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Biased perception misguided by affect: How does emotional experience lead to incorrect judgments about environmental quality?

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ABSTRACT

Understanding how the lay public judge air pollution is of high significance for creating effective pollution control targets in China. Emotion theories have great potential to advance relevant knowledge. Taking advantage of an environmental psychophysiological experiment in Nanjing, China, this study uncovers the underlying mechanism of why Chinese people have a biased perception towards improved air quality. The results from both self-report and physiological data first demonstrated individuals' emotional habituation to their surrounding pollution level. The participants were prone to have the most neutral emotional responses at around 42 μg/m^3 $PM_{2.5}$ concentration, which matched well with the average $PM_{2.5}$ concentrations of daylight hours in Nanjing. As $PM_{2.5}$ pollution improved (worsened), participants' pleasant (unpleasant) visceral reactions were thereby intensified. However, due to the Peak-end Rule, some extreme emotional experiences caused by heavily $PM_{2.5}$-polluted events in winter may overwhelm the public memory. Such negative emotions lead to incorrect judgments about overall improved air quality. The results also showed that people lacked defensive motivational arousal towards bad air quality. We suggest that the government should pay more attention to avoiding the "Peak" effect of heavily polluted weather, and promote individual adaptive behaviors. To our best knowledge, this is the first research introducing a psychological experiment into the perception study of air pollution. Great opportunity exists to further extend this novel method into understanding other environmental issues.

1. Introduction

With rapid urbanization and industrialization over recent decades, the worsening of air quality in China has become an urgent social issue (Liu et al., 2017). Given their severe physical health risk, particles less than 2.5 μm in aerodynamic diameter ($PM_{2.5}$) are currently perceived by the Chinese lay public as one of the most harmful pollutants (Liu et al., 2016). To relieve public concern, the Chinese government has made grand efforts to mitigate the deterioration of air quality in recent years. The annual average $PM_{2.5}$ concentrations in heavily polluted regions of China (e.g., the Jing-Jin-Ji region, Yangtze River Delta) have consecutively declined (Ma et al., 2016). However, a serious challenge is that most citizens have failed to cognitively detect the improvement. As a consequence, the lay public question the determination and effectiveness of the Chinese government regarding air pollution control. This dilemma undoubtedly places substantial pressure on future pollution control in China. In this context, knowledge about how people perceive $PM_{2.5}$ pollution is of high value for setting better phrasal pollution control targets and improving public communications.

In fact, public cognition and perception of $PM_{2.5}$ pollution has long been a hotspot issue attracting attention from multi-disciplinary angles (Bickerstaff, 2004; Bickerstaff and Walker, 2001; Tvinnereim et al., 2017), among which emotion theories offer us unique and important angles to explain the abovementioned dilemma. As an important psychological antecedent of cognition, emotion can often affect or even overwhelm our correct judgments. According to the famous dual process theory, the emotion process is one of the two fundamental pathways that shape our thoughts and decisions (Kahneman, 2003). The affect heuristic model (Slovic et al., 2007; Slovic and Peters, 2006), proposed by Slovic, indicates that risk perception in daily life is always handled quickly and automatically by the emotion-process system rather than the rational analysis-process system. Weber (2006) also claimed the importance of visceral judgment toward long-term risks such as global warming or climate change. Fear or worry are effective in motivating people to take mitigation or adaptation actions (Lu and Schuldt, 2015; Leiserowitz, 2006). Based on prior studies, it can be

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supposed that the emotion-process system significantly affects individual's perception of air pollution.

Among them, the Peak-end Rule Theory, proposed by Kahneman and Fredrickson (Kahneman et al., 1993; Fredrickson, 2000) is hypothesized as a psychological foundation to explain public misperception of air quality in this study. It holds the view that people judge an experience largely based on the utility at its peak (i.e., most affectively intensive moment) and at its end (i.e., the moment the experience ends) rather than the entire or average feeling of the experience. The Peak experience is crucial because people exhibit better memory for more intensive emotional moments. Better memory for the end experience can be attributed to recency bias. The theory has been well validated and applied in multi-disciplinary studies. For example, Mironshatz et al., (2009) validated the divergence between experience and memory both taking pleasant and unpleasant aspects into considerations. Hargreaves and Stych, (2013) tested the peak-end rule effect in the context of exercise by examining how the two effects can predict the global affective evaluation during exercise. End moments were also proved more influential when people decided how soon to repeat food consumption experience (Garbinsky et al., 2014). Given substantial literature support and experiment evidence, the Peak-end rule may explain the memory-experience discrepancy of air quality.

Before testing the hypothesis, two major challenges should be addressed. The first one is how to measure emotions. Several previous studies have quantified the relations between psychological effects and air pollution based on self-report happiness data from field survey (Welsch, 2006). A limitation of those studies is that immediate emotional indices obtained by questionnaire were often matched with monthly or yearly averaged $PM_{2.5}$ pollution data (Zhang et al., 2017). The mismatch in time scale definitely led to unexpected estimation bias. Moreover, it is almost impossible to exclude the interference of confounders such as noise, lighting and personal mood swings in the studies based on field survey (Llop et al., 2008). To address the above problems, laboratory experiment has been introduced by previous studies as a novel and helpful tool. For example, Jiang (2014b) created a 3-D dimensional videos of streets with varied density of tree canopy to stimulate exposure to nature in a laboratory setting, aimed to study the stress recovery effect of green space. Similar research paradigm has also been reported by Brown et al., (2013) who asked participants to watch slideshows depicting nature as well as building scenes in controlled laboratory conditions, also to study stress recovery process. The experimental design in the lab can avoid the mismatch of $PM_{2.5}$ concentrations and control the interference of external confounders.

Regarding the metric of emotions, self-report scales and physical signals are two common ones used in previous experiments (Jiang et al., 2014a, b). According to Bradley et al. (2001), emotion is fundamentally organized around two motivational systems - appetitive one and defensive one. These two systems are important to mediate transaction in the environment, to better help survival. Two indicators, hedonic valence and arousal, are seen reflecting those two motivation. Judgments of valence (from unhappy to happy) indicate which motivational system is active, and judgments of arousal (from calm to excited) indicate the intensity of motivational activation. Therefore, valence and arousal were two self-report dimensions most commonly adopted in the related literature to characterize emotions (Leviston et al., 2014b). At the same time, corrugator electromyography (CEMG) was documented by previous findings to be the physical signals varied with picture valence (Lang et al., 1993). Skin conductance response (SCR) was shown to be associated with both picture valence and arousal. Certainly, a significant main effect of arousal should be obtained when investigating appetitive activation or defensive activation independently (Bradley et al., 2001). In this context, CEMG and SCR were included by some previous studies as an objective confirmation for self-report valence and arousal (Maehr et al., 2015). In this study, both self-report valence and arousal and physical signals of CEMG and SCR were adopted as the metric of emotions. More details about the emotion metrics and relevant measurement instruments were described in Section 2.1.

The second challenge is how to directly establish the link between air pollution and emotional reaction. The lay public usually relate visibility degradation to particulate pollution due to high risk perception but insufficient knowledge (Hyslop, 2009). Field studies conducted in southern California (Loehman et al., 1994) and Hong Kong (Yue et al., 2016) and an online questionnaire survey conducted in China (Yu et al., 2015) all demonstrated that naive observers can see changes in haze through the decrease in the extinction coefficient of the atmosphere. Visual air quality (VAQ) preference studies have played a central role in the setting of secondary National Ambient Air Quality Standards (NAAQS) for PM pollution by the U.S. Environmental Protection Agency (Smith, 2013). The close linkage between visibility and $PM_{2.5}$ pollution provides an opportunity to relate $PM_{2.5}$ pollution to an individual's emotional status via its visual impacts.

This study is aimed at exploring the answers to environmental management dilemma regarding air pollution in China based on substantial emotion theories and psychological experiments. It is hypothesized that people are emotionally capable to detect visibility change caused by $PM_{2.5}$ pollution, and relevant emotional experience would further affect public perceptions or attitudes as the Peak-end Rule Theory indicates. Specifically, when air quality gets improved (or worsened), participants' pleasant (or unpleasant) emotional reactions were thereby intensified. Also, extremely good or bad air quality can induce highly aroused appetitive or defensive motivations. Memory impressed by extreme-concentration haze events can be regarded as the Peak experience which further dominates public perception of $PM_{2.5}$ pollution. To test the hypothesis, an environmental psychophysiological experiment was introduced to investigate the concentration-response curve between $PM_{2.5}$ pollution and visceral reactions. In general, standardized static images matched with varied hourly $PM_{2.5}$ concentrations as the stimuli were viewed by participants with similar personal characteristics in a quiet lab. Participants' immediate emotional responses after each stimulus were recorded, both using two self-report metrics (valence and arousal) and two physiological metrics (SCR and CEMG). To the best of our knowledge, this is the first experiment-based study to explore individuals' emotional responses to the visual impact of $PM_{2.5}$ pollution. The findings provide important policy implications for risk management of air pollution in developing countries as well as China.

2. Materials and methods

2.1. Materials and apparatus

2.1.1. Stimuli database

Text, images and videos containing emotionally salient information are all ideal materials to induce specific emotions. In this experiment, static picture stimuli (i.e., images with different $PM_{2.5}$ concentrations) were adopted due to the focus on the visual impact of $PM_{2.5}$ pollution. Moreover, compared with video, static picture stimuli are more efficient and convenient to manipulate, which allowed us to capture temporal reactions from participants.

There are several internationally recognized standard affective pictures systems, such as the International Affective Pictures System (IAPS) (Lang et al., 2008), the Nencki Affective Picture System (NAPS) (Marchewka et al., 2014), and the Geneva Affective Picture Database (GAPED) (Dan-Glauser and Scherer, 2011). To the best of our knowledge, however, there are no standard pictures about air pollution in those existing systems. Therefore, we established a novel air pollution affective pictures database, which included 12 photographs taken at a fixed location near Oriental Pearl Tower, the iconic Shanghai structure (Fig. 1). These 12 photos were screened and selected from the Archive of Many Outdoor Scenes (AMOS) dataset (Jacobs et al., 2007) according to the following principles. First, to guarantee adequate lighting sources, only photos taken within the same time period (10:00 A.M. to