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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.

Keywords: psychological expectations, symptom reporting, environmental risks, wind energy, infrasound

Sourcing renewable and sustainable energy is widely viewed as necessary to mitigate climate change and address the negative health impacts associated with fossil fuel consumption, such as mortality and morbidity due to cardiorespiratory diseases (Haines, Alleyne, Kickbusch, & Dora, 2012). To this end, harvesting wind power has become a key feature of clean energy development policies in many countries, with the aim of reducing greenhouse-gas emissions and related adverse health outcomes. Yet in many parts of the world wind farm implementation has been stalled by claims that living in the vicinity of wind farms may pose a health risk (Knopper & Ollson, 2011; Chapman, 2011). Given the importance of the role of wind energy in the attainment of clean energy targets worldwide, it is necessary to understand what could be causing reported health complaints and to explore approaches to address these complaints.

The type of health problems reported include a range of nonspecific physical symptoms, such as headache, nausea, ear problems, dizziness, and sleep dysfunction, as well as negative mood states, such as depression (e.g., Pierpont, 2009). Negative health effects from wind turbines have been attributed to the infrasound produced by the operation of wind turbines. Infrasound (sound between .01 and 20 Hz) is generally below the threshold of human hearing and is a common everyday phenomenon. Infrasound is produced by air turbulence and ocean waves, as well as by machinery such as air conditioners, and by internal physiological processes, such as respiration and heartbeat (Leventhall, 2007). Infrasound generated by wind turbines is subaudible and does not exceed typical levels of everyday infrasound exposure (Turnbull, Turner, & Walsh, 2012). Moreover, reviews of the scientific evidence have found the evidence does not support a direct pathophysiological link between the sound produced by wind turbine operations and the health of people living in the vicinity of wind farms (e.g., Ellenbogen et al., 2012; Fortin, Rideout, Copes & Bos, 2013; Knopper & Ollson, 2011).

Research has more recently focused on whether the health complaints by residents in the vicinity of wind farms could be due to psychological expectations. This work suggests that expectations could be established by media and Internet information asserting that adverse health effects are caused by exposure to infrasound produced by wind turbines. The expectations hypothesis is supported by a recent epidemiological analysis of health and noise complaints of Australian wind farms operating since 1993. This analysis shows that the majority of complaints commenced after 2009 and coincided with adverse health effects being promoted by groups opposed to the construction of wind farms

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(Chapman, St. George, Waller, & Cakic, 2013). Further support for the expectations hypothesis comes from a recent sham-controlled double-blind experimental study we conducted. The study showed that healthy volunteers, when given information designed to invoke either high or low expectations that exposure to infrasound causes symptom complaints, reported symptoms that were consistent with the level of expectation (Crichton, Dodd, Schmid, Gamble, & Petrie, 2013).

The provocative question that this research raises is that if negative expectations can create symptoms from wind turbines, can positive expectations produce a reduction in symptoms and improvements in reported health? To investigate this idea further we explored whether infrasound had ever been used as a therapy. We found that alternative medicine practitioners have explored the therapeutic impact of infrasound (e.g., Yount, Taft, West, & Moore, 2004) and therapeutic infrasound producing devices are now marketed to the public. These devices have been promoted as alleviating the very symptoms infrasound exposure from wind farms is said to trigger (Haneke, Carson, Gregorio, & Maull, 2001). We used this information to investigate whether positive health information about infrasound might create positive expectations leading to improved subjective health evaluation during exposure to wind farm sound. Such a finding would have the potential to inform interventions designed to safeguard against future symptom reporting and to reduce or reverse symptomatic experiences attributed to wind farms.

In this experimental study we tested whether the provision of either positive or negative health information about infrasound generated by wind turbines was reflected in participants' symptoms and health perceptions in response to wind farm sound. It was hypothesized that during listening sessions involving simultaneous exposure to audible wind turbine sound and infrasound, participants given negative expectations would experience an increase in the number and intensity of physical symptoms, an increase in negative mood, and a decrease in positive mood, and would evaluate exposure sessions as having adverse health impacts. In contrast, it was also hypothesized that participants given positive expectations would experience a decrease in the number and intensity of physical symptoms, a decrease in negative mood, and an increase in positive mood, and would evaluate exposure sessions as having health benefits.

Method

Sixty undergraduate participants (39 female, 21 male) with a mean age of 19.72 years ($SD = 2.66$) were recruited by flyers distributed at the University of Auckland. Following recruitment participants were randomly allocated to positive or negative expectation groups. All participants were told the purpose of the study was to investigate the effect of sound below the threshold of human hearing (infrasound) on the experience of physical sensations and mood. Experimental procedures were conducted in a listening room purpose built for subjective sound experiments to the standard set by the International Electrotechnical Commission (IEC268-13). Consistent with the cover story, the research was conducted in the Acoustic Research Centre, a facility associated with the School of Engineering.

Once baseline measurements were undertaken, participants viewed one of two 5-minute, 27-second DVD presentations, each of which contained wind turbine and health material available on the Internet. The negative health information DVD incorporated TV current affairs footage indicating that exposure to wind turbine sound, particularly infrasound, might pose a health risk. In contrast, the positive health information DVD framed wind turbine sound as containing infrasound, subaudible sound created by natural phenomena such as ocean waves and the wind, which had been reported to have positive effects and therapeutic benefits on health. Participants were contemporaneously and continuously exposed to infrasound (9Hz, 50.4dB) and audible wind farm sound (43dB), which had been recorded 1 km from a wind farm, during two 7-minute listening sessions. Both groups were made aware they were listening to the sound of a wind farm, and were being exposed to sound containing both audible and subaudible components and that the sound was at the same level during both sessions. Symptom and mood questionnaires were filled in at baseline and during each exposure period, prompted by a 2-second audible tone (middle C–262Hz) played 2 minutes into each session.

Symptoms and mood were assessed on a 7-point Likert scale ranging from 0 (*not at all*) to 6 (*extreme* or *extremely*). At baseline and during exposure sessions, participants evaluated their experience of 24 physical symptoms (e.g., headache, ear pressure, tiredness), and the extent to which they felt 12 positive mood items (e.g., relaxed, peaceful, cheerful) and 12 negative mood items (e.g., anxious, nervous, distressed). For each rating period a total symptom score was calculated as the number of symptoms experienced with a rating ≥ 1, and a total symptom intensity score was calculated as the sum of the ratings given for all symptoms experienced. Reliability of the symptom questionnaire was established in a previous study (Crichton et al., 2013). Further, for each rating period total positive mood and total negative mood scores were calculated. The symptom and mood scales all demonstrated good internal consistency (Cronbach's alpha for symptom intensity scale = .82; positive mood scale = .95; negative mood scale = .92). As a manipulation check to see if participants believed that exposure periods had influenced their symptoms, participants were asked whether they had experienced an improvement or worsening of symptoms during sessions on two 7-point Likert scales ranging from 0 (*not at all*) to 6 (*extreme*). Symptom improvement or worsening was assessed as a score ≥ 1. This assessment occurred in a room adjoining the listening room after experimental procedures had concluded.

Results

We first conducted mixed model analysis of covariance to assess within- and between-group differences in terms of change from baseline in symptom reporting during exposure session 1 and exposure session 2, controlling for baseline scores. These data are depicted in Figure 1. Results showed a significant interaction between expectation group and exposure session in relation to both symptom change scores, $F(1, 58) = 13.95$, $p < .001$, and symptom intensity change scores $F(1, 58) = 16.27$, $p < .001$. Tukey-Kramer post-hoc tests revealed that expectation group allocation differentially influenced symptom reporting during exposure sessions. There were significant differences between the negative expectation group and the positive expectation group in relation to symptom change scores during session 1 ($p = .005$) and session 2 ($p < .001$), and similarly, in relation

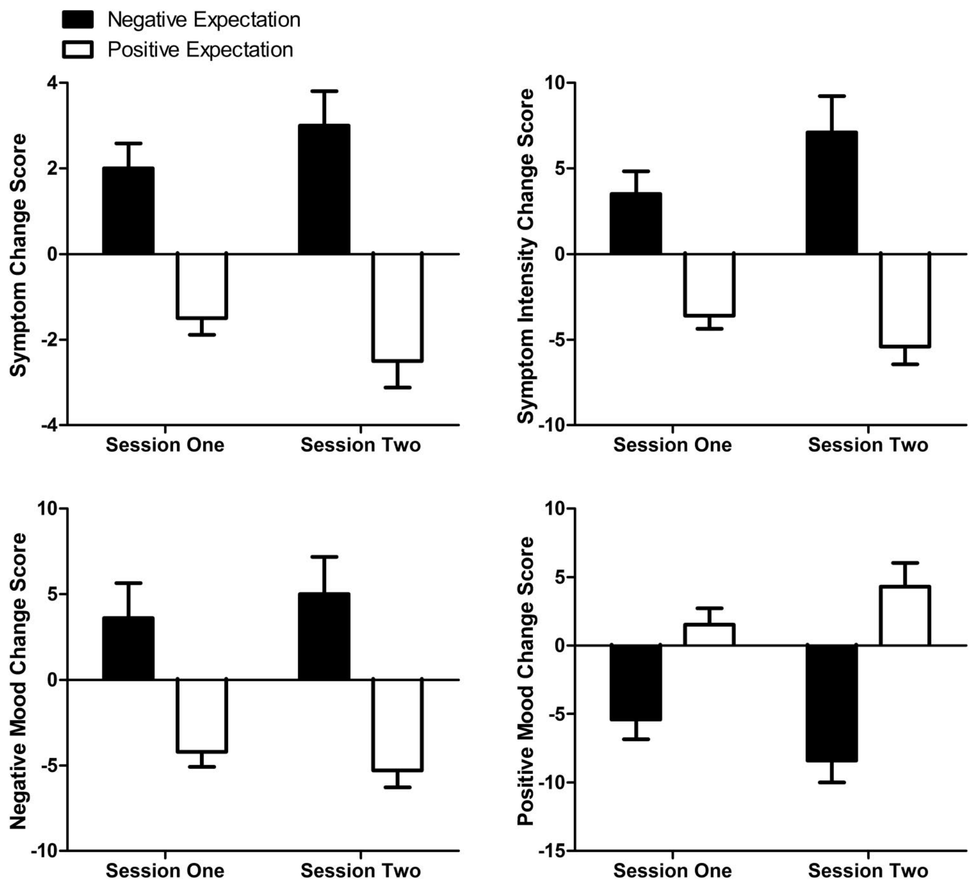

Figure 1. Changes in symptoms, symptom intensity, and mood in negative and positive expectation groups.

to symptom intensity change scores during session 1 (p = .01) and session 2 (p < .001). There were also within group differences in symptom reporting in the negative expectation group during session 1 and session 2 in respect of symptom change scores (p = .037) and symptom intensity change scores (p = .002). Thus negative expectation group participants became more symptomatic over time, suggesting that experiences during the first exposure session reinforced symptom expectations leading to heightened symptomatic experiences.

To check whether the manipulation had also triggered a significant symptomatic change from baseline, we conducted repeated measure ANOVAs, using Greenhouse-Geisser correction when the assumption of sphericity had been violated, on mean symptom and symptom intensity scores recorded at baseline, during Session 1, and during Session 2, as reported in Table 1. Results showed that participants in the negative expectation group recorded a significant increase from baseline in the number of symptoms experienced $F(1.36, 39.45) = 12.12$, $p < .001$, $\eta_p^2 = .30$. Analysis revealed there were significant increases from baseline in the number of symptoms reported during both session 1 (p = .002) and during session 2 (p = .001). This pattern was also seen in relation to symptom intensity, whereby, an increase in symptom intensity was recorded from baseline $F(1.32, 38.35) = 9.57$, p = .002, $\eta_p^2 = .25$, and analysis showed significant increases in symptom intensity from baseline reported both during session 1 (p = .013) and during session 2 (p = .002). As predicted, in the positive expectation group there were significant decreases from baseline in the reported experience of both the number of symptoms $F(1.31, 37.92) = 14.56$, $p < .001$, $\eta_p^2 = .34$ and symptom intensity $F(1.25,36.26) = 23.72$, $p < .001$, $\eta_p^2 = .45$.

In terms of the number of symptoms, there were decreases from baseline during session 1 (p = .001) and session 2 (p < .001). This pattern was also reflected in relation to reported symptom intensity, whereby there was a decrease from baseline during session 1 (p < .001) and session 2 (p < .001).

Table 1
*Mean (*SD*) Symptom and Mood Scores in the Negative Expectation (NE) and Positive Expectation (PE) Groups*

	N	Group	Baseline	Session 1	Session 2
Symptom score	30	NE	5.2 (2.8)	7.2 (3.1)	8.2 (3.6)
	30	PE	6.7 (3.2)	5.2 (2.9)	4.2 (3.3)
Symptom intensity score	30	NE	9.1 (5.8)	12.7 (6.3)	16.3 (10.0)
	30	PE	11.8 (7.4)	8.2 (5.2)	6.4 (4.7)
Negative mood score	30	NE	7.5 (6.8)	11.1 (10.4)	12.5 (11.0)
	30	PE	9.3 (10.7)	5.1 (8.1)	4.1 (6.8)
Positive mood score	30	NE	37.0 (10.1)	31.5 (13.3)	28.6 (14.1)
	30	PE	34.4 (9.3)	35.9 (9.7)	38.7 (10.4)

We further performed a mixed model analysis of covariance to assess within and between group differences in terms of change in positive and negative mood from baseline during exposure session 1 and exposure session 2, controlling for baseline scores. These data are also illustrated in Figure 1. In terms of change in negative mood from baseline, there was a significant main effect of group allocation, $F(1, 57) = 18.26$, $p < .001$. In relation to change in positive mood from baseline, analysis revealed a significant interaction between group and session, $F(1, 58) = 17.59$, $p < .001$. Tukey-Kramer post-hoc tests showed differences between the groups in relation to positive mood change scores during session 1 ($p = .011$) and during session 2 ($p < .001$). Further, there were within-group differences, such that from session 1 to session 2 there was a significant decrease in positive mood in the negative expectation group ($p = .016$), and a significant increase in positive mood in the positive expectation group ($p = .03$).

To assess whether mood during exposure sessions was significantly different from baseline assessment, we also conducted repeated measures ANOVA. Mood scores are also presented in Table 1. In relation to the negative expectation group, analysis revealed an increase in negative mood $F(1.48, 43.0) = 3.77$, $p = .043$, $\eta_p^2 = .12$, and a decrease in positive mood $F(1.46,42.18) = 20.48$, $p < .001$, $\eta_p^2 = .41$ from baseline. The increase in negative mood from baseline occurred during session 2 ($p = .031$). In relation to positive mood, there was a decrease from baseline during session 1 ($p = .001$) and session 2 ($p < .001$). In the positive expectation group there was a decrease from baseline in negative mood $F(1.66,48.12) = 21.54$, $p < .001$, $\eta_p^2 = .43$, and an increase in positive mood $F(1.46,42.31) = 4.99$, $p < .05$, $\eta_p^2 = .15$. Analysis showed a significant decrease from baseline in negative mood during session 1 ($p < .001$) and session 2 ($p < .001$). The significant increase in positive mood occurred during session 2 ($p = .02$).

In terms of the evaluation of perceived health impacts of infrasound exposure, 90% of the positive expectation group reported an improvement in physical symptoms after the listening sessions had concluded compared to 10% of the negative expectation group (χ^2 (1, $n = 60$) = 16.48, $p < .001$, $phi = -.52$). Consistent with this finding, 77% of the negative expectation group reported a worsening of symptoms during exposure, compared to 10% of the positive expectation group (χ^2 (1, $n = 60$) = 27.15, $p < .001$, $phi = .67$).

Discussion

In this study the experience of symptoms and mood during exposure to audible windfarm sound and infrasound was influenced by the type of expectations provided prior to the listening sessions. Participants randomized to the negative expectation group showed significant increases in the number and intensity of symptoms when exposed to windfarm sound, while participants given positive expectations about the sound showed the opposite pattern, with a significant reduction in the number and intensity of symptoms. The effect of expectations on mood following exposure to wind farm sound showed a very similar pattern with increases in negative mood in the negative expectation group and increases in positive mood in the positive expectation group.

The finding that negative expectations about windfarm sound prompted increased symptom reporting during exposure to infrasound is consistent with earlier research. In a previous sham-controlled experiment, the information that infrasound exposure has been reported to cause symptoms created elevated concern about the health effects of windfarms and triggered symptoms during exposure to both sham and genuine infrasound. The study demonstrated that symptom reports were provoked by expectations rather than any effect of actual infrasound (Crichton et al., 2013). The results are also consistent with other research indicating health warnings may elicit health complaints, even when the risk itself is purely one of perception and no genuine risk is posed (Colloca & Miller, 2011; Faasse, Gamble, Cundy, & Petrie, 2012; Faasse & Petrie, 2013). In one such study, viewing a TV report about purported health risks associated with exposure to electromagnetic fields produced by WiFi was shown to increase the likelihood of experiencing symptoms following sham exposure to a WiFi signal (Witthöft & Rubin, 2013). Evidence indicates that such information can increase anxiety and create related symptom expectations, which trigger later increased symptom reports (Faasse & Petrie, 2013).

It is important to note that this is the first study to demonstrate that participants exposed to wind farm sound experienced a placebo response elicited by positive pre-exposure expectations. Participants reported positive health effects during exposure to wind farm sound if they were given expectations that infrasound produced health benefits. These findings are consistent with previous work showing participants exposed to white noise, within a context designed to produce therapeutic expectations, evaluated the exposure as significantly more pleasant, relaxing, and beneficial than participants simply exposed to white noise without expectations (Kendrick & Elkins, 2012). The malleability of symptom reporting has also been demonstrated in an experiment where participants placing their finger on a rough vibrating surface interpreted the experience as pleasurable, painful or neutral, depending upon the way in which the stimulus was described prior to the experiment (Anderson & Pennebaker, 1980).

The study has two important implications. First, it provides further evidence that information easily accessible on the Internet concerning the health effects of wind turbines can create symptom expectations that are reflected in symptom and health reports. The fact that negative expectations in the current study were formed by viewing TV material sourced from the Internet suggests that a pathway for symptom reports attributed to wind farms could be via expectations created by media coverage about purported health effects. Second, the study demonstrates that if information about infrasound were framed in more neutral or benign ways, then reports of symptoms or negative health effects are likely to be nullified.

It should be noted that the study is limited by the fact that discrete sound exposure periods in a listening room may not entirely duplicate the experience of sound in the locale of a wind farm. However, the study has added ecological validity in that exposure was to audible sound recorded from a wind farm, overlaid with infrasound, and the health expectations were constructed using material easily available on the Internet. It should also be noted that it cannot be conclusively determined whether negative experiences triggered by negative health expectations can be reversed or alleviated by the later provision of positive information, or whether positive health information can protect against the future effects of exposure to negative health information, such as is often circulated in communities where wind farms are proposed or operating (Chapman, 2011). This issue is of importance given that current media coverage has been shown to incorporate fright factors that may induce fear, anxiety, and concern about the health risk posed by wind farms (Deignan, Harvey, & Hoffman-Goetz, 2013). Future research should investigate whether positive expectations can change symptomatic experiences in participants previously made aware of negative health information, or provide a buffer against the influence of the later delivery of negative expectations. As part of this research, it will be important to discuss the ethical implications of using placebo effects as part of a public health strategy to counteract the effect of negative expectations. Such research could provide further evidence useful to inform strategies designed to reduce anxiety and symptom reporting in those living in the vicinity of wind farms.

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