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Assessing Young People's Preferences in Urban Visibility in Beijing

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ABSTRACT

In the search for measures to address the severe air pollution problems that accelerated industrial development has caused in China, many studies have been conducted on the characterization and origin of the pollutants, but so far very little work has been done to assess the social and psychological dimensions that air pollution has. Among all of these, the effect of visual impairment is often underestimated. In this study we sought to estimate the way in which young people think about the problem of poor visibility in Beijing, and if their opinions vary compared to people accustomed to different levels of visual air quality in other urban areas. A survey was conducted with the participants all aged between 15 and 18 years old. It was found that the range of median preference value for an acceptable visibility was 34.5–45 dv (12–4 km), which was much worse than the 19–33 dv (58–14 km) reported in Northern America. An analysis of the hypotheses that could account for this observed difference was conducted. Recommendations to correct this difference were proposed.

Keywords: Air pollution; Visual air quality; Haze; Visual impairment.

INTRODUCTION

Particulate matter (PM) is a mixture of microscopic solid and/or liquid particles suspended in the air and are made up of a number of components, such as inorganic salts, organics, metals, and allergens (US EPA, 2012a). Particles emitted directly from a source are called primary while secondary refers to particles formed by photochemical reactions of gaseous precursors in the atmosphere. Particles, especially those with aerodynamic diameters smaller than 2.5 μm ($PM_{2.5}$), are closely related with respiratory diseases and premature mortality (Salma, *et al.*, 2002; Nel, 2005; Pope III and Dockery 2006; Anenberg *et al.*, 2010). They also can alter affective responses and impair cognition (Fonken *et al.*, 2011). Particulate matter can affect climate by scattering and absorbing radiation (Sun *et al.*, 2004) and thereby reducing visibility (Song *et al.*, 2003; Zhang *et al.*, 2010).

Particle light extinction is more complex than that caused by gaseous components. PM is responsible for most visibility impairment except under near pristine conditions, where Rayleigh scattering is the largest contributor to light extinction. While a larger particle scatters more light than a similar shaped smaller particle of the same composition, the light scattered per unit of mass concentration is greatest for particles with diameter of 0.3–1 μm. Particles composed of water soluble inorganic salts (ammonium sulfate, ammonium nitrate, sodium chloride, etc.) are hygroscopic such that they can absorb water as a function of relative humidity to form liquid droplets. Aside from the chemical consequences of this water growth, the droplets become larger when relative humidity increases, resulting in increased light scattering. Hence, the same PM dry concentration produces more haze at higher relative humidity.

The term visual air quality (VAQ) refers to the visibility effects caused solely by air quality conditions, so for example it excludes the visibility reduction caused by fog. Visibly poor air quality leads people to be concerned about substantive health risks, but degraded VAQ adversely affects people in additional ways. Visibility has direct significance to people's enjoyment of daily activities such as hiking or bicycling. For instance, psychological research has demonstrated that people are emotionally affected by poor VAQ such that their overall sense of wellbeing is diminished (Bickerstaff and Walker, 2001). Previous studies have also shown that perception of pollution is correlated with stress, annoyance, and symptoms of depression (Evans *et al.*, 1982; Jacobs *et al.*, 1984; Mace *et al.*, 2004). It also diminishes the enjoyment of scenic vistas and makes travel hazardous.

In China, economic growth and rapid urbanization have caused tremendous increase in energy consumption and

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therefore in emissions of primary particles and gaseous precursors such as SO_2, NO_x, and volatile organic compounds (Shao *et al.*, 2000; Hao *et al.*, 2001; Wang, 2010; Xiao *et al.*, 2011). Accordingly, PM is one of the major pollutants and is becoming the predominant pollutant causing poor visibility in most urban areas (Xiao *et al.*, 2011; Han *et al.*, 2012; Lin *et al.*, 2012; Zhou *et al.*, 2012), among which is its capital city, Beijing. Economic development in this city has led to a sharp increase in the total number of vehicles. By the end of 2011, the vehicle fleet had risen to 5 million, being one of the main sources of fine particles (Pu *et al.*, 2011). It is expected that by 2016 this number will hit 6 million.

Beijing is a major tourist spot given the rich history and cultural wealth. Its impressive traditional constructions contrasting with stunning modern structures, product of its accelerated development, attract thousands of visitors each year, but the heavy pollution and visibility impairment have been a major concern for a long time. In Beijing 47.8% of the time visibility was below 10 km between 1999 and 2007 and given the high relative humidity during summer season this period presents the lowest mean visibility (Zhang *et al.*, 2010). Because this warm season is a more prone time for traveling, low visibility directly impacts foreigner tourism that is uneasy of this kind of environment. Even local people in some occasions, such as visits to scenic views in the urban area, are motivated to observe a scene and may do so for several minutes, even hours, to appreciate the vista they choose to see. In such circumstances they may evaluate how the VAQ at the time improves or reduces the view (US EPA, 2012).

Although for many years in China there has been a standard for PM_{10} (particulate matter with an aerodynamic diameter less than or equal to 10 μm), only recently a $PM_{2.5}$ standard was implemented, mainly in response to strong social pressure exerted by society, failing to perceive an improvement in the environmental conditions, on the authorities. These standards are based primarily on the protection of public health but do not take into account other associated impacts, like visibility, which is the factor that people perceive and that causes concern. In the United States, EPA establishes two types of national standards for air quality: primary and secondary. The primary standard sets limits to protect public health including the health of sensitive populations such as asthmatics, children and elderly; the secondary standard sets limits for the protection of public welfare, including protection against visibility impairment, damage to animals, crops, vegetation and buildings. In there, EPA recognized that loss of visibility was associated with fine particles and the perception of visibility impairment is more related to short-term, near instantaneous levels of visual air quality. It focuses only on 24-hours secondary standard to achieve the required protection. Based on recent studies of visual impairment by fine particulate matter (Ely *et al.*, 1991; Abt Associates Inc., 2001; BBC Research and Consulting, 2003; US EPA, 2005; US EPA, 2011) and its relationship with particle composition and relative humidity, a new standard with more specifics for visibility will be enacted in US (US EPA, 2012b).

This study seeks to identify young Chinese people's opinions about environmental conditions in the city, especially in terms of visibility. To solve the severe air pollution problem in China, the participation of the general public with pro-environmental behaviors is highly relevant. It has been shown that younger generations tend to be more concern about environmental quality than older generations (Iizuka, 2000). There is no more favorable stage to motivate environmental awareness than at early ages. From these ideas surged the question if is there any difference in Chinese young people's acceptance of visibility impairment compared with similar studies in other countries? Young people in Beijing have grown in an environment where air quality and visibility are commonly precarious. Have this everydayness altered their perception on air quality compared with people in other parts of the world? Studies like this are vital when it comes to legislate and establish a standard since the legislature must have sufficient information to determine the parameters appropriate to the site and current conditions.

SURVEY

The air pollution's awareness has been surveyed in other countries since many years ago. In 1960s and 1970s, the first studies were performed in the United States (de Groot *et al.*, 1966; Shusky, 1966). Similarly in the early years of 1970s, some researchers searched public responses to air pollution in the UK (Blacksell, 1972; Mc Boyle, 1972). At that time some of these studies evaluated the perception of visibility related to health problems caused by air pollution, but not visibility preference as such. Instead, urban visibility preference studies examine individuals' preferences by investigating the amount of visibility degradation considered unacceptable. In recent years, there are three urban visibility preference studies and two additional pilot studies that provide information on individuals' preferences for good VAQ in urban setting. The completed studies were conducted in Denver, Colorado (Ely *et al.*, 1991), two cities in British Columbia, Canada (Pryor, 1996) and Phoenix, AZ (BBC Research and Consulting, 2003). The additional studies were conducted in Washington, DC (Abt Associates Inc., 2001). The range of median preference values for an acceptable amount of visibility degradation from the four urban areas was approximately 19–33 dv[1]. Measured in

[1] Deciview (dv) is one of the indices of visibility that have evolved since there is no definition of visibility that meets all the criteria of "seeing" characteristics of a landscape. It is related to light extinction but scaled in such a manner that is perceptually correct, i.e., the dv scale is near zero for a pristine atmosphere and increases as visibility degrades (IMPROVE, 1993). It is related to the visual range using the following equation,

$$Haziness\ (dv) = 10 \times \ln\left(\frac{391\ km}{VR}\right)$$

where VR is the visual range in km.

terms of visual range, these median acceptable values were between approximately 58 and 14 km. To the best of our knowledge, no study has addressed the visibility preferences in visual air quality in China. The present study followed those recent studies in Northern America, i.e., investigating what level of visibility degradation was acceptable to young people in Beijing.

The survey was conducted in June 2012 at the Yangzhen No. 1 Middle School located at the Shunyi District of Beijing. The participants were 85 Senior 1 and Senior 2 students between 15 and 18 years old. There were two main reasons for selecting this age range to be consulted. The first reason is that young people of this age, as mentioned above, are more likely to exhibit environmental awareness yet without social pressures that adults exhibit (Iizuka 2000). The second reason is that by this time they already began their training in abstract and critical thinking skills during the high school years. Those skills may not yet have been developed among younger children such that their environmental awareness may not have emerged.

The survey was designed based on the pilot study conducted in Washington (Abt Associates Inc., 2001). Those questions asked to the students during the survey are shown in Table 1.

The survey showed twenty photographs based on a single scene to the participants in random order. The images were developed using the currently available computer version of WinHaze software (version 2.9.9). The hourly daytime visibility in a visual range of 0–30 km is reported by Beijing Capital Airport (Wunderground, 2012). Based on this dataset, we estimated that the VAQ in Beijing for May 2011-May 2012. As shown in Fig. 1, the 5^{th}–95^{th} percentile was 25.7–56.3 dv and the average visibility value was 43.4 dv. To be consistent, the VAQ of twenty images ranges from 15 to 51 dv. The twenty images were randomly ordered, with all participants viewing the images in the same order. All participants were first asked to rate the shown images on a VAQ scale of 1 to 7. They were told to rate the photographs solely on visibility and not to consider related health impacts. Next, the students rated the slides as acceptable and not acceptable based on their personal opinion of good VAQ. Four of the twenty images were repeated once in order to evaluate the consistency. Subsequently, the students answered questions that sought to establish the frequency and conditions under which VAQ were considered, and the importance that each one of them ascribed to have a good visibility in the city.

RESULTS

Rating of Acceptability/Unacceptability

Fig. 2(a) presents VAQ acceptance percentages for all participants discriminated by grade. There is a visible trend in the acceptance curves generated from the student responses where more than 80% rated images with VAQ below 34.5 dv as acceptable, while images with VAQ superiors to 45 dv were not acceptable. Thus, the 50% division criterion occurs in the range of 34.5–45 dv. Compared with the results of previous studies in North America where the division occurs in the range of 19–33 dv this 50% acceptance is significantly worse. This would indicate that young students in Beijing do have a different tolerance in their VAQ perceptions. Some hypotheses are discussed below regarding important differences in VAQ preferences.

Table 1. Questions formulated on the survey.

Q1	How often do you see a view like the one in this slide? (note: 15 dv image)
Q2	Where are you/what are you doing when you see a view like the one in the first slide?
Q3	Generally speaking, how often do you notice the quality of visibility on a given day?
Q4	How important are visibility conditions in Beijing area to you?
Q5	Please indicate whether you find the quality of visibility Acceptable or Unacceptable for each of the slides presented.

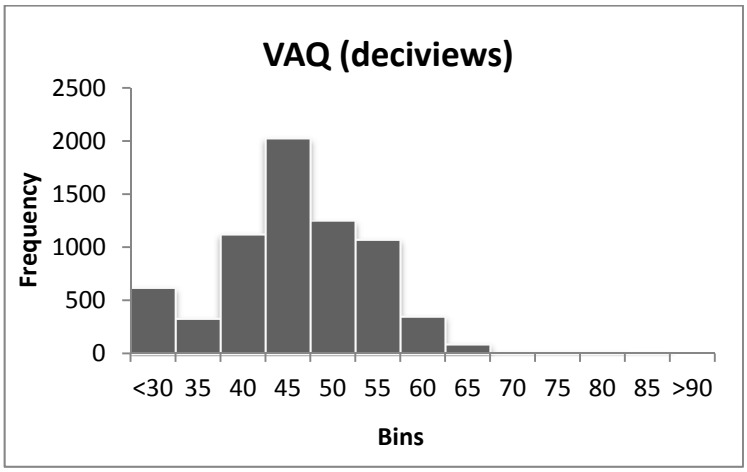

Fig. 1. Frequency of VAQ level in Beijing during May 2011–May2012. Data from Beijing Capital Airport.

Responses Inconsistencies

Figs. 2(b) and 2(c) present the ratings of the repeated images. All of them but the 48 dv were valuated almost equally, with points in the two series almost superimposed. Yet the two 48 dv images present a slight difference in the rating with a 25% in senior 1 and a 17% in senior 2 variations respectively.

Awareness of Visibility Conditions and Strength of Attitude

Fig. 3 displays the responses to the questions formulated in the survey seeking to determinate awareness of the students to the current city's VAQ. When a 15 dv VAQ image was displayed (Fig. 3(a)), 29.3% of students stated that frequently (at least once a day) can appreciate such a good VAQ, whereas nearly half of respondents (44.8%) said occasionally (at least once a week).

The question about "location and activity carried out when visibility is noticed" seeks to determine whether the perception of VAQ is influenced by any of these variables. According to the answers shown in Fig. 3(b), they become aware of the VAQ mainly while they are outdoors, once at home or at school no more attention is paid.

When confirming this awareness of the environmental situation with the question "How often do you notice the quality of visibility on a Given Day?" (Fig. 3(c)), 38.6% of the students expressed that just occasionally notice the VAQ while answers like infrequently, rarely and never notice it amounted to 40.4%.

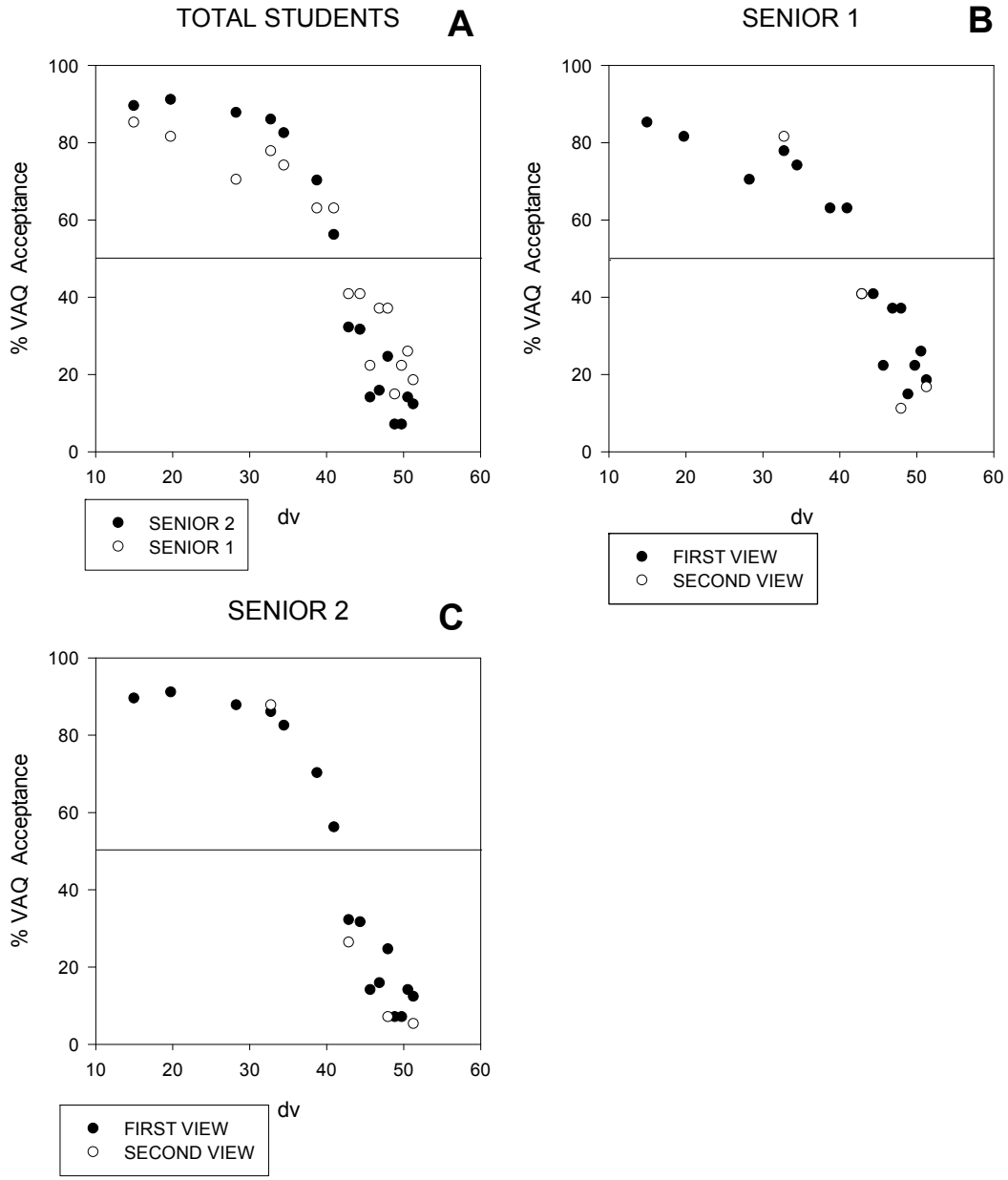

Fig. 2. (a) Visual Air Quality acceptance percentages for all surveyees discriminated by grade; (b) Visual Air Quality acceptance percentages for Senior 1 Grade. White points show acceptance for the repeated images displayed; (c) Visual Air Quality acceptance percentages for Senior 2 Grade. White points show acceptance for the repeated images displayed.

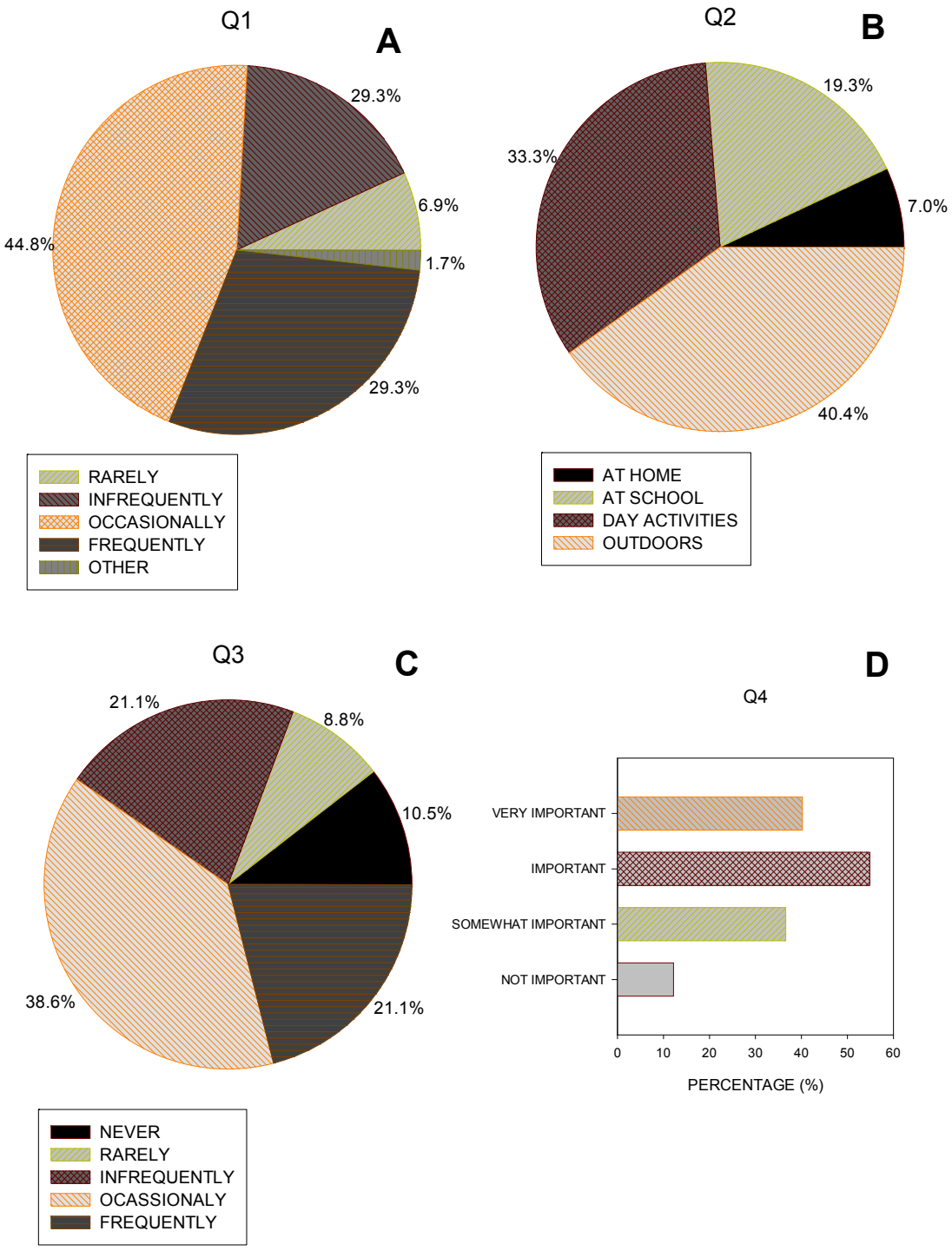

Fig. 3. Answers given by the students to the questions presented in Table 1.

When questioned about the importance that visibility has in Beijing for them, 94.9% of the students answered that is important or very important. Although it was suggested that the associated health risk should not influence their responses, it is very difficult to assure that their responses were exclusively based on visual effects.

DISSCUSION

First of the hypothesis for the observed differences in VAQ preferences is that the acceptable responses in an urban visibility preference study conducted with this common approach used in all the studies may be susceptible to the range of VAQ images presented, where participants consciously or subconsciously identify approximately the middle of the VAQ range presented. However, in this survey the twenty images were presented to students and rated in the first observation that they had of these. There was no "warm-up" session where they could subconsciously identify a midpoint of VAQ range.

A second hypothesis is that the preference for urban visibility may differ according to the targeted location and that the differences arise because of differences within the urban landscape image used in each study, for example the differences between the studies presented in Denver (Ely *et al.*, 1991) and Washington (Abt Associates Inc., 2001). In Denver were showed images with high haziness (11–41 dv). Participants were found to have lower acceptance than that obtained in Washington where images with low haziness (8.8–38.3 dv) were showed. It suggests that this may occur because of the presence of mountains on the distant horizon in Denver while in Washington the most prominent urban landscape features are buildings that are relatively close with little change in elevation (Abt Associates Inc., 2001). The image showed in this study presenting a mountainous area in the distance with the presence of buildings and constructions of the urban area in the foreground, however, the acceptability here is much higher than any of the previous studies.

A third hypothesis says that the variation in the degree of representativeness of the participants and the size of the participant samples could also be important factors. In this case the participants are teenagers while the participants in the previous studies are adults and with a completely different background. The number of participants in this study (85 individuals) was inferior to those of studies in Denver, British Columbia and Phoenix (214, 180, and 385 individuals, respectively) but larger than the two studies done in Washington in 2001 and 2009 (26 and 64 individuals, respectively). However, the acceptability in this study is consistently higher than previous studies, and we don't attribute the results to a difference in the participant's number.

We strongly believe that the difference in the acceptance of visual air quality lies in the familiarity that students have with low VAQ in Beijing. The subjective nature that has visibility's appreciation allows that same visual conditions are evaluated in different ways by more than one observer. There are two sources of personal cognition given by other authors in influencing people's awareness of air pollution. These are the nature or level of pollution (Smith *et al.*, 1964; de Groot *et al.*, 1966; Swan, 1970; Prescott-Clark, 1982) and publicity about it (Auliciems and Burton, 1971; Kirkby, 1972). Bickerstaff and Walker (2001) affirms the importance of the primary experience in the public recognition of pollution through the physical senses. But when these senses are used to this pollution, it would seem very difficult to recognize the presence of it. This is similar to Anosmia where the sense of smell is lost after a long exposure to a strong smell. In such cases, when it is not personal experience that directs the awareness of the effects of pollution, measures to sensitize the population should be made by local authorities. It is of great importance, in order to ensure in the future significant improvement of air quality conditions, the true involvement of the population to focus attention on the environmental factors that afflict them and understanding how they can be involved in the design or implementation of measures to remedy or appease such problems. It is vital that young people from their basic education begin this process of awareness and recognition of the problem. Also important is the open discussion of the current conditions, as Bickerstaff and Walker (2001) mentioned, publicity is one of the two sources that motivate the awareness of the problem.

About the few inconsistencies in the responses, this could be related to slide order effect, where the duplicate slide was preceded by a very good VAQ image causing a possible decreased rating. We considered these differences as no significance.

On the other hand, although visibility problems have affected Beijing for years (Song *et al.*, 2003; Zhang *et al.*, 2010) and citizens regularly complain they can rarely see blue skies or white clouds, the responses of these participants show a more positive perspective. Their answers in Fig. 3 do not seem to fit the reported visibility in Fig. 1 (Wunderground, 2012) where 52% of the times has the visibility inferior to the 50% acceptability range estimated above. They seem not to be aware of their environment, however, when asked about it, automatically their response try to show an optimistic view. This might have some similarities with the "Halo Effect" described in Bickerstaff (2001) where people tend to disregard air pollution when they are satisfied with their surroundings.

Perhaps the intuitive association between low VAQ and health risks from air pollution is the reason why, despite low awareness, visibility is considered of utmost importance (as shown in Fig. 3(d)). Perhaps the social activity that has emerged in recent years on social networks in China with respect to the poor air quality has its part for the answers given by students providing them with the idea that good air quality is a priority but is not yet fully assimilated in their everyday life.

CONCLUSIONS

The effect of air pollution not only affects the physical health of the population, but also has a negative outcome on the mental health and welfare of it. The impact on physical health has been comprehensively studied and quantified, but the psychological or mental disorders present another level of complexity. These disorders as a result of poor air quality and VAQ have not been studied to depths and there is still a large field for research, especially in China. This study established a difference between young Chinese people and North American people in their evaluation on VAQ. The 50% acceptance of VAQ of the former is in the range of 34.5–45 dv while that of the latter is in the range 19–33 dv. We discussed different hypothesis for the higher acceptance of low air quality for young people in China. The most possible cause is the everydayness of poor VAQ for young Chinese people that make them more flexible in their ratings. As for the analysis of awareness of visibility and strength of attitude, it was estimated that there exists the basic idea of the importance of good visibility. This perhaps is associated with the recognition of the impact of air pollution on physical health. In spite of this, it has not been assimilated into everyday life such that the force in attitude is also low and a very modest time is taken in the evaluation of VAQ.

China currently suffers problems that some decades ago affected Europe and North America. For these regions, the process to recover a good VAQ has taken a long period of multidisciplinary study and analysis. China can learn from their experience to enrich themselves and under the own characteristics of their problem take effective measures. This will result in improving the living conditions of its millions of inhabitants. It may also improve the experience of anyone who wants to come to know China's unlimited cultural, and more recently, economic wealth.

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