature, are reported and put into context with existing published works. Our analysis showed that indoor IS levels were below auditory threshold levels while LFN levels at distances >500 m were similar to background LFN

levels. A clear contribution to LFN due to wind turbine operation (i.e., measured with turbines on in comparison to with turbines off) was noted at a distance of 480 m. However, this corresponded to an increase in overall audible sound measures as reported in dB(A), supporting the hypothesis that controlling audible sound produced by normally operating wind turbines will also control for LFN. Overall, the available data from this and other studies suggest that health-based audible noise wind turbine siting guidelines provide an effective means to evaluate, monitor, and protect potential receptors from audible noise as well as IS and LFN.

PMCID: PMC4338604
PMID: 25759808 [PubMed]

7. Int J Environ Health Res. 2015;25(5):463-8. doi: 10.1080/09603123.2014.963034. Epub 2014 Oct 8.

On the biological plausibility of Wind Turbine Syndrome.

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An emerging environmental health issue relates to potential ill-effects of wind turbine noise. There have been numerous suggestions that the low-frequency acoustic components in wind turbine signals can cause symptoms associated with vestibular system disorders, namely vertigo, nausea, and nystagmus. This constellation of symptoms has been labeled as Wind Turbine Syndrome, and has been identified in case studies of individuals living close to wind farms. This review discusses whether it is biologically plausible for the turbine noise to stimulate the vestibular parts of the inner ear and, by extension, cause Wind Turbine Syndrome. We consider the sound levels that can activate the semicircular canals or otolith end organs in normal subjects, as well as in those with preexisting conditions known to lower vestibular threshold to sound stimulation.

PMID: 25295915 [PubMed - in process]

8. Front Public Health. 2014 Jun 19;2:63. doi: 10.3389/fpubh.2014.00063. eCollection 2014.

Wind turbines and human health.

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The association between wind turbines and health effects is highly debated. Some argue that reported health effects are related to wind turbine operation [electromagnetic fields (EMF), shadow flicker, audible noise, low-frequency noise, infrasound]. Others suggest that when turbines are sited correctly, effects are more likely attributable to a number of subjective variables that result in an annoyed/stressed state. In this review, we provide a bibliographic-like summary and analysis of the science around this issue specifically in terms of noise (including audible, low-frequency noise, and infrasound), EMF, and shadow flicker. Now there are roughly 60 scientific peer-reviewed articles on this issue. The available scientific evidence suggests that EMF, shadow flicker, low-frequency noise, and infrasound from wind turbines are not likely to affect human health; some studies have found that audible noise from wind turbines can be annoying to some. Annoyance may be associated with some self-reported health effects (e.g., sleep disturbance) especially at sound pressure levels >40 dB(A). Because environmental noise above certain levels is a

recognized factor in a number of health issues, siting restrictions have been implemented in many jurisdictions to limit noise exposure. These setbacks should help alleviate annoyance from noise. Subjective variables (attitudes and expectations) are also linked to annoyance and have the potential to facilitate other health complaints via the nocebo effect. Therefore, it is possible that a segment of the population may remain annoyed (or report other health impacts) even when noise limits are enforced. Based on the findings and scientific merit of the available studies, the weight of evidence suggests that when sited properly, wind turbines are not related to adverse health. Stemming from this review, we provide a number of recommended best practices for wind turbine development in the context of human health.

PMCID: PMC4063257
PMID: 24995266 [PubMed]

9. Can J Rural Med. 2014 Winter;19(1):21-6.

Industrial wind turbines and adverse health effects.

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Erratum in
Can J Rural Med. 2014 Spring;19(2):56.

INTRODUCTION: Some people living in the environs of industrial wind turbines (IWTs) report experiencing adverse health and socioeconomic effects. This review considers the hypothesis that annoyance from audible IWTs is the cause of these adverse health effects.
METHODS: We searched PubMed and Google Scholar for articles published since 2000 that included the terms "wind turbine health," "wind turbine infrasound," "wind turbine annoyance," "noise annoyance" or "low frequency noise" in the title or abstract.
RESULTS: Industrial wind turbines produce sound that is perceived to be more annoying than other sources of sound. Reported effects from exposure to IWTs are consistent with well-known stress effects from persistent unwanted sound.
CONCLUSION: If placed too close to residents, IWTs can negatively affect the physical, mental and social well-being of people. There is sufficient evidence to support the conclusion that noise from audible IWTs is a potential cause of health effects. Inaudible low-frequency noise and infrasound from IWTs cannot be ruled out as plausible causes of health effects.

PMID: 24398354 [PubMed - indexed for MEDLINE]

10. Health Psychol. 2014 Dec;33(12):1588-92. doi: 10.1037/hea0000037. Epub 2013 Nov 25.

The power of positive and negative expectations to influence reported symptoms and mood during exposure to wind farm sound.

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OBJECTIVE: Wind farm developments have been hampered by claims that sound from wind turbines causes symptoms and negative health reports in nearby residents. As scientific reviews have failed to identify a plausible link between wind turbine sound and health effects, psychological expectations have been proposed as an explanation for health complaints. Building on recent work showing negative expectations can create symptoms from wind turbines, we investigated whether positive expectations can produce the opposite effect, in terms of a reduction in

symptoms and improvements in reported health.
METHOD: 60 participants were randomized to either positive or negative expectation groups and subsequently exposed to audible wind farm sound and infrasound. Prior to exposure, negative expectation participants watched a DVD incorporating TV footage about health effects said to be caused by infrasound produced by wind turbines. In contrast, positive expectation participants viewed a DVD that outlined the possible therapeutic effects of infrasound exposure.
RESULTS: During exposure to audible windfarm sound and infrasound, symptoms and mood were strongly influenced by the type of expectations. Negative expectation participants experienced a significant increase in symptoms and a significant deterioration in mood, while positive expectation participants reported a significant decrease in symptoms and a significant improvement in mood.
CONCLUSION: The study demonstrates that expectations can influence symptom and mood reports in both positive and negative directions. The results suggest that if expectations about infrasound are framed in more neutral or benign ways, then it is likely reports of symptoms or negative effects could be nullified.

PMID: 24274799 [PubMed - indexed for MEDLINE]

11. Health Psychol. 2014 Apr;33(4):360-4. doi: 10.1037/a0031760. Epub 2013 Mar 11.

Can expectations produce symptoms from infrasound associated with wind turbines?

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OBJECTIVE: The development of new wind farms in many parts of the world has been thwarted by public concern that subaudible sound (infrasound) generated by wind turbines causes adverse health effects. Although the scientific evidence does not support a direct pathophysiological link between infrasound and health complaints, there is a body of lay information suggesting a link between infrasound exposure and health effects. This study tested the potential for such information to create symptom expectations, thereby providing a possible pathway for symptom reporting.
METHOD: A sham-controlled double-blind provocation study, in which participants were exposed to 10 min of infrasound and 10 min of sham infrasound, was conducted. Fifty-four participants were randomized to high- or low-expectancy groups and presented audiovisual information, integrating material from the Internet, designed to invoke either high or low expectations that exposure to infrasound causes specified symptoms.
RESULTS: High-expectancy participants reported significant increases, from preexposure assessment, in the number and intensity of symptoms experienced during exposure to both infrasound and sham infrasound. There were no symptomatic changes in the low-expectancy group.
CONCLUSIONS: Healthy volunteers, when given information about the expected physiological effect of infrasound, reported symptoms that aligned with that information, during exposure to both infrasound and sham infrasound. Symptom expectations were created by viewing information readily available on the Internet, indicating the potential for symptom expectations to be created outside of the laboratory, in real world settings. Results suggest psychological expectations could explain the link between wind turbine exposure and health complaints.

PMID: 23477573 [PubMed - indexed for MEDLINE]

12. J Laryngol Otol. 2013 Mar;127(3):222-6. doi: 10.1017/S0022215112002964.

'Wind turbine syndrome': fact or fiction?

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OBJECTIVE: Symptoms, including tinnitus, ear pain and vertigo, have been reported following exposure to wind turbine noise. This review addresses the effects of infrasound and low frequency noise and questions the existence of 'wind turbine syndrome'.
DESIGN: This review is based on a search for articles published within the last 10 years, conducted using the PubMed database and Google Scholar search engine, which included in their title or abstract the terms 'wind turbine', 'infrasound' or 'low frequency noise'.
RESULTS: There is evidence that infrasound has a physiological effect on the ear. Until this effect is fully understood, it is impossible to conclude that wind turbine noise does not cause any of the symptoms described. However, many believe that these symptoms are related largely to the stress caused by unwanted noise exposure.
CONCLUSION: There is some evidence of symptoms in patients exposed to wind turbine noise. The effects of infrasound require further investigation.

PMID: 23331380 [PubMed - indexed for MEDLINE]

~~13. Pol J Vet Sci. 2013;16(4):679-86.~~

~~Preliminary studies on the reaction of growing geese (Anser anser f. domestica) to the proximity of wind turbines.~~

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Wind farms produce electricity without causing air pollution and environmental degradation. Unfortunately, wind turbines are a source of infrasound, which may cause a number of physiological effects, such as an increase in cortisol and catecholamine secretion. The impact of infrasound noise, emitted by wind turbines, on the health of geese and other farm animals has not previously been evaluated. Therefore, the aim of this study was to determine the effect of noise, generated by wind turbines, on the stress parameters (cortisol) and the weight gain of geese kept in surrounding areas. The study consisted of 40 individuals of 5-week-old domestic geese Anser anser f domestica, divided into 2 equal groups. The first experimental gaggle (I) remained within 50 m from turbine and the second one (II) within 500 m. During the 12 weeks of the study, noise measurements were also taken. Weight gain and the concentration of cortisol in blood were assessed and significant differences in both cases were found. Geese from gaggle I gained less weight and had a higher concentration of cortisol in blood, compared to individuals from gaggle II. Lower activity and some disturbing changes in behavior of animals from group I were noted. Results of the study suggest a negative effect of the immediate vicinity of a wind turbine on the stress parameters of geese and their productivity.

PMID: 24597302 [PubMed - indexed for MEDLINE]

14. Environ Health. 2011 Sep 14;10:78. doi: 10.1186/1476-069X-10-78.
Health effects and wind turbines: a review of the literature.
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BACKGROUND: Wind power has been harnessed as a source of power around the world. Debate is ongoing with respect to the relationship between reported health effects and wind turbines, specifically in terms of audible and inaudible noise. As a result, minimum setback distances have been established world-wide to reduce or avoid potential complaints from, or potential effects to, people living in proximity to wind turbines. People interested in this debate turn to two sources of information to make informed decisions: scientific peer-reviewed studies published in scientific journals and the popular literature and internet.
METHODS: The purpose of this paper is to review the peer-reviewed scientific literature, government agency reports, and the most prominent information found in the popular literature. Combinations of key words were entered into the Thomson Reuters Web of KnowledgeSM and the internet search engine Google. The review was conducted in the spirit of the evaluation process outlined in the Cochrane Handbook for Systematic Reviews of Interventions.
RESULTS: Conclusions of the peer reviewed literature differ in some ways from those in the popular literature. In peer reviewed studies, wind turbine annoyance has been statistically associated with wind turbine noise, but found to be more strongly related to visual impact, attitude to wind turbines and sensitivity to noise. To date, no peer reviewed articles demonstrate a direct causal link between people living in proximity to modern wind turbines, the noise they emit and resulting physiological health effects. If anything, reported health effects are likely attributed to a number of environmental stressors that result in an annoyed/stressed state in a segment of the population. In the popular literature, self-reported health outcomes are related to distance from turbines and the claim is made that infrasound is the causative factor for the reported effects, even though sound pressure levels are not measured.
CONCLUSIONS: What both types of studies have in common is the conclusion that wind turbines can be a source of annoyance for some people. The difference between both types is the reason for annoyance. While it is acknowledged that noise from wind turbines can be annoying to some and associated with some reported health effects (e.g., sleep disturbance), especially when found at sound pressure levels greater than 40 db(A), given that annoyance appears to be more strongly related to visual cues and attitude than to noise itself, self reported health effects of people living near wind turbines are more likely attributed to physical manifestation from an annoyed state than from wind turbines themselves. In other words, it appears that it is the change in the environment that is associated with reported health effects and not a turbine-specific variable like audible noise or infrasound. Regardless of its cause, a certain level of annoyance in a population can be expected (as with any number of projects that change the local environment) and the acceptable level is a policy decision to be made by elected officials and their government representatives where the benefits of wind power are weighted against their cons. Assessing the effects of wind turbines on human health is an emerging field and conducting further research into the effects of wind turbines (and environmental changes) on human health, emotional and physical, is warranted.

PMCID: PMC3179699
PMID: 21914211 [PubMed - indexed for MEDLINE]

15. Hear Res. 2010 Sep 1;268(1-2):12-21. doi: 10.1016/j.heares.2010.06.007. Epub 2010 Jun 16.
Responses of the ear to low frequency sounds, infrasound and wind turbines.
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Infrasonic sounds are generated internally in the body (by respiration, heartbeat, coughing, etc) and by external sources, such as air conditioning systems, inside vehicles, some industrial processes and, now becoming increasingly prevalent, wind turbines. It is widely assumed that infrasound presented at an amplitude below what is audible has no influence on the ear. In this review, we consider possible ways that low frequency sounds, at levels that may or may not be heard, could influence the function of the ear. The inner ear has elaborate mechanisms to attenuate low frequency sound components before they are transmitted to the brain. The auditory portion of the ear, the cochlea, has two types of sensory cells, inner hair cells (IHC) and outer hair cells (OHC), of which the IHC are coupled to the afferent fibers that transmit "hearing" to the brain. The sensory stereocilia ("hairs") on the IHC are "fluid coupled" to mechanical stimuli, so their responses depend on stimulus velocity and their sensitivity decreases as sound frequency is lowered. In contrast, the OHC are directly coupled to mechanical stimuli, so their input remains greater than for IHC at low frequencies. At very low frequencies the OHC are stimulated by sounds at levels below those that are heard. Although the hair cells in other sensory structures such as the saccule may be tuned to infrasonic frequencies, auditory stimulus coupling to these structures is inefficient so that they are unlikely to be influenced by airborne infrasound. Structures that are involved in endolymph volume regulation are also known to be influenced by infrasound, but their sensitivity is also thought to be low. There are, however, abnormal states in which the ear becomes hypersensitive to infrasound. In most cases, the inner ear's responses to infrasound can be considered normal, but they could be associated with unfamiliar sensations or subtle changes in physiology. This raises the possibility that exposure to the infrasound component of wind turbine noise could influence the physiology of the ear.

PMCID: PMC2923251
PMID: 20561575 [PubMed - indexed for MEDLINE]