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ORIGINAL ARTICLE

How can environmental knowledge transfer into pro-environmental behavior among Chinese individuals? Environmental pollution perception matters

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Abstract

Aim Our study examines the transformation of environmental knowledge into pro-environmental behavior using national survey data under the framework of social cognitive theory.

Subjects and methods A total of 11,438 respondents (male = 5756, mean age = 48.60 years, SD = 16.39) participated in the Chinese General Social Survey. Analysis included descriptive and correlation analysis, hierarchical regression and structural equation modeling.

Results Our findings suggest that dwelling environmental knowledge is a stronger predictor of private pro-environmental behavior than professional environmental knowledge, while professional environmental knowledge is the only contributor to public pro-environmental behavior. Moreover, only dwelling environmental pollution perception shows additional variances in explaining private pro-environmental behavior, while both dwelling and natural environmental pollution perceptions have significant and additional effects on public pro-environmental behavior.

Conclusion Integrating these variables into a single comprehensive model via structural equation modeling reveals that dwelling environmental pollution mediates the relationship between dwelling environmental knowledge and the two types of environmental behavior (i.e., private pro-environmental behavior and public pro-environmental behavior) and that professional environmental knowledge only shows a direct effect on public pro-environmental behavior.

Keywords Environmental knowledge · Environmental behavior · Environmental pollution status · Environmental concern · Environmental education

Introduction

China is currently facing deteriorative pollution in its air (Rohde and Muller 2015), water (Lu et al. 2015) and soil (Li et al. 2014; Lu et al. 2015) that harms the mental and physical health of its population. The acquisition of environmental knowledge may be positively related to improvement of public health if the environmental knowledge can be transformed into pro-environmental behavior efficiently. In response to this issue, Hong and Xiao (2007) used a national sample in 2003 to explore gender differences in environmental concerns and found that using environmental knowledge as a mediator could eliminate such differences. They also identified a direct relationship between levels of environmental knowledge and pro-environmental behavior regardless of gender (Xiao and Hong 2010), thereby contradicting the findings of some western studies (e.g., Gotschi et al. 2010). Western researchers also studied the relationship between environmental knowledge and behavior. According to Polonsky et al. (2012), general environmental knowledge and carbon offset environmental knowledge are positively related to environmental attitude, which can give rise to general pro-environmental behavior and carbon offset-related behavior, respectively. However, another study showed that there is no relationship between environmental knowledge and behavior, as well as attitude (Paço

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and Lavrador 2017). Polonsky et al. (2011) demonstrated that the level of consumers' general knowledge has no impact on their general pro-environmental behavior, so it is the same as the relationship between the level of carbon offset knowledge and behavior. According to these inconsistent results, we can conclude that the successful and effective transformation of environmental knowledge into pro-environmental behavior remains unclear. Therefore, our research aims to fill the gap by studying the mechanism that underlies the association between environmental knowledge and pro-environmental behavior.

In China, public environmental cognitions have been improved through 1998 to 2007. According to Yan et al. (2010), during the past decade, the overall Chinese public environmental awareness has been enhanced and people lay more stress on the importance of environmental issue. What is more, Yan et al. (2008) also found that people in Hong Kong and Shanghai paid close attention to global environmental changes. Hence, it is necessary for scientists to study the relationship between environmental knowledge and pro-environmental behavior to cater to increasing public environmental awareness. On the theoretical level, our findings reveal the paths from environmental knowledge to pro-environmental behavior, while on the practical level, we propose new approaches for developing environmental education programs in mainland China.

Literature review

Actually, previous studies have mostly demonstrated an uncertain relationship between environmental knowledge and pro-environmental behavior. Kollmuss and Agyeman (2002) observed that many studies have explained such a relationship using different conceptual and theoretical frameworks, thereby producing inconsistent results. For example, Gotschi et al. (2010) suggested that different "knowledge" concepts have varying effects on conservation behavior. In other words, those individuals equipped with different environmental knowledge may behave differently from one another. Frisk and Larson (2011) showed that declarative knowledge, which is associated with the functioning of and information about a socioecological system (Carmi et al. 2015; Frisk and Larson 2011), could indirectly motivate behavior (Frisk and Larson 2011), while procedural knowledge, which pertains to basic information about how an action must be performed (Carmi et al. 2015; Frisk and Larson 2011), is sometimes more effective in promoting pro-environmental behavior than theoretical declarative knowledge (Frisk and Larson 2011).

Other environmental studies have also made a distinction between subjective knowledge and objective knowledge. On the one hand, subjective knowledge refers to the perception toward the knowledge possessed by an individual that is related to his/her confidence (Brucks 1985). On the other hand, objective knowledge refers to accurately stored knowledge (Moorman et al. 2004). Subjective knowledge makes a stronger contribution to the environmental attitudes and behavior of individuals than objective knowledge (Aertsens et al. 2011). Subjective knowledge may also be divided into different categories that have not yet been explored in the literature. The knowledge that we perceive can be classified into common sense (e.g., how to recycle used batteries or how to dispose of household waste) and curricular knowledge (e.g., how much nitrogen will lead to eutrophication in lakes or how can a marine dead zone be defined) (Muller 2012), which are constructed in the dwelling and professional fields, respectively (Kasanda et al. 2005).

The perception of contextual factors benefits pro-environmental behavior under the theoretical framework of social cognitive theory. Social cognitive theory (SCT) was recently introduced into the environmental protection research field to highlight contextual influence as a complement to the theory of planned behavior (Corraliza and Berenguer 2000; Sawitri et al. 2015). According to SCT, "individuals with favorable contextual conditions and high environmental self-efficacy judgments will have more outcome expectations and will set more challenging goals, and also will engage more in pro-environmental behavior than individuals with a lower perception of their efficacy to perform such acts" (Sawitri et al. 2015). Sawitri et al. (2015) highlighted the central role of contextual factors in self-efficacy (i.e., evaluating the ability of an individual to influence the environment positively), expectation outcomes (i.e., results of pro-environmental behavior) and goals (i.e., intention of an individual to act environmentally). Contextual factors refer to the perceived environmental resources surrounding an individual (Lent et al. 2000; Sawitri et al. 2015). Many contextual factors "help" individuals take pro-environmental behavior actions. Diepen and Voogd (2001) found that the availability of recycling facilities in western societies strongly helped citizens engage in pro-environmental behavior. In other words, the larger the amount of available environmental resources (e.g., public transport and waste separation facilities), the more easily individuals can engage in pro-environmental behavior.

However, some other contextual factors may "force" individuals to adopt pro-environmental behavior. For instance, the perception of environmental pollution (environmental pollution perception, EPP) is a contextual factor that may force individuals to protect the environment. One of the most important associations between individuals and the environment is "inclusion with nature" (Carmi et al. 2015), which covers connectedness with nature (e.g., the belief that an individual is connected with nature), caring for nature (e.g., the care that an individual has for nature) and commitment to protecting nature (e.g., the motivation of an individual to behave environmentally) (Schultz 2002). With increasing pollution perception, those individuals living in the environment may show "environmental concern." Because of the connectedness with nature they have, they worry that deterioration of the environment will harm them. In this way, environmental pollution perception motivates them to engage in pro-environmental behavior (Carmi et al. 2015).

Capaldi et al. (2014) noted that human evolutionary environments such as natural environments differ from contemporary dwelling environments. The environmental pollution in a dwelling environment may also motivate individuals to engage in pro-environmental behavior (Blake 2001; Ghai and Vivian 2014). However, few studies have explored such relationships in the natural environmental pollution context.

The present study

The above literature review on environmental knowledge, pro-environmental behavior and environmental pollution indicates that the different categories of environmental knowledge may reveal various associations between environmental knowledge and pro-environmental behavior. The contextual factor, environmental pollution perception, may "force" individuals to take pro-environmental behavior actions. Therefore, environmental pollution perception may mediate the relationship between environmental knowledge and pro-environmental behavior. In other words, an individual with a high level of environmental knowledge tends to a severe environmental pollution perception, thereby increasing his/her pro-environmental behavior. As a result, the current study aims to explore the paths from environmental knowledge to pro-environmental behavior within the SCT framework. Specifically, the following hypotheses were proposed for examination:

H1. The more environmental knowledge an individual possesses, the more pro-environmental behavior he or she will display.

H1a. Compared to professional environmental knowledge, dwelling environmental knowledge is a stronger predictor of private pro-environmental behavior.

H1b. Compared to dwelling environmental knowledge, professional environmental knowledge is a stronger predictor of public pro-environmental behavior.

H2. Environmental pollution perception can mediate the relationship between environmental knowledge and pro-environmental behavior.

H2a. Dwelling environmental pollution perception can mediate the relationship between dwelling environmental knowledge and private pro-environmental behavior.

H2b. Natural environmental pollution perception can mediate the relationship between professional environmental knowledge and public pro-environmental behavior.

Method

Research population and data

This study is part of the Chinese General Social Survey 2013 (CGSS 2013), which is a large and comprehensive national investigation at the societal, community, family, and individual levels (http://www.chinagss.org). The CGSS adopted the multi-stage, stratified random sampling design to ensure the representativeness of its sample. CGSS 2013 had a proposed sample size of 12,000 and a final sample of 11,438 participants (male = 5756, female = 5682) with a mean age of 48.60 years (SD = 16.39) from all provinces in mainland China, except for Hainan Province and the Xinjiang Uygur Autonomous Region. A total of 6954 respondents (60.80%) came from cities, while 4484 (39.20%) came from townships. The sample had a median education level of high school or 12 years and a mean annual personal income of RMB 21,326.18 (SD = 35,535.02; roughly $3092 USD). All data were collected via face-to-face interviews. Written informed consent was obtained from all respondents. The data were published on the http://www.cnsda.org/index.php?r=projects/view&id=93281139 website on January 1, 2015.

Measures

Environmental knowledge Ten items with sound psychometric properties were designed to measure the perceived environmental knowledge of the respondents in the Chinese context (Hong and Xiao 2007; Xiao and Hong 2010). Environmental knowledge was divided into two subscales, namely, the seven-item dwelling environmental knowledge scale (items 1, 2, 3, 4, 5, 6 and 10) and three-item professional environmental knowledge scale (items 7, 8 and 9). The participants were asked to choose between *True*, *False* and *Do not Know* when answering each item based on their knowledge level and scope. Items 2, 4, 6, 8 and 10 were true, while the other items were false. The participants received one point whenever they answered an item correctly and zero points otherwise. The mean scores of the subscales were calculated to indicate the level of environmental knowledge. A confirmatory factor analysis (CFA) supported the correlated model of dwelling environmental knowledge and professional environmental knowledge [chi square = 2316.031, CFI = 0.927, TLI = 0.901, RMSEA = 0.078, 90% CI = (0.076, 0.081)].[1] The standardized factor loadings ranged from 0.402 to 0.732 with significance at the 0.001 level. Dwelling environmental knowledge and professional environmental knowledge had composite reliabilities of 0.819 and 0.747, respectively.

Pro-environmental behavior Pro-environmental behavior was measured using a ten-item questionnaire to indicate the degree of engagement in environmental protection (Xiao and Hong 2010). We adopted the concepts of private behavior and public behavior according to the research of Xiao and Hong (2010): "Environmentally friendly behavior includes behaviors such as recycling, purchasing organic produce, and conserving energy, all of which are typically private pro-environmental behaviors, while activism includes actions such as donating money to environmental organizations, signing petitions and writing letters, and attending publicly held movement events, all of which are common public environmental behaviors" (Xiao and Hong 2010, p. 90). The face validity and principle component analysis of Xiao and Hong (2010) divided this questionnaire into two subscales, namely, private pro-environmental behavior and public pro-environmental behavior, with each subscale containing five items (private pro-environmental behavior: items 1, 2, 3, 4 and 6; public pro-environmental behavior: items 5, 7, 8, 9 and 10). The participants were asked to choose among never (1), occasionally (2) and often (3) when answering each item depending on the frequency of their environment protection actions over the past year. The mean scores of each subscale were calculated to indicate the frequency of different pro-environmental behaviors. The CFA showed the acceptable goodness of fit [chi-square = 1703.751, CFI = 0.939, TLI = 0.917, RMSEA = 0.067, 90% CI = (0.064, 0.070)] of the correlated model in the sample. The standardized factor loadings ranged from 0.506 to 0.786 with significance at the 0.001 level. Private pro-environmental behavior and public pro-environmental behavior had composite reliabilities of 0.761 and 0.821, respectively.

Environmental pollution perception Environmental pollution perception was evaluated using six items on dwelling environmental pollution perception (e.g., noise pollution and food contamination; items 1, 2, 3, 4, 5 and 10) and six items on natural environmental pollution perception (e.g., forest and vegetation damage and desertification; items 6, 7, 8, 9, 11 and 12). The participants were presented with 12 types of environmental pollution and were asked whether they observed any of these types in their living areas (yes/no). If they answered "yes," then the respondents were asked to rate the pollution severity from 1 (not serious) to 5 (very serious). The mean scores of these subscales were calculated to indicate the severity of environmental pollution. The CFA showed an acceptable goodness of fit of the two-factor correlated model [chi-square = 2072.292, CFI = 0.930, TLI = 0.913, RMSEA = 0.058, 90% CI = (0.056, 0.060)] in the sample. The standardized factor loadings ranged from 0.410 to 0.767 with significance at the 0.001 level. Dwelling environmental pollution perception and natural environmental pollution perception had composite reliabilities of 0.813 and 0.779, respectively.

Appendix A presents the full description and descriptive statistics (mean and SD) of each item. Given that a self-reported questionnaire was used to collect data in the same period, the common method bias must be examined (Heine and Buchtel 2009). As recommended by Podsakoff et al. (2003), a single factor test was performed to detect potential bias. The results showed no common method bias because the first extracted component only contributed 17.227% of the variances (initial eigenvalues = 5.513), which was less than the 40.00% threshold.

Data analysis plan

The descriptive statistics of and partial correlations among environmental knowledge, pro-environmental behavior and environmental pollution perception were first calculated. The demographic variables, including gender, age, location (i.e., city or township), education and annual income, were controlled in the correlation analysis. Annual income ranged from 0 RMB to 1,000,000 RMB and was recoded into ten groups. Then, hierarchical regressions were performed using the enter method to explore the different roles of environmental knowledge (i.e., dwelling environmental knowledge and professional environmental knowledge) and environmental pollution perception (i.e., dwelling environmental pollution perception and natural environmental pollution perception) in explaining pro-environmental behaviors (i.e., private pro-environmental behavior and public pro-environmental behavior). In the first hierarchical regression, private pro-environmental behavior was used as the dependent variable. The five demographic variables were entered in step 1, followed by dwelling environmental knowledge and professional environmental knowledge in step 2 and dwelling environmental pollution perception and natural environmental pollution perception in step 3. Similarly, the second hierarchical regression used public pro-environmental behavior as the dependent variable. Third, structural equation modeling (SEM) was conducted to test the mediating role of environmental pollution perception in the relationship

[1] CFI mean comparative fit index
TLI mean Tucker-Lewis index
RMSEA mean root mean square error of approximation
CI, mean confidence interval

between environmental knowledge and pro-environmental behavior, which was constructed based on the regression results. Dwelling environmental pollution perception and natural environmental pollution perception were used as the mediators. CFI, TLI and RMSEA were adopted to evaluate the goodness of fit of the models. SPSS 24.0 and Mplus 7.0 were used to conduct the above-mentioned analyses.

Results

Descriptive and correlation analysis

Table 1 lists the mean and SD values of environmental knowledge, environmental pollution perception and pro-environmental behavior. A paired-sample t-test revealed that individuals had more dwelling environmental knowledge than professional environmental knowledge ($t = 102.966$, $p < 0.001$). The living environments of these respondents faced a higher degree of dwelling environmental pollution perception than natural environmental pollution perception ($t = 4.315$, $p < 0.001$). These individuals also had more private pro-environmental behavior than public pro-environmental behavior ($t = 153.741$, $p < 0.001$). As shown in Tables 1 and 2, all these variables were positively correlated ($r = 0.060$ to 0.519, $p < 0.001$). However, after controlling for gender, age, location, education and annual income, the degree of these correlations declined. Specifically, the associations between environmental pollution perception and environmental knowledge became insignificant.

Hierarchical regression analysis

Two hierarchical regressions were conducted using private pro-environmental behavior and public pro-environmental behavior as the dependent variables. All regression equations were statistically significant ($F > 119.416$, $p < 0.001$). The collinearity statistics indicated that all VIF values were less than five, thereby indicating that the multicollinearity of environmental knowledge and environmental pollution perception was not an issue in our data. In sum, the contributors to private pro-environmental behavior differed from those to public pro-environmental behavior.

Older ($t = 4.411$, $p < 0.001$) females ($t = 8.969$, $p < 0.001$) living in the city ($t = -17.297$, $p < 0.001$) with higher education levels ($t = 22.797$, $p < 0.001$) and a personal income ($t = 7.086$, $p < 0.001$) were more engaged in private pro-environmental behavior than their counterparts. These demographic variables remained significant contributors even after entering environmental knowledge and environmental pollution perception. Dwelling environmental knowledge ($t = 19.574$, $p < 0.001$) was a stronger predictor of private pro-environmental behavior than professional environmental knowledge ($t = 3.963$, $p < 0.001$) (H1a is supported). However, both dwelling environmental knowledge and professional environmental knowledge significantly explained additional 4.60% variances in private pro-environmental behavior. Environmental pollution perception was entered in the regression at the third step, and the results showed that only dwelling environmental pollution perception ($t = 4.465$, $p < 0.001$) managed to contribute small yet significant explained variances to private pro-environmental behavior.

Throughout the entire regression, those individuals living in the city ($t = -4.023$, $p < 0.001$) with higher

Table 1 Descriptive and partial correlations

Variables	Pearson correlations (partial correlations)					
	1	2	3	4	5	6
1 Dwelling environmental knowledge	–	0.509*** (0.401***)	0.132*** (0.021*)	0.080*** (−.0005)	0.390*** (0.236***)	0.189*** (0.037***)
2 Professional environmental knowledge		–	0.104*** (0.032**)	0.060*** (0.006)	0.253*** (0.132***)	0.208*** (0.111***)
3 Dwelling environmental pollution perception			–	0.519*** (0.495***)	0.161*** (0.064***)	0.114*** (0.057***)
4 Natural environmental pollution perception				–	0.107*** (0.036**)	0.089*** (0.047***)
5 Private pro-environmental behavior					–	0.391*** (0.315***)
6 Public pro-environmental behavior						–
Mean	0.560	0.257	2.980	2.952	1.842	1.189
SD	0.323	0.314	0.781	0.531	0.472	0.325

Note: The controlled variables were gender, age, location, education and annual income

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table 2 Hierarchical regressions of demographic variables, environmental knowledge and environmental pollution perception on pro-environmental behavior

Independent variables	Dependent variable								
	Step 1			Step 2			Step 3		
	Beta	*t*	VIF	*Beta*	*t*	VIF	*Beta*	*t*	VIF
	Outcome: private pro-environmental behavior								
Gender	0.083	8.969***	1.051	0.099	11.002***	1.057	0.098	10.852***	1.058
Age	0.001	4.411***	1.230	0.002	7.684***	1.255	0.002	7.595***	1.255
Location	−0.182	−17.297***	1.303	−0.138	−13.264***	1.349	−0.128	−12.094***	1.391
Education	0.045	22.797***	1.713	0.031	15.748***	1.869	0.031	15.503***	1.873
Income	0.019	7.086***	1.491	0.013	5.204***	1.506	0.013	4.921***	1.511
Dwelling environmental knowledge				0.349	19.574***	1.694	0.349	19.567***	1.695
Professional environmental knowledge				0.065	3.963***	1.374	0.062	3.825***	1.375
Dwelling environmental pollution perception							0.029	4.465***	1.422
Natural environmental pollution perception							0.009	0.907	1.378
R^2	0.190			0.236			0.239		
F	424.354***			399.975***			315.796***		
ΔR^2				0.046			0.003		
ΔF				274.832***			16.404***		
	Outcome: public pro-environmental behavior								
Gender	−0.007	−1.033	1.051	−0.005	−0.725	1.057	−0.006	−0.874	1.058
Age	< 0.001	−1.447	1.230	< 0.001	−1.070	1.255	< 0.001	−1.145	1.255
Location	−0.030	−4.023***	1.303	−0.026	−3.394**	1.349	−0.018	−2.380*	1.392
Education	0.023	16.173***	1.714	0.020	13.820***	1.870	0.020	13.613***	1.874
Income	0.014	7.492***	1.491	0.012	6.598***	1.506	0.012	6.286***	1.512
Dwelling environmental knowledge				−0.011	−0.812	1.694	−0.011	−0.826	1.695
Professional environmental knowledge				0.120	10.052***	1.374	0.118	9.942***	1.375
Dwelling environmental pollution perception							0.016	3.338**	1.422
Natural environmental pollution perception							0.015	2.198*	1.378
R^2	0.092			0.103			0.106		
F	183.192***			148.665***			119.416***		
ΔR^2				0.011			0.003		
ΔF				56.710***			15.388***		

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Beta means beta densities

VIF means variance inflation factor

education levels ($t = 16.173$, $p < 0.001$) and a personal income ($t = 7.492$, $p < 0.001$) showed more public pro-environmental behavior than their counterparts. After entering dwelling environmental knowledge and professional environmental knowledge into the regression, only professional environmental knowledge ($t = 10.052$, $p < 0.001$) significantly contributed to public pro-environmental behavior (H1b is supported). Both dwelling environmental pollution perception ($t = 3.338$, $p < 0.001$) and natural environmental pollution perception ($t = 2.198$, $p < 0.05$) had significant effects on public pro-environmental behavior as indicated in the third step.

Mediating role of environmental pollution perception

SEM with maximum likelihood (ML) estimation was performed to evaluate the three comparable models. An initial SEM model was constructed in which dwelling environmental knowledge and professional environmental knowledge were used as correlated predictors, dwelling environmental pollution perception and natural environmental pollution perception were used as meditators, and private pro-environmental behavior and public pro-environmental behavior were used as outcomes. Following the above-mentioned results, the paths between natural environmental pollution perception and private pro-environmental behavior as well as those between dwelling environmental knowledge and public pro-environmental behavior were removed. The goodness of fit indicated that the current model was acceptable [chi-square = 7872.321, CFI = 0.919, TLI = 0.910, RMSEA = 0.038, 90% CI = (0.038, 0.039)]. However, the paths from professional environmental behavior to private pro-environmental behavior, dwelling environmental pollution perception and natural environmental pollution perception were all insignificant. Thus, a revised model was constructed after removing the three above-mentioned paths. The revised model was established with an unchanged goodness of fit [chi-square = 7877.969, CFI = 0.919, TLI = 0.911, RMSEA = 0.038, 90% CI = (0.037, 0.039)]. Nevertheless, the path from natural environmental pollution perception to public pro-environmental behavior was insignificant (H2b is rejected). Accordingly, a third model (Fig. 1) was constructed without natural environmental pollution perception, and the final model showed an excellent goodness of fit (chi-square = 5963.050, CFI = 0.926, TLI = 0.918, RMSEA = 0.042, 90% CI = (0.041, 0.043)]. These findings indicated that dwelling environmental pollution perception significantly and partly mediated the relationship between dwelling environmental knowledge and private pro-environmental behavior (H2a is supported) as well as fully mediated the relationship between dwelling environmental knowledge and public pro-environmental behavior. Meanwhile, professional environmental knowledge only showed a direct effect on public pro-environmental behavior.

Discussion

Using data from a national survey, we found that the different classifications of environmental knowledge had various influences on private pro-environmental behavior and public pro-environmental behavior. Specifically, dwelling environmental knowledge was a stronger predictor of private pro-environmental behavior than professional environmental knowledge, while professional environmental knowledge was the only contributor to public pro-environmental behavior. Moreover, only dwelling environmental pollution perception showed additional

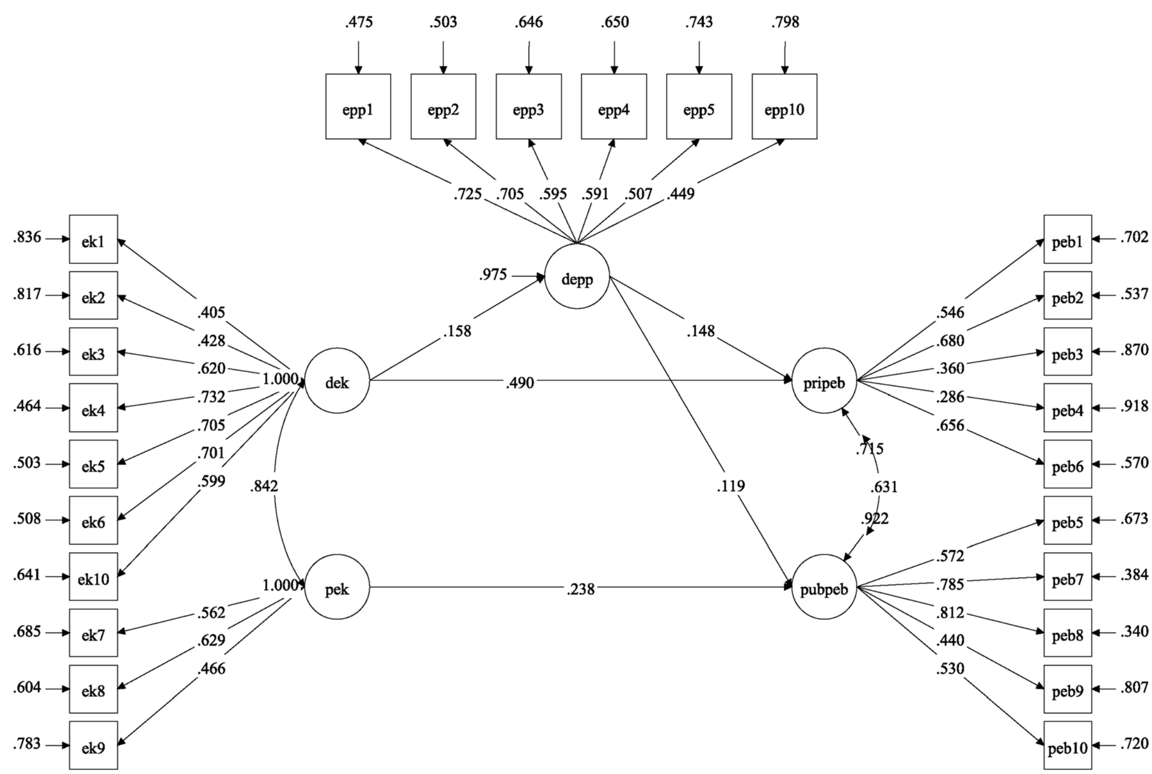

Fig. 1 Standardized structural equation modeling for the mediation effects of environmental pollution status in the associations between environmental knowledge and pro-environmental behavior. *Note.* ek = environmental knowledge, epp = environmental pollution perception, peb = pro-environmental behavior, dek = dwelling environmental knowledge, pek = professional environmental knowledge, epp = environmental pollution perception, depp = dwelling environmental pollution perception, pripeb = private pro-environmental behavior, pubpeb = public pro-environmental behavior; all path coefficients are standardized and significant ($p < 0\ 0.001$)

variances to explain private pro-environmental behavior, while both dwelling environmental pollution perception and natural environmental pollution perception had significant and additional effects on public pro-environmental behavior. Integrating these variables into a single comprehensive model via SEM revealed that dwelling environmental pollution perception mediated the relationship between dwelling environmental knowledge and the two types of pro-environmental behavior (i.e., private pro-environmental behavior and public pro-environmental behavior) and that professional environmental knowledge only showed a direct effect on public pro-environmental behavior. Therefore, the deterioration of dwelling environmental pollution perception can help transform the dwelling environmental knowledge of an individual into pro-environmental behavior.

This conclusion may be attributed to "environmental concern," which pertains to the evaluation and emotional attitude of an individual toward environmental issues (Fransson and Gärling 1999; Takala 1991). Magnier and Schoormans (2015) applied environmental concern to study green attitudes and behavior and found that the environmental concern of consumers positively affected their reactions to sustainable packages. According to the Feedback System (DeWall et al. 2015), an emotional attitude (i.e., environmental concern) is considered a feedback, that is, an individual decides to adopt a specific behavior to pursue his/her desired emotion. When individuals perceive the deterioration of their environment, they tend to show environmental concern, which in turn helps them use their environmental knowledge to develop different if-then rules of pro-environmental behavior. Moreover, to change their negative emotions, people tend to perform environmental actions according to their if-then plans when they face a different environmental pollution perception. Nisbet et al. (2008) found that those individuals with a high level of nature relatedness (i.e., strong subjective connection to nature) showed more environmental concern and self-reported pro-environmental behavior than those with low levels of nature relatedness. The environmental pollution in dwelling environmental pollution perception can bring more nature relatedness to individuals than the environmental pollution in natural environmental pollution perception. Moreover, knowledge based on living conditions (i.e., dwelling environmental knowledge) is more useful than that based on ecological and scientific knowledge (i.e., professional environmental knowledge). By posing a significant threat to individuals, dwelling environmental pollution perception produces environmental concern that eventually transforms dwelling environmental knowledge into both private pro-environmental behavior and public pro-environmental behavior.

The demographic variables are also worth discussing. We found that older females living in the city with a higher education level and personal income were more engaged in private pro-environmental behavior compared with their counterparts. In addition, those individuals living in the city with a high education level and personal income tend to demonstrate public pro-environmental behavior. Gender differences in private pro-environmental behavior have also been observed (Blocker and Eckberg 1997; Hunter et al. 2004). Such differences may be partly attributed to the different roles that women (e.g., caregivers) (Tindall et al. 2003; Xiao and Hong 2010) and men (e.g., breadwinners) (Wehrmeyer and McNeil 2000; Xiao and Hong 2010) perform in traditional societies. Specifically, women tend to show environmental concern when making decisions about their living conditions (e.g., recycling and discussing environmental protection issues with friends and relatives), while men tend to encourage others to participate in environmental initiatives (e.g., environmental campaigns sponsored by governments and workplaces and protests) and express grievances about environmental problems (Stern et al. 1993).

Although many studies show that age is either negatively associated with (Grossman and Potter 1977) or not related to (Costantini and Hanf 1972; Koenig 1975) pro-environmental behavior, we found that age has a significant and positive effect on private pro-environmental behavior. This finding may be attributed to the fact that the elderly, given their slow movement, tend not to participate in those outdoor activities (i.e., public pro-environmental behavior) that appeal to young men. In line with our findings, only a few recent studies have found that the elderly tend to adopt conservation actions (Gifford and Nilsson 2014; Hertel et al. 2013; Wiernik et al. 2016). Education, income and location all influence private pro-environmental behavior and public pro-environmental behavior. Specifically, income is positively related to pro-environmental behavior (Gifford and Nilsson 2014; Mantovani et al. 2017), although Xiao et al. (2013) demonstrated that income is not related to environmental concern in China. Some papers even indicate that low-income individuals show more environmental concern than high-income ones (Uyeki and Holland 2000), thereby contradicting our conclusions. Therefore, the effects of income on pro-environmental behavior may vary across the different development stages of a society. On the one hand, the blossoming of the economy and the societal progress in mainland China have contributed to a change in values, which means that high-income individuals have shifted from materialism to post-materialism (i.e., they may show more environmental concern in the latter than in the former) (Gifford and Nilsson 2014; Inglehart 1997). On the other hand, given the close relation between socioeconomic status and education, wealthy people tend to acquire better education and be more knowledgeable than poor people (Chanda 1999; Gifford and Nilsson 2014), thereby helping the latter solve their problems when engaging in environmental action. To this end, these high-income individuals are highly engaged in pro-environmental behavior. Regarding education, well-educated people tend to possess a high level of knowledge, thereby promoting their pro-environmental behavior. This finding is in line with the conclusions of Meyer (2015). Previous studies have also noted that individuals with high education levels tend to show environmental concern (Carmi et al. 2015; Gifford and Nilsson 2014; Xiao et al. 2013), thereby increasing their tendency to engage in pro-environmental behavior. Location (i.e., city or township) has also been related to education. Those people living in cities tend to engage in pro-environmental behavior because education in urban areas is generally better than that in the rural areas of mainland China. Therefore, those individuals living in cities have high levels of pro-environmental behavior, as suggested by Chen et al. (2011).

The limitations of this article must be acknowledged. First, the CGSS uses a self-created measurement scale with weak psychometrics features. Although we tested the internal consistency and construct validity of this scale, future research must verify our results using solid tools. Second, we adopted a self-reported, subjective measure of pro-environmental behavior. However, the ability of this scale to reflect the pro-environmental behavior of an individual must be discussed further. Performing a tracking observation or recording behavior in an objective approach can improve the reliability and validity of future research. Third, we only consider environmental pollution perception in this study, even though many other contextual variables are available (e.g., environmental resources, environmental policy and infrastructure related to environment). To enhance the present understanding of the transformation from environmental knowledge into pro-environmental behavior, highly precise research must be conducted in the future.

Despite these limitations, our findings are generally affirmative because they suggest an explicit way to transform environmental knowledge into pro-environmental behavior. It is acknowledged that pro-environmental behavior is a key factor to promote the public environment, which means research related to pro-environmental behavior is apt to exert significant influence on Chinese public policy. The Chinese government has adopted some strategies to enhance pubic pro-environmental behavior, for example, China established the Environment Label system (Li 2014), and the Chinese government also published the emissions cap policy, intensity target policy and emission tax policy to control air pollution (Xu et al. 2015), and administrative orders (Sun and Hu 2014) are a common way to deal with environmental issues. However, these public policies are too macroscopic to be evaluated effectively. According to Cotton et al. (2016), environmental education plays a significant role in a more sustainable society. However, the fact can be another picture in which environmental education has fewer effects on the public than we thought. The reason is that macro public policies leave the public a wrong impression that government should take the major responsibility of environmental issues (Yan et al. 2010). In this way, people in China are likely to think little of the importance of environmental education. On top of this, our environmental education policy ignored that the essence of environmental education is to spur individuals to take effective pro-environmental behavior in accordance to their environmental knowledge. That is to say, environmental education will become useless if environmental knowledge is not transformed into pro-environmental behavior.

To solve above problems, our research displayed a new pathway to improve individuals' pro-environmental behavior, that is, environmental pollution perception can be very important during the transformation into pro-environmental behavior. If environmental education policy tries to promote people in China to have a deeper perception about their dwelling environmental pollution, they will be prone to follow more pro-environmental behavior. To achieve this goal, the Chinese government can adopt situation education, which means people can experience the deterioration of the dwelling environment in peculiar situations. Hence, based on the perception of environmental pollution, people will have a stronger incentive to follow pro-environmental behavior to change the environmental pollution.

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Appendix

Table 3 Dimensions and items of China General Social Survey in this study

Dimensions and items	Mean (SD)
Environmental knowledge	
Dwelling environmental knowledge (true/false)	
Item 1: Automobile exhaust will not harm people's health	0.77 (0.42)
Item 2: Overusing fertilizer and pesticides will damage the environment	0.79 (0.41)
Item 3: Using detergent powder containing phosphorus will not cause water pollution	0.56 (0.50)
Item 4: Chlorofluorocarbon (CFC) emissions from refrigerators are one of the causes of ozone depletion	0.44 (0.50)
Item 5: Acid rain has nothing to do with coal burning	0.40 (0.49)
Item 6: Due to the interdependency among species, one species vanishing will cause chain reactions	0.47 (0.50)
Item 10: The increasing carbon dioxide in the atmosphere is one of the factors causing a climate change	0.49 (0.50)
Professional environmental knowledge (true/false)	
Item 7: In the air quality report, the air quality at grade III is better than the air quality at grade I	0.21 (0.41)
Item 8: A single variety of trees in woods is more likely to cause pests and diseases	0.42 (0.49)
Item 9: In the water pollution report, V(5) water quality is better than I(1) water quality	0.14 (0.35)
Pro-environmental behavior	
Private pro-environmental behavior	
Item 1: Recycle	1.57 (0.70)
Item 2: Discuss environmental protection issues with friends and relatives	1.57 (0.63)
Item 3: Bring your own shopping bag to grocery stores	2.15 (0.78)
Item 4: Save and reuse plastic shopping bags	2.31 (0.77)
Item 6: Actively pay attention to environmental protection and information in the media	1.63 (0.70)
Public pro-environmental behavior	
Item 5: Make a monetary donation to an environmental protection cause	1.20 (0.44)
Item 7: Actively participate in environmental campaigns sponsored by government and workplace	1.27 (0.53)
Item 8: Actively participate in environmental protection activities sponsored by non-governmental environmental organizations	1.19 (0.45)
Item 9: Maintain public woods or forests and grasslands with your own money	1.19 (0.48)
Item 10: Participate in protests and express grievances about environmental problems	1.11 (0.36)
Environmental pollution perception	
Dwelling environmental pollution perception	
Item 1: Air pollution	2.99 (1.25)
Item 2: Water pollution	2.95 (1.21)
Item 3: Noise pollution	2.91 (1.13)
Item 4: Industrial waste pollution	2.91 (1.02)
Item 5: Domestic waste pollution	2.96 (1.18)
Item 10: Food contamination	3.16 (1.08)
Natural environmental pollution perception	
Item 6: Lack of green space	2.93 (0.93)
Item 7: Forest and vegetation damage	2.89 (0.87)
Item 8: Quality of cultivated land degradation	3.00 (0.87)
Item 9: Freshwater shortage	2.91 (0.98)
Item 11: Desertification	2.96 (0.61)
Item 12: Reduced wildlife	3.03 (0.72)

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