Journal of Environmental Management 200 (2017) 484–489

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Research article

Application of electroencephalographic techniques to the study of visual impact of renewable energies

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ARTICLE INFO

Article history:
Received 10 April 2017
Received in revised form
29 May 2017
Accepted 31 May 2017

Keywords:
Visual impact
EEG
Human emotions
Environmental studies
Renewable energies
Landscape studies

ABSTRACT

Much is currently being studied on the negative visual impact associated to the installation of large wind turbines or photovoltaic farms. However, methodologies for quantitatively assessing landscape impact are scarce. In this work we used electroencephalographic (EEG) recordings to investigate the brain activity of 14 human volunteers when looking at the same landscapes with and without wind turbines, solar panels and nuclear power plants. Our results showed no significant differences for landscapes with solar power systems or without them, and the same happened for wind turbines, what was in agreement with their subjective scores. However, there were clear and significant differences when looking at landscapes with and without nuclear power plants. These differences were more pronounced around a time window of 376–407 msec and showed a clear right lateralization for the pictures containing nuclear power plants. Although more studies are still needed, these results suggest that EEG recordings can be a useful procedure for measuring visual impact.

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1. Introduction

Due to climate change, nuclear and renewable (wind, solar …) energy sources are increasingly being encouraged to be used in place of to fossil fuels (a policy framework for climate and energy in the period from 2020 to 2030, Brussels, COM, 2014) and can be considered as potential solutions to the problems raised by energy security and climate change (Mbarek et al., 2015). Thus, according to the US Department of Energy (DOE), renewable energy are clean, inexhaustible, and affordable (Yan et al., 2016). Furthermore, unlike most electric power plants, they do not require water. However the installation of these renewable energies on large farms inevitably involves a change in the landscape and many complain that renewable energy farms are unsightly (Klæboe and Sundfør, 2016; Larson and Krannich, 2016; Rogers et al., 2008).

Although there are numerous calculation and study techniques to minimize visual effects when building a new renewable energy station (Rodrigues et al., 2010; Wróżyński et al., 2016), it will always be visible in some areas since it is not possible to completely hide it. In addition, some renewable energies such us nuclear power plants have little social acceptance and their visual impact is generally more negative. All these decisions are mainly unconscious and generally the first impression is crucial (Harris and Garris, 2008; Kim and Fesenmaier, 2008), what emphasizes the importance of unconscious processing in the perception of visual impact.

Taken into account all the above issues, we should be aware that the human brain tries to classify all kind of events into categories or classes: positive or negative, friend or enemy, attractive or not attractive. Furthermore, this processing is very fast, in the range of milliseconds, what means that there is not enough time for rational thinking. Therefore it seems that the emotional aspects are added at later times (Damasio, 2010, 1994) and could be explained, at least partially, by different motivational structures (Cacioppo and Berntson, 1994; Davidson et al., 1990), (Fanselow, 1994).

In this research we aimed to get insights into the temporal dynamics of emotion processing when looking at different landscapes (Linden et al., 2012; Waugh and Schirillo, 2012). In particular, we investigated differences in temporal dynamics of neural activity associated with biphasic emotions (like/dislike) produced by the view of complex pictures of landscapes with and

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http://dx.doi.org/10.1016/j.jenvman.2017.05.096
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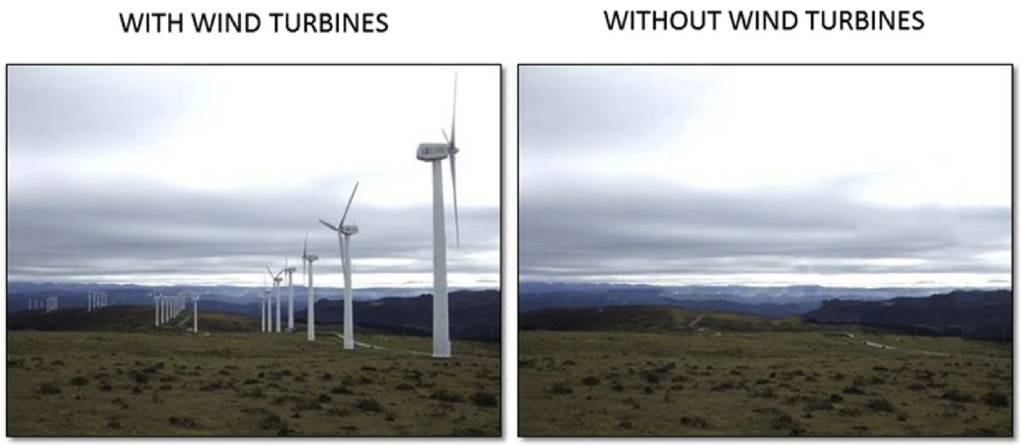

Fig. 1. Example of a representative landscape with and without wind turbines.

without renewable energies (solar, wind and nuclear). We used electroencephalographic recordings (EEG) to capture the unconscious brain activity and then analyzed the correspondences between different groups of images and the neural signatures coming from the temporal profiles related to each perception. Furthermore, we correlated the subjective scores and the test results with the generic knowledge of solar, wind and nuclear energy. Our results provided valuable and quantitative data to better understand the temporal dynamics associated with the early emotional processing of landscapes. Although more studies are still needed, our results suggest that EEG studies can be a useful technique, in addition to standard procedures, to analyze emotional processing related to visual impact of different types of power generation.

2. Method

2.1. Participants

Fourteen volunteered peoples took part in the research (mean age: 24; range: 18.9–34.2; six men, eight women). None of participants had personal history of psychiatric or neurological disorder, alcohol or drug or abuse, or current medication, and their vision were normal or corrected to normal. They were all right handed and their laterality index was at least +0.4 (mean 0.7, SD: 0.2) on the Edinburgh Inventory (Oldfield, 1971). All of them were comprehensively informed about the details and the aim of the research and gave their written agreement for participation.

2.2. Visual stimuli and questionnaire

60 images were used as stimuli. These images were divided into three groups: images with wind turbines and the same pictures without wind turbines, images with and without photovoltaic plates and images with and without nuclear power plants. All the images were presented in color and had the same contrast and luminance although the images with aerogenerators, photovoltaic plates or nuclear plants had more qualitative complexity (Papadimitriou, 2012, 2010). Fig. 1 shows a representative sample of the same landscape with (left) and without (right) wind turbines.

At the end of the experiment all the participants filled a questionnaire for the assessment of the levels of social acceptability (Kaldellis et al., 2012). The whole questionnaire is provided in the supplementary information, but briefly the first three questions were focused on the awareness regarding the researched renewable energies, whereas the others were related with the feeling and potential involvement of the participants regarding wind turbines and photovoltaic systems. Thus, question 4 dealt with the opinion related to renewable energy projects (photovoltaic and wind), while the questions 5 and 6 tried to identify how people react to

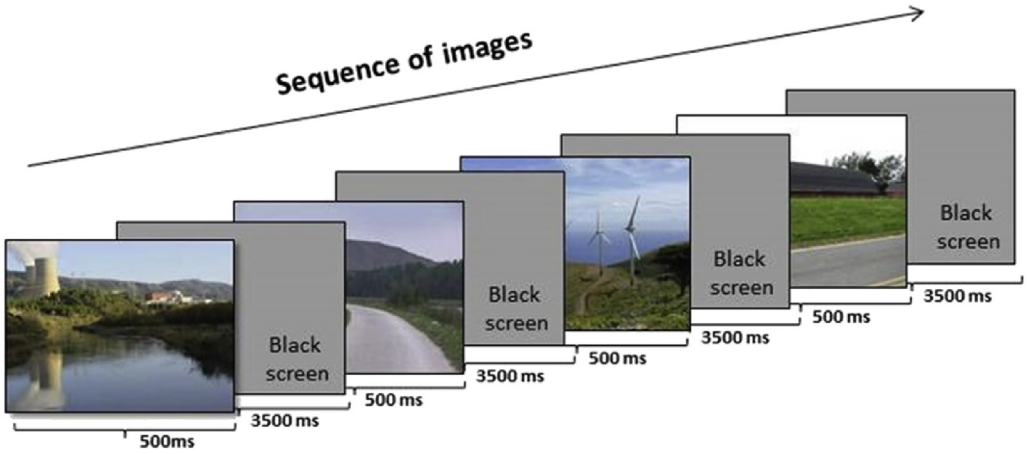

Fig. 2. Design of experiment. The stimuli were displayed randomly and continuously by means of a commercial stimulus presentation software (STIM2, Compumedics, Charlotter, NC, USA).

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