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Framing sound: Using expectations to reduce environmental noise annoyance

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ABSTRACT

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 7 min 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.

1. Introduction

It has become increasingly important to understand human reactions to environmental noise given the growing pervasiveness of exposure to noise in everyday life (Stansfeld and Matheson, 2003). In particular, insight into reported noise annoyance, as a common non-auditory adverse effect of environmental sound exposure, is important from a public health perspective. This is because, although the experience of noise annoyance alone is not classified as a disease or health state, noise annoyance is related to psychological stress, which can lead to stress related symptoms and poorer subjective health (Basner et al., 2014). A relatively new source of environmental sound is that generated by wind turbines.

Harvesting wind power has the potential to provide a significant contribution to world energy requirements, while providing health benefits associated with reduced fossil fuel emissions, such as reducing the incidence of respiratory and cardiovascular diseases linked to air pollution (Smith et al., 2013). However, although wind energy production does not generate hazardous waste by-products or release greenhouse gases which contribute to climate change, the emission of noise is linked to the experience of environmental noise annoyance in some people (Knopper et al., 2014). This is of importance because, while evidence does not indicate residents would experience direct adverse physiological effects from wind turbine sound, there are indications that wind farm noise annoyance is associated with psychological distress, perceived sleep disturbance, and subjective physical symptoms, such as headache (Bakker et al., 2012; Pedersen, 2011). Therefore, to optimise the overall health benefits associated with wind farms it is pertinent to explore the factors which influence wind farm noise annoyance, so that useful strategies can be implemented to prevent or mitigate noise annoyance in residents living in the locale of a wind farm.

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There is considerable variability in the reported prevalence of wind farm noise annoyance and the factors that explain reported noise annoyance are far from clear (Merlin et al., 2013). Annoyance with wind farm sound may be explained, in part, because mechanical sounds are more likely to be evaluated negatively than the sounds of nature, such as the sound of wind, or water, which are not generally viewed as unpleasant or intrusive (e.g. Andringa and Lanser, 2013; Yang and Kang, 2005). However, in comparison with other mechanical noises, such as industrial noise from stationary sources or transportation noise, wind farm noise annoyance has been found at relatively low noise exposure levels, suggesting that there are some variables unique to wind farm sound exposure influencing annoyance reactions (Janssen et al., 2011; Pedersen and Persson Waye, 2004).

One explanation for annoyance reactions might be that there is some idiosyncratic feature of wind farm sound that explains annoyance reactions at low sound levels. One suggestion is that exposure to the sub-audible sound or infrasound (sound below 20 Hz) generated by wind turbines accounts for elevated annoyance reactions (Pierpont, 2009). However, human beings are consistently exposed to atmospheric infrasound, created by natural phenomena such as weather variations and ocean waves, and generated by anthropogenic sources, such as traffic and air-conditioning units (Leventhall, 2006, 2013). The evidence shows that the level of infrasound measured near windfarms does not exceed levels found in everyday urban and rural environments, and that windfarm infrasound makes an insignificant contribution to the background level of environmental infrasound (Evans et al., 2013; Turnbull et al., 2012). Therefore annoyance reactions are unlikely to be explained by wind farm infrasound exposure (Bolin et al., 2011)

It has also been suggested that wind farm noise is more annoying than equivalent levels of other environmental noise because of the production of fluctuating aerodynamic sound, which embodies acoustic properties shown to contribute both to awareness of sound, and perceptions of unpleasantness (Pedersen and Persson Waye, 2008). This is supported by evidence that annoyance with wind turbine sound is associated with modulations in sound, sometimes described onomatopoeically as swishing or lapping (Pedersen and Persson Waye, 2004; Pedersen et al., 2009).

It has also been theorized that wind farm noise annoyance is related to noise sensitivity and that there is an element of inevitability that noise sensitive people will find wind turbine noise annoying, even when exposure is within recognised health and safety limits, putting them at risk of psychological stress and stress related health effects over time (Shepherd et al., 2011). While, evidence indicates noise annoyance is not closely related to a general neurophysiological sensitivity (Öhrsröm et al., 1988), consistent associations have been found between subjective noise sensitivity and noise annoyance (Job, 1988; Miedema and Vos, 2003). Subjective noise sensitivity has been found to moderate the effect of noise exposure on annoyance and has been viewed as a stable personality trait reflecting a predisposition to attend to noise and evaluate that noise negatively (Stansfield, 1992), linked to negative affectivity (Smith, 2003), and perceived stress (Nordin et al., 2013). The idea that subjective noise sensitivity may help explain reported annoyance with wind turbine sound is supported by associations between perceived noise sensitivity and annoyance found in field research (e.g. Pederson and Persson Waye, 2008).

Wind turbine noise annoyance is also associated with a number of subjective factors, such as attitude to the visual impact of wind turbines on the landscape (e.g. Pederson et al., 2009), attitude to wind turbines in general (e.g. Pedersen and Persson Waye, 2004), and satisfaction with the living environment e.g. (Pedersen et al., 2007). This suggests that contextual factors are also influencing annoyance reactions. One of the contextual matters likely to create negative attitudes to wind farms, and trigger wind farm noise annoyance, is accessing material available on the internet and disseminated though social dialogue about negative health effects said to occur as a result of exposure to wind farm produced infrasound, sound below 20 Hz (Crichton et al., 2014a; Chapman et al., 2014; Rubin et al., 2014). Exposure to this narrative has been shown to increase concern about health effects of wind farms and create negative expectations leading to symptom reporting during periods of exposure to both genuine infrasound and sham infrasound (Crichton et al., 2014c). Importantly, elevated reports of annoyance and health effects have been shown to occur primarily in localities where there has been targeted publicity about the alleged harmful impacts of wind farms (e.g. Chapman et al., 2013). Thus exposure to a negative narrative about wind farms appears to be a stronger initiator of reported noise annoyance, than the inherent characteristics of the sound or the perceived noise sensitivity of residents.

Given that exposure to a negative narrative about wind farms may elevate noise annoyance, the converse may also be true; that accessing a positive narrative about wind farms may inhibit reported annoyance, even in those rating themselves as noise sensitive. If this were found to be the case this would have implications for the implementation of effective interventions and strategies to overcome annoyance reactions in those living in the vicinity of wind farms.

An experimental study was therefore designed to assess whether framing wind farm sound in either positive or negative ways would differentially influence annoyance reactions to that sound. The experiment was also devised to test whether exposure to wind farm sound was inherently annoying and whether the way in which the sound was described influenced associations between perceived noise sensitivity, and noise annoyance. Given the consistent relationship seen in the literature between negative affect and noise sensitivity, the relationship between noise sensitivity and negative mood was also assessed. Our primary hypothesis was that participants delivered negative expectations about wind farm sound, created from material available on the internet, would be significantly more annoyed during exposure to wind farm sound, than participants given positive expectations. We also hypothesised that positive expectation participants would experience very low levels of annoyance indicating that the sound was not inherently annoying. We further hypothesised that noise sensitivity would predict annoyance, but only in the negative expectation group.

2. Materials and method

2.1. Study design

The study received University of Auckland Human Participants Ethics Committee approval (reference number 8436). Recruitment was by way of a flyer placed on the University of Auckland website. Participants were informed that this was an experiment designed to assess subjective responses to wind farm sound and were blind to the hypotheses being tested. Given that this was an experiment testing noise annoyance, participants were also required to pass a threshold hearing screening test prior to experimental procedures. Sixty healthy student volunteers (21 male, 39 female) completed the experiment, which took place in a listening room constructed to international standards for the execution of subjective listening experiments (IEC268-13).

Participants were randomised to positive or negative expectation groups using a random number generator. The optimal sample size was evaluated employing G-Power (Faul et al., 2007), on the basis of analysis involving a 2×2 mixed design analysis of