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## Personality and Individual Differences

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## The influence of negative oriented personality traits on the effects of wind turbine noise

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### ARTICLE INFO

#### Article history:

Received 19 April 2012

Received in revised form 11 September 2012

Accepted 25 September 2012

Available online 23 October 2012

#### Keywords:

Negative orientated personality traits

Wind Turbine Syndrome

Non-specific symptom reporting

Negative Affectivity

Frustration Discomfort

Neuroticism

### ABSTRACT

Concern about *invisible* environmental agents from new technologies, such as radiation, radio-waves, and odours, have been shown to act as a trigger for reports of ill health. However, recently, it has been suggested that wind turbines – an archetypal green technology, are a new culprit in explanations of medically unexplained non-specific symptoms (NSS): the so-called Wind Turbine Syndrome (Pierpont, 2009). The current study assesses the effect of negative orientated personality (NOP) traits (Neuroticism, Negative Affectivity and Frustration Intolerance) on the relationship between both actual and perceived noise on NSS. All households near ten small and micro wind turbines in two UK cities completed measures of perceived turbine noise, Neuroticism, Negative Affectivity, Frustration Intolerance, attitude to wind turbines, and NSS (response  $N = 138$ ). Actual turbine noise level for each household was also calculated. There was no evidence for the effect of calculated actual noise on NSS. The relationship between perceived noise and NSS was only found for individuals high in NOP traits the key role of individual differences in the link between perceived (but not actual) environmental characteristics and symptom reporting. This is the first study to show this effect in relation to a so called 'green technology'.

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### 1. Introduction

Recent evidence suggests that the public are increasingly blaming environmental features as causes for their non-specific symptoms and malaise when medicine cannot offer satisfactory explanations (Page, Petrie, & Wessely, 2006). For example to make sense of broad symptoms of ill health, individuals may attribute symptoms to the presence of a nearby mobile phone mast or radio transmitter (Petrie et al., 2001). Similarly, increases in perceptions of ill health at a time when general health is improving (the paradox of health) demonstrate that other, potentially psychological, factors may be at play when understanding people's propensity to report feeling unwell. Concern about *invisible* environmental agents especially those from new technologies, such as radiation, radio-waves, and odours, appear to act as a trigger for such reports of ill health (Petrie et al., 2001). Indeed, it has been argued that a rise in green politics and environmental consciousness may contribute towards this effect (Page et al., 2006). Recently, however, wind turbines – an archetypal green technology, have been accused as being a possible culprit in the search for explanations of medically unexplained non-specific symptoms (NSS): the so-called Wind Turbine Syndrome (Pierpont, 2009). In

addition, while psychological distress (Kroenke & Spitzer, 1998) the presence of a monotonous environment (Pennebaker, 1982) and heightened awareness of environmental hazards (McMahan & Meyer, 1995) have all been shown to increase symptom reporting attributed to environmental factors, the role of individual differences in negative oriented personality (NOP) traits, for example, Neuroticism, Frustration Intolerance and Negative Affect, may also be an exacerbating factor (Ferguson, Daniels, & Jones, 2006). The study reported here therefore examines the influence of negative orientated personality in influencing the link between exposure to a 'green' new technology (micro and small sized wind turbines) and NSS reporting. Specifically, this paper aims to answer the following questions: is any link between wind turbine noise and NSS reporting due to actual noise levels from the turbine, or individuals' perceptions of noise? In either case, are these relationships stronger for individuals who also have NOP traits?

#### 1.1. Wind turbines and symptom reporting

While there is *general* public support for renewable energy, individuals are often more negative when faced with the prospect of having structures to produce this energy sited within their community e.g. wind turbines (Devine-Wright, 2005; Simon, 1996; Wolsink, 2007). Negative responses are typically related to anticipated or experienced noise, and the anticipation of negative health

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effects of living close to wind turbines. While noise levels for small wind turbines are typically much lower than for large wind turbines, their closer proximity to dwellings and business properties may increase the likelihood of noise annoyance resulting in reported physical and psychological ill-health (Belojevic, Jakovljevic, & Aleksic, 1997; Stansfeld & Matheson, 2003). As increased symptom reporting is one of the main determinants of contact with health services (Kroenke, 2001), it is important to know whether there is a link between typical or perceived noise from wind turbines and symptom reporting. This study explores this question, but crucially, it focuses on the role of individual differences with respect to (i) actual noise from wind turbines, (ii) perceived noise from small wind turbines, (iii) the link between both actual and perceived noise and symptom reporting.

### 1.2. Individual differences in NOP traits in responses to environmental stressors

The current study focuses on three NOP traits in particular: Neuroticism, Negative Affect, and Frustration Intolerance. Previous research has demonstrated that individuals high in Neuroticism (N) and Negative Affectivity (NA) typically experience more Negative Affect (Watson & Pennebaker, 1989), and evaluate their environment more negatively (Ferguson et al., 2006). While N and NA are conceptually related, there are empirically demonstrated distinctions between the two, with NA being more related to the externalising aspects of N such as impulsivity and hostility (Miller, Vachon, & Lynam, 2009). In addition, trait Frustration Intolerance (FI) (Harrington, 2005), may differentially impact on the way environmental factors are perceived and evaluated. FI is the propensity to be unable to cope with or 'bear' negative emotions, thoughts, and events, rather than the experience of negative emotions per se. As a result, FI trait assesses individuals' responses to the experience of Negative Affect, thoughts and experiences. This trait has four subscales: emotional intolerance, discomfort intolerance, entitlement and achievement. Most relevant here are the subscales *discomfort intolerance* – the inability to bear any discomfort (which uncontrollable noise could hypothetically generate) and *emotional intolerance* – the inability to bear Negative Affect. As a result, it is possible to see whether NOP traits in general influence any association between environmental stressor and reported NSS, or whether the different traits operate in a unique fashion via three related but distinct aspects of NOP: general personality dimension, general negative emotion, or individuals' ability to cope with negative experiences.

### 1.3. NOP traits and the perception of turbine noise

Individuals sensitive to noise experience the most annoyance from noise in their community (Waye & Ohrstrom, 2002). As NA and N are strongly associated with noise sensitivity (Stansfeld, Sharp, Gallacher, & Babisch, 1993) these traits should have an influence on perceived wind turbine noise. Furthermore, compared with individuals low in N, higher N individuals perceive the same events to be more stressful, and are more emotionally reactive to stressors (Engelhard, van den Hout, & Kindt, 2003; Kennedy & Hughes, 2004; Schneider, 2004). Therefore, as wind turbine noise could be conceptualised as an environmental stressor, it is expected that those with higher levels of NOP traits (i.e. higher N, NA, FI) will report the noise from small wind turbines to be both louder and to occur more frequently than those lower in these traits. If the association between wind turbine noise is due to individual differences rather than an actual link between the noise from turbines and ill health, then there should be no link between actual noise and NSS reporting, NOP traits should be associated positively with perceived but not actual noise, and any link

between perceived noise and NSS reporting should be moderated by NOP traits.

### 1.4. NOP traits, perceived noise and symptom reporting

Crucially, to date, no studies have examined the influence of personality and perceived turbine noise on non-specific symptom reporting, however, Lercher (1996) suggested that N and NA may be influential variables in the link between environmental noise and health outcomes. Similarly, Belojevic et al. (1997) found that individual differences in noise sensitivity and N influenced the effect of traffic noise on individuals' sleep patterns and psychological disturbance. Finally, Mroczek and Almeida (2004) found a stronger relationship between daily stress and subsequent Negative Affect amongst individuals high in Neuroticism.

These findings can be examined in the light of the interaction between response to environmental characteristics and individual differences on reported physical or psychological health (see Ferguson et al., 2006 for a meta-analytic review). According to Ferguson et al. (2006), the existing data are best represented by (i) a positive association between NOP traits and *perception* of negative environmental characteristics, with (ii) a greater relationship between NOP traits and health (especially physical health) than between perceived environmental characteristics and health. It is reasonable, therefore, to anticipate that NOP traits and perceived wind turbine noise should be positively associated. In addition, we hypothesise that the link between symptoms and perceived noise will be moderated by NOP traits.

Importantly, the effect of perceived noise on symptom reporting may be due to the fact that those who perceive more noise actually do experience more noise from the turbine. Therefore, this study also assesses the level of noise each household would actually experience (based on calculated noise maps for each turbine) and examines the effect of this calculated actual noise on NSS. If this association is non-significant, then this would further support the role of individual differences and perceptions of environmental triggers, rather than the impact of noise from the turbine on health as suggested by Wind Turbine Syndrome (Pierpont, 2009).

## 2. Method

### 2.1. Participants and procedure

Households ( $N = 1270$ ) within 500 m of eight 0.6 kW micro turbine installations and within 1 km of four 5 kW small wind turbine installations in two cities in the Midlands of the UK were sent a questionnaire pack by postal mail. Any member of each household over the age of 18 could anonymously complete the survey; with the choice to complete the survey and return by pre-paid postal mail or complete and return via the internet. In total, 138 completed surveys were returned (age range of respondents = 20–95; mean age = 53.80,  $SD = 15.59$ ; 1.4% were aged between 18 and 25, 12.3% between 26 and 35, 15.9% between 36 and 45, 23.2% between 46 and 55, 22.5% between 56 and 65, 12.3% between 66 and 75, 7.3% between 76 and 85 and 5.1% between 86 and 95) resulting in a response rate of 10.86%, 54.4% were male. The demographic characteristics of participants were representative of the relevant wider populations (Warwickshire Observatory, 2011).

### 2.2. Measures

#### 2.2.1. Attitude to wind power (ATT)

To ensure that those returning the survey were not simply particularly negative towards wind turbines – hence potentially biasing any findings, participants were asked to report their general

attitude to wind power using a single item: “Please rate how you feel about wind power in general”. Participants responded using a 7 point Likert type scale (1 = very positive to 7 = very negative).

### 2.2.2. Calculated actual sound level from the turbine (ACTUAL)

A series of geographical sound maps was generated using the DataKustik CadnaA software package. This uses the ISO 9613-1 (ISO, 1993) and ISO 9613-2 (ISO, 1996) standards to map how sound from a noise source attenuates over a site based on its topography by calculating the sound pressure level at receiver positions located on a 1 m grid over the map area. Figure 1 shows results from one of the sites used in this study with the grid plane located 1.5 m above ground level. Key features in these maps are an increase in attenuation with increasing separation between source and receiver (as might be expected from the spherical spreading of sound) and the presence of acoustic shadows behind buildings, which are behaving as acoustic barriers. These are external noise levels and in practise there would be additional attenuation provided by the building envelope. The maps were used to generate a three point scale to quantify the level of noise subjects are exposed to. The red region in Fig. 1 encloses properties where attenuation of up to 35 dB occurs and there is a high probability of noise being heard (rated 2). The blue region encloses properties where attenuation of between 35 and 55 dB might be expected and the probability of noise being heard is moderate (rated 1). The green region encloses properties where attenuation is in excess of 55 dB and the probability of turbine noise being heard is low (rated 0). These maps were used in conjunction with the addresses to derive a noise score for each subject participating in the study. Within each region, participants had a broadly equivalent probability of hearing the noise from the nearest

turbine. Across all turbine sites, approximately 9.5% of those living within region 2, 13.5% living within region 1 and 10% living within region 0 responded.

### 2.2.3. Perceived turbine noise

Ten sound types were selected (i) based on those reported by Pedersen, van den Berg, and Bakker (2009) and (ii) following pilot studies where participants living with 500 m of a similar small wind turbine ( $N = 10$ ) were asked simply to describe the sounds they commonly heard from the wind turbine they lived or worked near to. Pilot participants were not included in the main study. The ten sounds were: swooshing, screeching, whistling, humming, throbbing, thumping, scratching, high frequency, low frequency and buzzing). For each sound, participants had to rate (a) how often they had heard ten sounds from the micro or small turbine close to their dwelling, and (b) how loud each sound was when it was heard. Both occurrence and loudness were rated on a five point Likert-type scale. For occurrence, 0 = ‘never noticed’ and 4 = ‘notice continuously’ and for loudness, 0 = ‘never heard’ and 4 = ‘extremely loud’. A mean score was calculated for both the occurrence and loudness scales for each participant.

### 2.2.4. Positive and Negative Affectivity

To restrict the length of the survey sent to households, six Positive Affectivity (PA) and six Negative Affectivity (NA) items were selected by taking the highest six loading items from the original 20-item Positive and Negative Affectivity scales (Watson, Clark, & Tellegen, 1988). Items were scored using a Likert-type scale where 1 = very slightly or not at all to 5 = extremely.

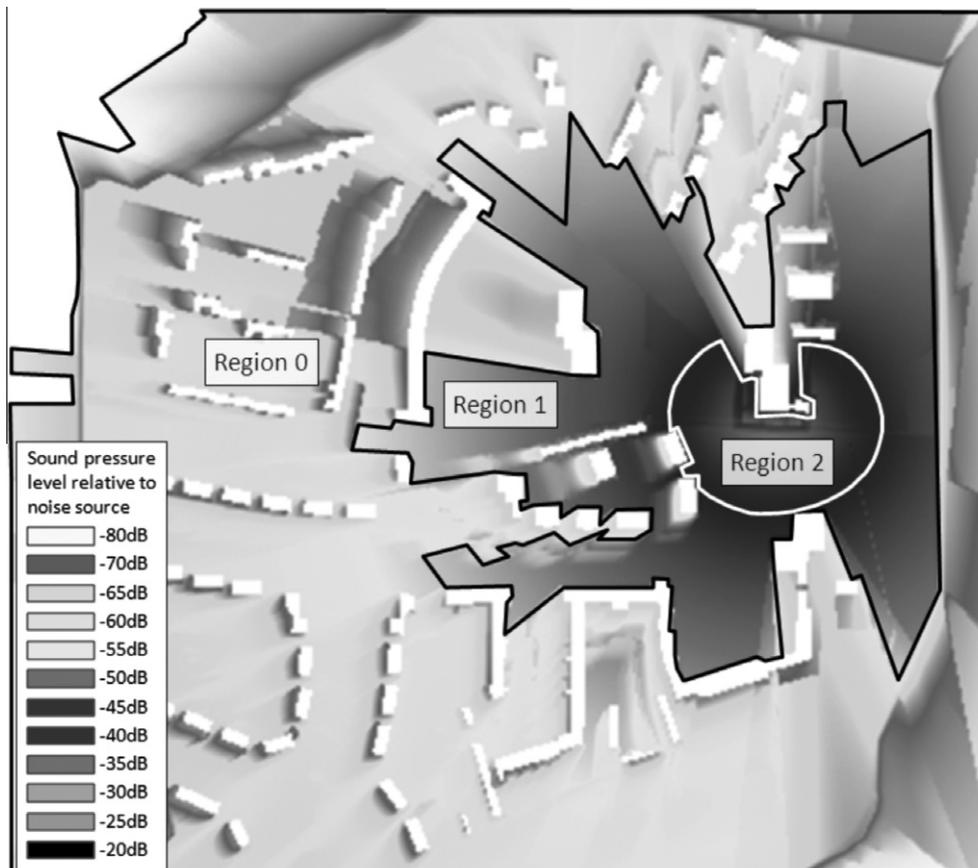


Fig. 1. An example sound map used to determine typical noise levels at each household. Data shown are sound pressure levels relative to the noise source.

**Table 1**  
Zero-order correlations, descriptive statistics and reliability for all measures.

	1	2	3	4	5	6	7	8	9	α	Mean	SD
ATT <sup>(1)</sup>											2.33	1.76
ACTUAL <sup>(2)</sup>	.015										.620	.776
LOUD <sup>(3)</sup>	.279**	.332**							.90		.225	.551
OCCUR <sup>(4)</sup>	.284**	.363**	.951**						.89		.225	.505
SYMP <sup>(5)</sup>	.023	-.029	.228*	.213*					.85		8.49	6.87
PA <sup>(6)</sup>	-.283**	-.312**	-.159	-.166	-.015				.93		2.56	1.14
NA <sup>(7)</sup>	.219*	.036	.399**	.400**	.346**	.272**			.85		1.76	0.90
N <sup>(8)</sup>	.081	.146	.163	.216*	.441*	-.269**	.323**		.84		2.59	0.76
F-disc <sup>(9)</sup>	.236*	-.134	.054	.053	.373*	.076	.191*	.226*	.85		2.29	0.77
F-emot <sup>(10)</sup>	.139	-.027	.261**	.243**	.391**	.104	.379**	.493**	.766**	.86	2.33	0.88

Note: ATT, attitude to wind power generally; ACTUAL, estimated sound level score for each household; LOUD, perceived loudness of turbine; OCCUR, perceived occurrence frequency of turbine noise; SYMP, mean symptom score; PA, Positive Affectivity; NA, Negative Affectivity; N, Neuroticism; F-disc, discomfort intolerance; F-emot, emotional intolerance.

\*  $p < .05$ .  
\*\*  $p < .01$ .

2.2.5. Neuroticism (N)

Neuroticism was assessed using the 10-item IPIP Neuroticism scale (Goldberg et al., 2006). Items were scored using a Likert-type scale where 1 = very inaccurate for me to 5 = very accurate for me.

2.2.6. Frustration Intolerance

Participants' inability to cope with frustration was assessed using two sub-scales of the Frustration Discomfort (FD) scale (Harrington, 2005); emotional intolerance (F-emot) (7 items e.g. 'I can't bear disturbing feelings') and discomfort intolerance (F-disc) (7 items e.g. 'I can't stand doing tasks that seem too difficult'). Participants responded to both sub-scales using a 5 point Likert scale with the following anchors: (1) absent, (2) mild, (3) moderate, (4) strong and (5) very strong.

2.2.7. Non-specific somatic symptoms (SYMP)

Participants reported their experience of 12 common symptoms (e.g. headache, fatigue) over the preceding 6 months, with each symptom being rated on a five point scale (0 = did not experience the symptom, with 1–4 indicating the severity of any experienced symptom) (Isaac et al., 1995). Reliabilities for all scales are reported in Table 1.

3. Results

3.1. Descriptive statistics

Descriptive statistics, scale reliabilities and zero-order correlations for all measures are shown in Table 1. All scales were reliable, and mean values and standard deviations for personality variables and trait mood were in typical ranges. Attitude to wind turbines was generally positive, indicating that the sample was not weighted in terms of individuals who were negative about wind turbine use. Participants' personality, trait mood, symptom reporting, and reported perceived noise from turbines did not vary as a function of participants' age or sex (all  $ps > .05$ ), although older participants reported a slightly more negative attitude to wind power ( $r = .231$ ;  $p < .05$ ).

As there was an extremely high correlation between perceived loudness and perceived occurrence of sound from the wind turbine ( $r = .95$ ), subsequent analyses are presented for relationships with perceived loudness only. In all cases, the same findings were obtained for perceived occurrence of noise.

Perceived noise, but *not* calculated actual noise, was associated with more negative attitudes to wind turbines, showing that negative attitudes to wind turbines amongst those reporting hearing greater noise is not due to the *actual* noise levels

experienced by these individuals. The calculated actual noise was, however, associated with the perceived noise from the turbines. Therefore, an individual living in a household with a higher probability of experiencing noise from the turbine did indeed perceive increased noise levels from that turbine. Importantly, calculated actual noise *did not* predict individuals' symptom reporting. Increased perception of noise from the turbines was associated with higher levels of NOP traits – specifically NA and N. When these analyses were conducted using a series of regression analyses controlling for age and sex of participants, the same results were obtained.

From calculated actual noise, individuals living in three main regions had either high, moderate or low probability of hearing

**Table 2**  
Moderation results for loudness/occurrence of noise – symptom link with NOP measures as moderator.

	ΔR <sup>2</sup>	β		ΔR <sup>2</sup>	β
Step1	.229*		Step1	.001	
LOUD		.231*	ACTUAL		.028
PA		-.022	PA		-.027
Step 2	.003		Step 2	.004	
LOUD × PA		-.055	ACTUAL × PA		.063
Step1	.359***		Step1	.122**	
LOUD		.107	ACTUAL		-.49
NA		-.303**	NA		-.349**
Step 2	.038		Step 2	.001	
LOUD × NA		-.390*	ACTUAL × NA		-.004
Step1	.469***		Step1	.204**	
LOUD		.160	ACTUAL		-.098
N		-.415**	N		-.455**
Step 2	.016		Step 2	.002	
LOUD × N		-.135	ACTUAL × N		.056
Step1	.427***		Step1	.139**	
LOUD		.208*	ACTUAL		.008
F-disc		-.362**	F-disc		-.374**
Step 2	.039*		Step 2	.027	
LOUD × F-disc		-.230*	ACTUAL × F-disc		-.231
Step1	.412***		Step1	.153**	
LOUD		.135	ACTUAL		-.018
F-emot		-.355**	F-emot		-.390**
Step 2	.041*		Step 2	.018	
LOUD × F-emot		-.338*	ACTUAL × F-emot		-.192

Note: ACTUAL, estimated sound level score for each household; LOUD, perceived loudness of turbine; SYMP, mean symptom score; PA, Positive Affectivity; NA, Negative Affectivity; N, Neuroticism; F-disc, discomfort intolerance; F-emot, emotional intolerance.

\*  $p < .05$ .  
\*\*  $p < .01$ .  
\*\*\*  $p < .001$ .

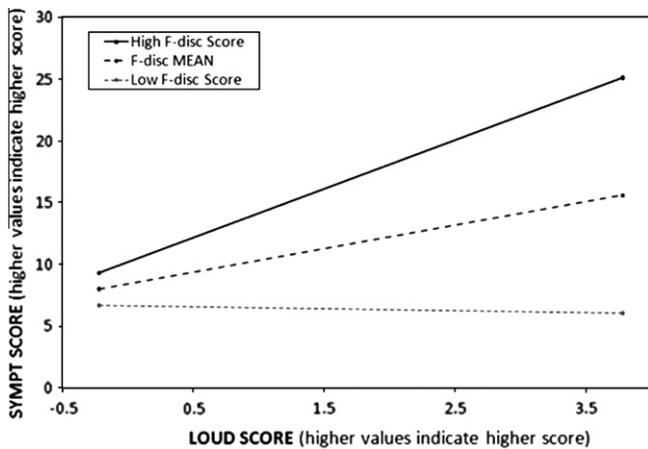


Fig. 2. Simple slopes for the loudness of noise–symptoms link with F-disc as moderator. Note: LOUD = perceived loudness of wind turbine noise, F-disc = discomfort intolerance; SYMP = mean symptom score.

the turbine noise. Just over half of participants (56%) had a low probability of actually hearing the turbine noise (region 0), 26% had a moderate probability of hearing the turbine (region 1) and 18% had a high probability of hearing the turbine (region 2). A series of one-way between subjects ANOVAs were conducted to examine individual differences between these three regions different on measured variables. Individuals across the three regions did not differ in age, NA, discomfort intolerance, emotional intolerance or Neuroticism (all  $p$ s > .1). However, those living in areas with low probability of hearing turbine noise had higher PA (mean = 2.86; SD = 1.05) than those living in areas with moderate (mean = 2.38; SD = 1.21) or high (1.97; SD = 1.04) probability of hearing turbine noise ( $p$ s ≤ .05) ( $F_{2, 118} = 6.40$ ; partial  $\eta^2 = .10$ ;  $p < .01$ ). There were no sex differences across the three regions ( $\chi^2 = 2.11$ ;  $p = .35$ ).

### 3.2. The role of NOP traits in moderating of the noise perception – Reported symptom association

Two-step hierarchical regression analyses were carried out to examine the moderating impact of NOP traits on the perceived noise loudness – reported symptom relationship. These analyses showed that discomfort intolerance and emotional intolerance moderated the relationship between perceived noise loudness and symptom reporting (see Table 2). All predictor variable scores

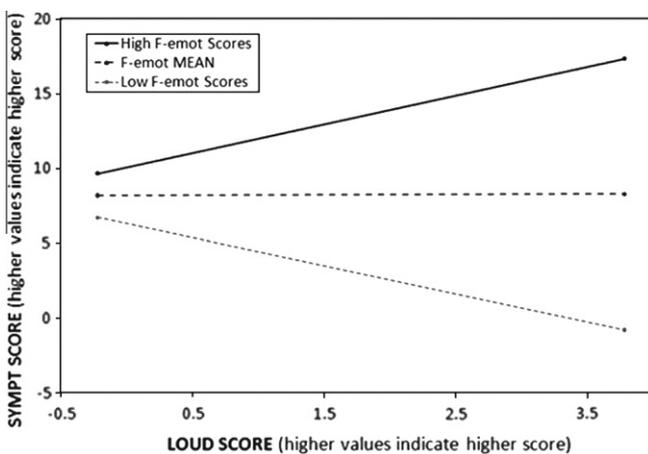


Fig. 3. Simple slopes for the loudness of noise–symptoms link with F-emot as moderator. Note: LOUD = perceived loudness of wind turbine noise, F-emot = emotional intolerance; SYMP = mean symptom score.

were mean centred. Simple slopes analyses were carried out 1 SD above and below the moderator variable where a moderating effect was found and all values entered into the simple slopes analyses were standardised and were conducted following Preacher's approach (Preacher, Curran, & Bauer, 2006).

The simple slope analyses showed that the link between perceived loudness and symptom reporting only occurred at high levels of discomfort intolerance ( $\beta = 3.954$ ,  $t = 3.4815$ ,  $p < .001$ , Fig. 2) and emotional intolerance ( $\beta = 1.921$ ,  $t = 1.677$ ,  $p = .096$ , Fig. 3). However, the simple slope analyses examining the link between perceived loudness and symptom reporting did not reach significance at any level of NA.

Finally, to examine whether calculated actual noise from the turbines interacted with NOP traits to influence symptom reporting, a second series of five hierarchical regression analyses examined the interaction between calculated actual noise from the turbine and NOP traits on symptom reporting. As can be seen from Table 2, calculated actual turbine noise did not affect symptom reporting directly or interactively.

## 4. Discussion

This is the first study to investigate the moderating impact of individual differences in negative oriented personality (NOP) traits with respect to reported non-specific symptoms. While calculated actual wind turbine noise did not predict reported symptoms, perceived noise did. Importantly, following Ferguson et al. (2006) and Watson and Pennebaker (1989), this link between perceived noise and symptom reporting was moderated by NOP traits, and the association between NOP traits and symptom reporting was greater than that between calculated actual noise and symptom reporting. Specifically, for those higher in NOP traits, there was a stronger link between perceived noise and symptom reporting. There was, however, no relationship between calculated actual noise from the turbine and participants' attitude to wind turbines. This means that those who had a more negative attitude to wind turbines perceived more noise from the turbine, but this effect was not simply due to individuals being able to actually hear the noise more.

Thus, the notion that turbine noise is linked to increased symptoms per se, is simplifying reality. Conversely, the current study suggests that individual differences play a key role in the link between perceived noise and symptom reporting. These findings suggest that it is the perception of noise rather than actual noise that is important in predicting symptoms of ill-health, and that this relationship is stronger in those who have personality characterised by Negative Affect, and intolerance of negative emotion and events. NOP traits have been demonstrated elsewhere to be associated with negative and threatening evaluations of events and ambiguous environmental stimuli (Engelhard et al., 2003; Kennedy & Hughes, 2004; Schneider, 2004) and these results confirm that for individuals low in NOP traits, the link between noise perception and symptoms is dramatically attenuated. The role of NOP traits, therefore, is key in understanding how perception of environmental negative characteristics (such as noise, stress, odours or electricity) may be translated into symptoms of ill health.

Interestingly, while Neuroticism is associated with increased non-specific symptom reporting, and the perception of more frequent noise from the wind turbines, Neuroticism did not moderate the relationships between the perception of either occurrence or perceived loudness of noise and symptom reporting. Rather the lower level traits relating to Negative Affectivity and individual differences in the inability to cope with negative emotions and discomfort are key in these relationships. Future research should be directed towards understanding the possible reasons for this distinction. One possibility may be that Neuroticism is less associated

with negative reactions to adverse events and stress (Engelhard, van den Hout, & Lommen, 2009; Howren & Suls, 2011), whereas more specific level traits – particularly related to mood (e.g. Negative Affectivity) may be more influential.

**Limitations:** The current study asked individuals to report their perceptions of noise from turbines and symptoms at the same time point. As a result, participants made retrospective judgements about both noise and symptoms. This means it is possible that the current study is subject to common method variance and retrospective bias. However, the fact that actual noise was not related to symptom reporting highlights the important finding that symptom reporting appears to be strongly associated with individual differences in negative oriented personality traits. Future work should examine these findings further in longitudinal design in order to investigate these effects. Finally, while those who participated in the current study were representative of the local population (e.g. Warwickshire Observatory, 2011), and were moderately positive in attitudes towards wind turbines, it is possible that those who returned the questionnaires were significantly different from those who did not in terms of the variables measured. From the data collected here, it can be seen that the proportions of returned questionnaires approximately match the proportions of households in the three zones. Future work should endeavour to increase the response rate, by, for example door-to-door data collection or similar methodologies.

## Acknowledgements

This work was funded by a National Environment Research Council (NERC) Grant issued by UK Energy Research Centre (UKERC) NER/S/R/2007/14440.

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