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Research Paper

Emotional response to images of wind turbines: A psychophysiological study of their visual impact on the landscape

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HIGHLIGHTS

- Wind turbine images were rated as equally pleasant as churches, but were less calming.
- Wind turbines were rated as more pleasant than other energy-production facilities.
- The emotional arousal of all energy-production facilities was equivalent.
- Our methods may help planners estimate emotional reactions to Turbines' visual impact.

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ABSTRACT

Social acceptance for wind turbines is variable, providing a challenge to the implementation of this energy source. Psychological research could contribute to the science of climate change. Here we focus on the emotional responses to the visual impact of wind turbines on the landscape, a factor which dominates attitudes towards this technology. Participants in the laboratory viewed images of turbines and other constructions (churches, pylons and power-plants) against rural scenes, and provided psychophysiological and self-report measures of their emotional reactions. We hypothesised that the emotional response to wind turbines would be more negative and intense than to control objects, and that this difference would be accentuated for turbine opponents. As predicted, the psychophysiological response to turbines was stronger than the response to churches, but did not differ from that of other industrial constructions. In contrast with predictions, turbines were rated as less aversive and more calming compared with other industrial constructions, and equivalent to churches. Supporters and non-supporters did not differ significantly from each other. We discuss how a methodology using photo manipulations and emotional self-assessments can help estimate the emotional reaction to the visual impact on the landscape at the planning stage for new wind turbine applications.

1. Introduction

Energy supply is one of the leading causes of greenhouse gas emission (Pachauri & Reisinger, 2007). Wind turbines have a low power production carbon footprint, and it has been suggested that by 2030, half of the worldwide power demand could theoretically be covered by wind energy (Jacobson & Archer, 2012). One challenge for wind turbine implementation is social acceptance. For example in the UK, 63% are in favour of wind turbines, 28% show balanced views, 5% oppose and 4% do not know (Kondili & Kaldellis, 2012). Thus, technically sound wind energy projects may fail because of residential opposition.

Psychological research can contribute positively to the science of climate change (Swim et al., 2009). Historically, research on social acceptance of wind turbines has been conducted in a market-research manner (Devine-Wright, 2007), with limited academic peer reviewed research (McGowan & Sauter, 2005). Our understanding of the determinants of attitudes wind turbines has developed since then. For example, Jones and Eiser (2009, 2010) show that even when general attitude to wind turbines is progressive, specific attitudes to proposed development nearer to homes are usually more negative. Because the latter situations

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are more emotionally evocative, their findings demonstrates that psychological sciences and deeper understanding of psychological and physiological factors leading to wind turbine acceptance and opposition could be useful in the planning implementation stage. Similarly, the number of peer-reviewed papers on the effect of wind turbines on human health grew 6-fold between 2011 and 2014 (Knopper & Ollson, 2011; Knopper et al., 2014). Knopper et al.'s review was also suggestive of the key role of psychological factors above and beyond objective impact of wind turbines' noise and operational effects.

The visual impact of wind turbines on the landscape plays a significant role in attitudes towards this technology (Wolsink, 2000). A recent review (Knopper et al., 2014) concluded that "when sited properly, wind turbines are not related to adverse health effects", but that subjective reports of detrimental health impact have more to do with "visual cues and attitudes". This conclusion is supported by the findings that visual aspects can influence the perception of noise from wind turbines (Maffei et al., 2013) and that when turbines are located 'out of sight' they are more acceptable (Jones & Eiser, 2010). Similarly, De Vries, de Groot, & Boers (2012) found that participants generally perceived wind turbines as negative man-made structures and that closeness to turbines and landscape beauty influenced the perceived impact, and Pedersen and Persson (2007) suggest a link between perception of turbines as 'ugly' and annoyance. This may be because turbines reduced the restorative attributes of landscape images (Chang, Hammitt, Chen, Machnik, & Su, 2008). Indeed, wind turbines have been shown to reduce tranquillity as shown by the relatively low ratings given by jury members' evaluations of a 50 m high installation (Watts & Pheasant, 2013). The current study extends this research by focusing on the emotional domain and analysing psychophysiological reactions to wind turbines using photo manipulated pictures. When it comes to judging the visual impact of wind turbines, supporters and opponents pay attention to different details. While supporters focus on benefits, such as environmental values, opponents mostly see the negative effects, for example a "disharmony" with the landscape (Krohn & Damborg, 1999). Anger and surprise, which may characterise opponents (Cass & Walker, 2009), are associated with bodily reactions (Jasper, 1998). These emotional reactions are mostly manifested as increased activation of the sympathetic nervous system; a system that predominantly responds to sudden changes in the environment, such as a threat or an injury, and prepares the body for a fight-or-flight reaction. Consequently a number of physiological changes are initiated, including changes in heart rate and increase in sweat secretion (Kandel, Schwartz, & Jessell, 2000). The conductance of the skin gradually increases with self-reported emotional arousal (Lang, Greenwald, Bradley, & Hamm, 1993).

Current literature on wind turbine opposition is limited because it relies on data from questionnaires and interviews, which are often influenced by factors beyond the emotional response itself, such as beliefs about the efficiency of this technology (Krohn & Damborg, 1999). Differences between reported and felt emotions could arise, on the one hand, when questionnaires are answered by individuals who are directly affected by an upcoming installation, where responses may be more goal-directed. On the other hand, Jones and Eiser (2009, 2010) data on the difference between general attitudes and specific attitudes to wind farms closer to home suggest that attitudes reflected in questionnaires and interviews may change when people are confronted with a wind turbine environment. Here we propose a novel method for assessing to assess attitudes to wind turbines. Skin conductance changes are not under voluntary control and therefore could provide an objective index of the emotional reaction (Smith & Ellsworth, 1985). To date, no study has used a psychophysiological approach to quantify objectively the intensity of emotions associated with the visual impact of wind turbines; this was the goal of the current experiment.

The current study investigated physiological responses to pictures of wind turbines against a range of rural scenes. Looking at pictures is very different from experiencing events, but their symbolic threat is sufficient to trigger an emotional arousal response and a concomitant sympathetic reaction, including skin conductance responses (SCRs) (Bradley, Codispoti, Cuthbert, & Lang, 2001; Chang et al., 2008; Lang et al., 1993). Chang et al. (2008), for instance, found an increase in alpha frequency when participants viewed natural scenes judged to be 'restorative'. Clearly, still images do not capture the full visual impact of wind turbine. Nevertheless blade rotations may be assumed by viewers such that any assessed impacts may provide a reasonable indication of operating turbines. Still images also do not capture the noise produced by turbines, which also contributes to wind turbine opposition (Knopper et al., 2014). However, this soundscape aspect has already been well researched (Fiumicelli, 2011) and it has been found that visual aspects affect noise perception of wind turbines (Maffei et al., 2013).

We hypothesised that landscapes with wind turbine will generate stronger SCRs than control sceneries, but lower SCRs than aversive pictures selected to evoke negative emotions (e.g. war scenes, bee sting). Churches were chosen as control images because, like turbines, they are prominent, man-made environmental stimuli, but unlike turbines, they are familiar, usually not controversial, and have been shown to have little or no detrimental effect on the tranquillity of the countryside (Pheasant, Watts, & Horoshenkov, 2009). Other familiar, man-made environmental stimuli associated with energy production were used as additional controls. We distinguished between participants who were for and against wind turbines with a novel questionnaire, and further hypothesised that wind turbines would be associated with stronger SCRs than control sceneries, and that this difference would be stronger for opponents.

We also collected subjective self-report data on participants' emotional arousal and the valence of these emotions. Valence ratings are important because SCRs and arousal ratings do not reflect the degree of pleasure or displeasure associated with viewing pictures (Bradley, Cuthbert, & Lang, 1990). We hypothesised that turbines will be rated as more arousing and more negative than control images and that this effect will grow for opponents.

2. Methods

2.1. Participants

Sixty University of Manchester undergraduate students (54 female, 6 male) aged 18–35 (mean age $M = 20.67$, standard deviation SD = 2.92) completed the online questionnaire for course credits. Respondents were ranked by their degree of wind turbine support. Thirty participants with the higher and lower scores were classified as supporters or non-supporters and invited to participate in the subsequent laboratory study for course credits or reimbursement (£7). 23 took part and 21 completed the study, one was excluded because of a skin condition and one because of a fire alarm. The study was approved by the local Research Ethics Committee and participants gave written informed consent. All participants were fluent English speakers, had normal or corrected-to-normal vision and no history of mental illnesses or neurological problems.

2.2. Materials

2.2.1. Wind attitude questionnaire

A new questionnaire consisting of 9 wind turbine related questions and 6 more general questions (asking about other