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Economic incentive and social influence to overcome household waste separation dilemma: A field intervention study

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ABSTRACT

China has experienced a rapid growth of solid waste over the years, household waste source-separation is becoming a nationwide strategy for promoting recycling economy and improving urban environmental sustainability. Waste separation, however, may end in failure due to the free-rider problem similarly existing in other pro-environmental collective actions. Along with the economic and sociological/social psychological logic respectively, this study tested the effects of economic incentive and social influence, which are theoretically considered as two general solutions to domestic waste separation dilemma. One hundred and eighty-eight residents in the three communities of Hangzhou, Zhejiang Province were assigned to a control group or one of two experimental scenarios, where they were encouraged to participate in waste separation activities through either the economic rewards given on their performance, or door-stepping campaigns aimed at constructing a supportive social environment. Six-month intervention effects were analyzed and showed that economic inducement was more effective than social mobilization in promoting waste separation. Further mediation tests indicated that self-efficacy partially mediated the effects of both strategies, while personal norms were positively associated with two treatments instead of behavior demonstration. In addition, the moderating effects of several socio-demographic factors on psychological mechanisms were also explored. The findings, limitations and implications for future research and policy are discussed in the concluding section.

1. Introduction

Household solid waste management is widely accepted as a key indicator in measuring both the quality of life of dwellers and urban sustainability. China has recently experienced a dramatic increase in domestic waste production at the rate of 8%-10% per year[1] – approaching an alarming level that poses a severe threat to the environment and citizens' living standards. As one of the major strategies adopted in many countries, promoting source-separation of household waste to increase recycling and lighten the load of landfill and incineration (Stoeva and Alriksson, 2017), has become one of the most pressing issues on Chinese government agenda. In particular, the State Council has issued its Implementation Program of Household Garbage System in March 2017, highlighting the urgency and importance of this work.

Undoubtedly, the widespread participation of general public is the key to the success of waste separation in a society, since it requires a concerted effort of social members. Like other pro-social behaviors, however, such collective action is vulnerable to the free-rider problem (Olson, 1965) and easily ends in failure. By its nature, waste separation is a voluntary provision of such public goods as a cleaner environment and more efficient utilization of energy resources (Yau, 2010), yet these longer-term and collective benefits may not cover the time, energy and/or other costs paid by individuals for accurately separating (GarcÉS et al., 2002). Moreover, they need to be supplied jointly but not excludable to anyone (Yau, 2010). Driven by rationality, hence, residents seeking utility maximization tend to free ride on others' efforts and choose not to engage in waste separation.

While collective-action problem, or "tragedy of commons" (Hardin, 1968), seems inevitable under this rational egoist assumption, it can be solved through several well-designed institutions or behavioral interventions that increase individuals' objective payoff or motivation and hence facilitate altruistic behaviors (Ostrom, 2000). From the perspective of environmental collectivism that is seldom discussed by domestic waste separation or recycling literature (Yau, 2010), the aim of this intervention study was to

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[1] Retrieved on 11 September 2017, from http://news.feijiu.net/infocontent/html/201412/16/16320111.html [Chinese].

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compare economic incentive and social influence, which are acknowledged as two effective solutions to collective dilemma (Olson, 1965; Ostrom, 1990), in terms of their effects at promoting waste separation. We further investigated a range of psychological and socio-demographic factors that were expected to mediate or moderate these intervention effects, since it is helpful to better understand the mechanisms and scopes of such initiatives. Nonetheless, these factors are severely neglected by existing intervention-oriented studies within the domain of waste separation (Varotto and Spagnolli, 2017).

2. Two solutions to waste separation dilemma

In most cases, a successful collective action is indispensable for effectively providing a public good. Following the rational choice theory, Olson (1965) asserted that no self-interested person would contribute to public goods unless the group size is small or she/he is coerced or induced by some external devices such as selective economic incentives, which can increase individual payoff and conformity to collective interest. Subsequently, Ostrom (1990, 2000) and other scholars challenged this "zero contribution thesis" and proposed that self-organized governance system, where people voluntarily cooperate with each other to protect common resources, could be achieved with the strong social influence or conduct norms. In regard to waste separation situation, economic incentive and social influence are not only two sets of important determinants predicting waste separation behavior in psychological literature (e.g., Grazhdani, 2016; Kirakozian, 2016; Pakpour et al., 2014; Xu et al., 2017), but also the clearly theoretical references linked to the designing of behavioral interventions (Varotto and Spagnolli, 2017).

2.1. Economic incentive

Under the circumstance of voluntary provision, a rational agent will contribute nothing to public goods as she/he can still gain the non-excludible collective benefits at the expense of others' efforts. Harnessing this self-interested logic, rewarding participation (or punishing nonparticipation) in provision of public goods would effectively induce individual contribution and achieve group interest, since actions can bring about more personal benefits than inactions (Olson, 1965). Apart from the extrinsic inducement or price effect, economic incentives may also affect some psychological conditions. For example, incentives can be given on an individual level and act as a feedback about individual performance (Thøgersen, 2005), which may enhance recipients' feeling of *self-efficacy* and, in turn, increase their willingness to contribute (Finkel et al., 1989). On the other hand, however, reward schemes sometimes appear to backfire and have a negative effect on uptake of the recommended behavior. Of the range of mechanisms expected to be involved, the "overjustification effect" theorizing (Deci et al., 1999) has been widely adopted by scholars to explain this anomaly, which highlights the tendency of attributing contribution to the external factors and the so-called "*crowding-out effect*" on intrinsic motivations such as *personal norms*[2] (Ariely et al., 2009; Varotto and Spagnolli, 2017).

A variety of incentive-based strategies (e.g., pricing schemes, rewards, and gifts) have been applied to encourage domestic waste separation. Their effects are also analyzed by limited field studies, suggesting that, (1) the overall effectiveness of economic incentives is still inclusive (Yau, 2010), with quite few studies failing to demonstrate the successfulness of economic instruments in increasing waste separation behavior (e.g., Allen et al., 1993; Scott, 1999; Timlett and Williams, 2008); (2) individual-based incentives are usually more effective than those contingent on group performance (Harder and Woodard, 2007); (3) incentives could achieve more for residents with lower initial separating rate (Harder and Woodard, 2007). More importantly, it seems that the systematically empirical evidence about effects of recycling incentives on intrinsic motivations is still lack to date.

2.2. Social influence

In sharp contrast with rational choice theory insisting the determinism of individual benefit balance sheet, social psychologists and sociologists instead value norms as another kind of general rule motivating voluntary behaviors (Kreps, 1997). Indeed, people are not perfectly rational actors in the real world filled with uncertainty and ambiguity. They might behave in a pro-social manner to just follow others or to live up to their own expectations without external incentives to do so. Social norms are beliefs about which actions are obligatory, permitted, or forbidden shared by members in a group (Ostrom, 2000), and those favoring reciprocity, trust, and cooperation can guide voluntary behaviors by forming social pressure and/or reshaping self-cognition. Specifically, people usually want to gain social approval and try to escape potential social criticism or sanctions by others (Abrahamse and Steg, 2013; Abrahamse et al., 2005; Suh, 2002), for which they may be more willing to act in a pro-social way under a strong social norm (Cialdini et al., 1990). Moreover, outer norms can further be internalized or introjected as personal norms and identification with the shared standards through a repeated communication, interaction, social learning, and cooperation in the longer term (Bertoldo and Castro, 2016; Ostrom, 1990). Evidently, those with a more salient sense of self-obligation might be more likely to avoid distressful cognitive dissonance, as well as consistently participating in volunteer behaviors. Besides, the comparison between individual performance and a predefined standard may function as a feedback and make residents more capable of voluntary engagement (Abrahamse and Steg, 2013; Varotto and Spagnolli, 2017). This increased self-efficacy can also be acquired by watching others' successful behavior (Bandura, 1986). Therefore, constructing or reshaping a supportive social environment can help resolve a collective-action problem. Self-efficacy and personal norms are also the key factors in understanding how social influence encourages one's contribution to collective goods.

There are at least two kinds of social influence techniques pertaining to promoting residential waste separation. For example, conveying information regarding either a predefined standard or performance of others who have been already dedicated to separating their daily refuse (e.g., friends, neighbors, groups or communities) can establish normative conducts and prompt social comparison (Abrahamse and Steg, 2013; Varotto and Spagnolli, 2017), helping people have a better understanding of currently social situations and expectations (Cialdini and Goldstein, 2004). Another application is social modeling, which means community members or volunteers who have performed recycling are recruited to act as block leaders to encourage actions of nonparticipants via communication, demonstration and/or door-stepping campaigns (Osbaldiston and Schott, 2012). As evidenced by a meta-analysis review conducted by Varotto and Spagnolli (2017), socially modeling waste separation behavior tends to outperform the sole information provision, which might be because face-to-face interaction among members occurring in social modeling situation are more conductive to increasing efficacy-related beliefs and accelerating a social learning process (Bandura, 1977).

[2] Intrinsic motivations can be based either on enjoyment of a task or on a sense of introjected regulation/ obligation, while the latter is more related to behaviors associated with more effort and less pleasure, such as civic and environmentally responsible actions (van der Werff, Steg, and Keizer, 2013). Furthermore, obligation-based intrinsic motivation is very similar to personal norms since both of them stress the feeling of being morally obliged to perform a targeted behavior (van der Werff et al., 2013). Hence, our study tested the negative mediation of personal norms, for examining the potential crowding-out effect of economic incentives.

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2.3. Summary and predictions

Following the two different approaches respectively, economic incentive and social influence are considered as two persuasive solutions to collective dilemma in theory, and their potentials on increasing household waste separation have been supported by previous research to a varying extent. Hence, their positive effects were also expected in this study, but it was difficult to predict which one was more effective a priori.

Previous research mainly focuses on whether different strategies could promote waste separation and recycling, while little dedicates to investigating the underlying mechanisms behind these intervention effects, leading to a weak connection between intervention-based research and psychological research into key determinants of individual behavior (Varotto and Spagnolli, 2017). In order to contribute to filling this gap and provide some advances to existing literature, we further investigated how these initiatives influenced individual performance. In addition of the price effect involved in externally financial inducement and outer pressure resulting from social mobilization, which were approximated as direct paths to increase waste separation, self-efficacy and personal norms were considered as two important mediators responsible for the indirect effects of both strategies on behavioral demonstration. As the two core constructs in social cognitive theory (Bandura, 1986; Thøgersen and Grønhøj, 2010), self-efficacy and personal norms have been repeatedly demonstrated important for predicting resident pro-environmental behavior within different domains (Thøgersen and Grønhøj, 2010; Steinhorst et al., 2015). Meanwhile, they are the key factors for the prediction of individual choice in collective action dilemmas (Jugert et al., 2016; Ostrom, 1998), as well as the clear references in explaining the effectiveness of economic and social interventions as mentioned above. We thus examined their mediating effects while controlling for other behavioral determinants such as demographic features and separation habit.[3] Nevertheless, they are only two possible mechanisms involved, and other underlying factors should also be studied carefully by future research (see Section 5.4).

With regard to the specific hypotheses, economic incentive given on individual performance would increase separation behavior by strengthening self-efficacy, but it was expected to exert a negative influence on behavioral demonstration due to its crowding-out effect on personal norms. By contrast, social influence was expected to increase separation behavior by enhancing both self-efficacy and personal norms due to a social learning process and the internalization of social norms respectively.

Besides, this study also shed light on exploring the differentiated effects of external influences on waste separation behavior under different demographic backgrounds, since it would be more beneficial to segmenting population and discussing for which audiences these strategies are particularly effective (Jesson, 2009; Varotto and Spagnolli, 2017; Xu et al., 2016). However, little prior literature that have developed this segmentation model especially for Chinese residents could be located by us.

3. Methods

3.1. Separation practices in Hangzhou

As a leading pilot metropolis in China, Hangzhou has been promoting household waste separation since 2000, while it is only restricted to a few areas and the overall urban waste generation is still increasing over the years (Xu et al., 2017). The main approach used by the local government of Hangzhou is providing sorting facilities (e.g., garbage bags and recycling bins) and information about how/why to carry out waste separation for residents via community education campaigns. Some informal recycling sectors including waste pickers, itinerant buyers, and venders also play a role in motivating household recycling, but they have almost disappeared (especially in our experiment field) due to officially-launched large-scale regulations and an ongoing recession in commodity trading market in these years. Recently, government purchase of public services from formal recycling enterprises have emerged and become a new approach to encourage waste separation in Hangzhou. A popular way is that recycling companies provide a performance-based reward scheme to entice household waste separation, and make profits mainly from government subsidies and reproduction of recyclables.

3.2. Procedure

A framed field experiment was designed to achieve the goals set in this study, which was conducted from April to November 2017 in three geographically adjacent communities in Yuhang District of Hangzhou (120.30°E, 30.43°N). As part of a collaborative project supported by university, local governments and recycling firm, this study was conducted to evaluate multiple waste separation initiatives prior to they being formally rolled out to every household in the targeted area. Apart from matching the abilities of the local government and business plan of the company, there are another two reasons why these three communities were chosen for this study. Firstly, they belong to the same district and are located next to each other and, hence, share almost the same externally socio-economic situations and institutional culture. Meanwhile, they are similar in terms of population structure and community construction. All of these make this study more controllable and reliable. Secondly, these communities were not exposed to any formal promotion of waste separation (e.g., education campaigns and voluntary activities) until this study, which helps largely eliminate the potential noise from remaining effects of historical or other existing interventions.

One hundred addresses were randomly selected from a complete list of residences in each community. Participants were recruited by community neighborhood committees among adult residents of the 300 selected homes, and the recruitment of two or more participants coming from the same family was not allowed. In other words, participants in this study were from different households. Two hundred and twenty-five residents registering for the experiment were rewarded with some commodities (e.g., hand-sanitizers and tissues) and required to answer the pre-assessment questionnaires for establishing their basic information about demographic characteristics, (self-reported) waste separation performance at baseline (T1), general environmental concerns and specific attitudes towards waste separation. These psychological factors were not the focus of this study, but they could help detect the initial nonequivalence between experimental conditions (see Section 4.2). Afterwards, each group (participants residing in the same community) was assigned to either of three scenarios (i.e. social influence, economic incentive or control) in order to facilitate the intervention distribution process and reduce the likelihood of mutual interference between treatments via participants in different experimental conditions communicating with each other.

Behavioral interventions were administrated from May to October. All participants in three groups were provided with garbage bags periodically. Volunteers in "Yuyatuan", a well-known voluntary organization in local communities that actively contributes

[3] Although social influence is theorized to function via both social and personal norms, the study by Bertoldo and Castro (2016) empirically demonstrated that the positive influence of perceived social norms on waste recycling behavior is mediated by personal norms. The current study thus specially focused on the proximal and more internal determinant (i.e. personal norms).

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to community affairs and hence has strong ties with local residents, were employed as block leaders to conduct a door-stepping campaign for those in the social influence scenario. More specifically, volunteers organized monthly face-to-face visits to each participant, each lasting approximately 30 min. They disseminated oral information about the environmental benefits and necessities of waste separation, communicated to participants that other people and many adjacent communities had already performed it, established the social expectation, as well as demonstrated the way to do it. Requiring residents to make a distinction between recyclables, hazardous waste, other dry waste and wet garbage (especially kitchen garbage) was implemented in this group, consistent with the current standard prevailing in Hangzhou. In matters like these, norms in favor of waste separation were expected to be constructed and enhanced.

Alternatively, those in another scenario were rewarded on their actual separating performance by "Huge", a local renewable resource company. Participants were repeatedly informed that they could earn "green scores" through separating dry waste from the daily garbage and selling them to the company (by sending them to company's stores scattered over the residential areas, or reserving home service). Moreover, they could earn more if the recyclables with higher residual value (e.g., waste household appliance) were isolated from the dry waste. However, participants would gain nothing if they mixed dry waste with wet garbage. The scores were completely equivalent to RMB (the Chinese currency) and could be used to buy life necessities such as edible oil, rice and condiments in company's stores near the uptown. By contrast, those in control group were not imposed with such two interventions during the experimental period.

After interventions, participants were asked to join in a follow-up assessment to survey their behavioral demonstration (T2) and some new questions related to self-efficacy and personal norms about waste separation. One hundred and eighty-eight participants (111 in experimental scenarios, 77 in control group) completed all the processes and sufficiently filled out the questionnaires (84% of the initial sample).

3.3. Measures

The questionnaires were designed by reference to prior research and served for a larger project. The Chinese version was pre-tested on a small number of residents in targeted areas in order to check clarity and avoid ambiguity of questions. The key items related to this study are displayed in Table 1.

Regarding the measurement of waste separation behavior, we simplified the indicators developed by Xu et al. (2017) to ask participants about the frequency of separating four kinds of household waste (i.e., recyclables, hazardous waste, other dry waste and kitchen garbage) in the form that "How often do you separate X [each kind of waste] this month?", based on a 5-point Likert-scale from 1 ("never") to 5 ("always").[4] (Cronbach's α = .827 and .867 at T1 and T2 respectively). A Principle Component Analysis (PCA) was applied to merge behavior items and extract common factor without substantial loss of information. The factor score was calculated and used as waste separation scale at both measurement times (all loadings $\geq$.807 and $\geq$.766 at T1 and T2 respectively) for the regression analysis.

Table 1
Key survey items and response options.

Household waste separation (HWS)[a]
HWS1: Separate recyclables (paperboards, rubbers, metals, glass, plastic bottles, waste household appliances, etc.)
HWS2: Separate kitchen garbage (e.g., leftovers)
HWS3: Separate hazardous waste (waste batteries, lamps, expired drugs etc.)
HWS4: Separate other dry waste (ceramics, disposable paper cups, etc.)
Self-efficacy for waste separation (SE)[b]
SE1: I am certain I can do waste separation well
SE2: I believe I can do waste separation well
Personal norms for waste separation (PN)[b]
PN1: Due to my personal values/principles for environmental protection I feel obliged to separate waste during my everyday life
PN2: No matter what other people think or do, due to my personal values/principles for environmental protection, I feel personally obliged to separate waste during my everyday life

[a] 1 = "never", 5 = "always"
[b] 1 = "strongly disagree", 5 = "strongly agree".

For the psychological mediators, self-efficacy for waste separation was operated as two items adopted from Steinhorst et al. (2015) (α = .800); personal norms for waste separation were measured with two items adapted from Steinhorst and Matthies (2016) and Thøgersen (2006) (α = .905). All of them were presented in the form that "Do you agree with Z [each statement]" and measured on a 5-point Likert-scale from 1 (1="strongly disagree") to 5 ("strongly agree"). Composite score for each construct were also calculated by PCA (all loadings $\geq$.90 for both self-efficacy and personal norms). Items related to other psychological scales that were used to detect the nonequivalence between experimental groups are available online in Appendix A.

Meanwhile, gender (0 = male, 1 = female), age, education level (1 = "no education", 7 = "Graduate and above"; see Table 2), monthly household disposable income (1 = "<¥5000", 6 = "$\geq$¥25000"; see Table 2), household size (number of family members), and years of residence in local communities were also measured to capture the socio-demographic features of respondents.

4. Results

4.1. Descriptive statistics

Table 2 presents basic demographic composition of the final sample (N = 188), which consisted of more women, young and well-educated people in comparison to the Chinese population overall (51% male/ 49% female; 16% $\geq$60 years old; 7% undergraduate or above.[5]) The properties and correlation matrix of key variables are available online in Appendix B.

4.2. Analytical strategy

Preliminary tests (one-way ANOVAs) on personal characteristics were also conducted to detect the nonequivalence of the remaining participants between three conditions, indicating that there were significant differences in several socio-demographic factors and waste separation performance at baseline but not in a range of psychological constructs inclusive of environmental concerns and self-identity, moral norms and other factors related to

[4] Although participants in economic incentive group were not specially induced to separate hazardous materials from other waste, we still incorporated this indicator into evaluating separation performance for them because local government had set special trash bins dedicated to collecting hazardous materials in communities before our study and, thus, there was the possibility that participants in economic group also voluntarily took part in hazardous waste separation, which could be understood as a positive spillover between pro-environmental behavior(s) targeted by intervention and non-targeted behavior(s) within the domain of recycling (Lanzini and Thogersen, 2014; Truelove et al., 2014). We also recalculated the models displayed in Section 4 when the item related to hazardous waste was excluded and found there was no significant difference from the results inclusive of this item.

[5] Census data from the latest Chinese Statistical Yearbook in 2016 provided by the National Bureau of Statistics (NSBC). Retrieved on 17 August 2017, from http://www.stats.gov.cn/tjsj/ndsj/2016/indexch.htm.5

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Table 2
Sample profile.

	Total	Male	Female
	(N = 188)	(N^M=93)	(N^F=95)
Age: (%)			
<20	1.06	.53	.53
20–29	6.38	3.19	3.19
30–39	42.02	17.02	25.00
40–49	29.26	17.02	12.23
50–59	16.49	8.51	7.98
≥60	4.79	3.19	1.60
Education level: (%)			
No education	2.66	.00	2.66
Primary school	5.32	1.06	4.26
Junior high school	19.15	8.51	10.64
High school	36.17	20.74	15.43
College	18.09	9.04	9.04
Undergraduate	17.02	9.04	7.98
Graduate and above	1.60	1.06	.53
Occupation: (%) (0.53% missing)			
Government organization	1.60	1.07	.53
Company business	41.18	22.99	18.09
Undertaking employment	14.44	6.95	7.49
Social group	1.60	1.60	.00
Self-employment	17.65	6.42	11.23
Retirement	7.49	2.14	5.35
Student	.53	.53	.00
Others	15.51	7.49	8.02
Monthly household disposable income: (%)			
<¥5000	15.96	9.57	6.38
¥5000–10,000	42.02	19.15	22.87
¥10,000–15,000	21.28	10.64	10.64
¥15,000–20,000	13.83	5.32	8.51
¥20,000–25,000	2.13	2.13	.00
≥¥25,000	4.79	2.64	2.13
Household size: (%)			
≤3	42.55	20.74	21.81
≥4	57.45	28.72	28.73
Years of residence in local communities			
≤2	52.66	53.76	51.58
>2	47.34	46.24	48.42

waste separation and generally pro-environmental behavior. Hence, only socio-demographic variables and baseline behavior were controlled in following analyses for preserving the degree of freedom.

Although the data collected were hierarchical, that is, the respondents were nested within communities, a multi-level model was not suitable for this study because of the one-group-per-condition design (one community per scenario) applied in this study, which run a risk of compounding the variation due to group with that due to condition (Varnell et al., 2001). A few studies have developed three remedial methods such as conducting analysis at an individual level, dividing a group into subgroups and analyzing data at a subgroup level, or applying a *post hoc* correlation to individual-level analysis based on an artificial estimate of Intra-class Correlation (ICC) coefficient (Varnell et al., 2001). We adopted the first remedial method and conducted analysis at an individual level since the overall difference between three communities are quite small on account of their strong similarities in either external environment or internal construction, and it is reasonable to neglect the group-level variance.[6] In this regard, the subgroup (e.g., diving communities into residential buildings) and external correction methods seem meaningless, and may also increase the inflated Type I error rates (Varnell et al., 2001). Therefore, the effectiveness of two interventions were evaluated at the level of residents by using multiple regression technique.

4.3. Examining the mediating effects of self-efficacy and personal norms

The effects of two initiatives on waste separation behavior, and psychological mechanisms involved, were first examined. Two dummy variables were constructed for identifying the scenario in which each participant was (0 = control group, 1 = economic incentive condition; 0 = control group, 1 = social influence condition). For examining the potentially mediating mechanisms pertaining to self-efficacy and personal norms, a four-step procedure developed by Baron and Kenny (1986)[7] was adopted. In each model, socio-demographic variables as well as waste separation performance at baseline were controlled. Furthermore, non-dichotomous variables were standardized before fitting for avoiding the potential bias from multicollinearity and making it easy to compare the relative impact of determinants with different measurement units. The *Robust* standard errors were also applied in each model for coping with a potential heteroskedasticity problem. Table 3 shows the fitted results.

As is clear in Model 1, both economic incentive and social influence could significantly boost waste separation behavior when controlling for multiple personal features. In terms of their effect size, financial inducement (β = .953) had a larger positive influence on individual performance than social influence (β = .650). In Model 2–4 aimed at testing the mediating effects of two psychological constructs, both two strategies were significantly positively related to participants' self-efficacy (see Model 2) and personal norms (see Model 3), consistent with several previous predictions but contrary to the theorizing on "crowding-out" effect of economic intervention. Besides, only self-efficacy was found to increase with behavioral demonstration, and two interventions could also positively affect the dependent variable while controlling for two potential mediators (see Model 4). According to the study by Baron and Kenny (1986), therefore, self-efficacy partially mediated the positive effects of both economic and social approaches, while the mediation of personal norms could not be validated here.

4.4. Examining the moderating effects of separation habit and socio-demographic factors

Since socio-demographic characteristics are also treated as moderators in investigating attitude-behavior relations (Ajzen and Fishbein, 1980; Xu et al., 2017), the overall effects and mechanisms involved in two initiatives may vary with different subpopulations. We applied interaction term technique that is widely used for testing moderation hypothesis in multiple linear regression (Wang et al., 2014) to detect the possible differences attributable to personal features. More specifically, 14 interaction terms were generated through multiplying 7 control variables (baseline behavior and 6 socio-demographic variables) with two treatment dummies separately and then incorporated into each model displayed in Table 3. Another 14 interaction terms were also produced

[6] In order to support this, we also conducted a random-intercept model by using full maximum likelihood method in which baseline behavior was the dependent variable, with personal characteristic factors measured at T1 entering into the fixed effect part. The result revealed that the ICC coefficient was very close to zero ($p > .1$), indicating a non-significantly systematical variance resulting from communities *per se*.

[7] Step 1: establish that the independent variable (IV) would significantly affect dependent variable (DV); step 2: show that IV would have a significant influence on the mediation (M); step 3: show that M would significantly influence DV while controlling for IV; step 4: there is a "partial mediation" case if the relationship between IV and DV in step 3 is significantly different from zero, otherwise, this is a "complete mediation" case. Especially, we expected partial instead of complete mediation for self-efficacy and personal norms since they are not the necessary steps in linking two interventions to waste separation behavior.

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Table 3
Multiple regressions for examining the mediating effects of self-efficacy and personal norms ($N = 188$).

	Model 1	2	3	4
	behavior T2	self-efficacy	personal norms	behavior T2
Behavior T1	.195**	.256***	.183**	.036
	(.077)	(.076)	(.071)	(.062)
Gender	.383***	.238	.134	.237**
	(.138)	(.145)	(.145)	(.110)
Age	.026	.06	−.082	−.005
	(.066)	(.080)	(.100)	(.066)
Years of residence	−.127*	−.188*	−.189*	−.007
	(.073)	(.102)	(.105)	(.080)
Income	−.014	.091	.018	−.068
	(.070)	(.079)	(.074)	(.060)
Household size	−.058	−.015	−.001	−.049
	(.061)	(.060)	(.068)	(.052)
Education level	−.102	−.133	−.054	−.021
	(.080)	(.091)	(.105)	(.063)
Self−Efficacy				.583***
				(.076)
Personal norms				.054
				(.056)
Economic incentive	.953***	.455*	.701**	.649***
	(.236)	(.271)	(.299)	(.219)
Social influence	.650***	.569**	.421*	.296*
	(.179)	(.232)	(.233)	(.170)
Constant	−.634***	−.435***	−.369**	−−.360***
	(.152)	(.163)	(.173)	(.131)
R^2	.217	.183	.099	.518

Notes: B-coefficients are listed on top and *Robust* standard errors are in parentheses below.
*** $p < .01$.
** $p < .05$.
* $p < .1$.

by multiplying control variables with two psychological constructs separately. They were included in the last model in Table 3 together with previous 14 terms. However, incorporating interaction terms into basic regression model might increase the risk of multicollinearity since interactions co-vary with independent variables. We thus calculated the value of each variable's variance inflation factor (*VIF*) in each newly generated model. The results revealed that the variable, 'years of residence', and its interaction with social influence dummy had the highest *VIF*s that were above 10, one of the common threshold values over which multicollinearity would pose a significant threat to regression estimates (Freund and Wilson, 1998; Grazhdani, 2016). Given that the duration of residence in local community was also a significant predictor of waste separation behavior (see Table 3), we instead deleted the interaction from each model and *VIF*s in the adjusted regressions were below 8. The final fitted results are showed in Table 4[8].

As indicated in the test results, two strategies could increase waste separation after controlling for interaction terms, while financial inducement worked better than social influence (see Model 5). Meanwhile, the partial mediation of self-efficacy was found again (see Model 6 and 8). However, the "crowding-in" effect of economic incentive on personal norms was not significant (see Model 7). In regard to socio-demographic factors, gender was found to moderate the intervention effects, and males tended to improve more compared with their female counterpart when exposed to either of two external influences. This could not be attributed to a variation in effect of efficacy- or norm-related belief since indirect paths of both strategies were not significantly moderated by gender (see Model 6 and 7). Residents with higher family income were found to be less susceptible to both strategies, which was due to a weaker link between self-efficacy and separation behavior. Especially, economic rewards also had a stronger monetary appeal (i.e. the direct path) for those from a poorer background (see Model 8). Residents with higher behavior baseline displayed higher confidence and achieved more performance when induced by economic rewards. Moreover, their personal norms were also strengthened, indicating that "crowding-in" effect of monetary rewards could occur for this population. In addition, monetary rewards could increase self-efficacy for people residing in local communities over a longer period. Age, education level and household size were not found to influence the effects and mechanisms of two approaches. These findings will be discussed in more detail below.

5. Discussion and conclusions

5.1. Overall effects of two initiatives

As one of few intervention-based studies from an environmental collectivism perspective, this study tested two strategies, namely, economic incentive and social influence, in terms of their effects at facilitating public participation in practices of household waste source-separation. It was found that both of them could promote residential waste separation behavior, whereas the former seemed more effective than the latter. The reason might be that the establishment and individual introjection of social norms cannot be accomplished immediately, and the advantages of social interaction and mobilization might be allowed to shine over a longer period. Therefore, both the economic and sociological/social psychological logics seem applicable to solve the free-rider problem and, hence, prompt individual effort to engage in separating their daily garbage, corroborating earlier research (e.g., Boonrod et al., 2015; Iyer and Kashyap, 2007; Mickael, 2014; Yau, 2010). More importantly, an economic instrument can work more

[8] For each model displayed in Table 4, we also ran a stepwise regression in which each interaction was entered at separate steps for further reducing the likelihood of bias from multicollinearity. Eventually, the *VIF*s in all sub-models dropped below 4 while the regression results were basically similar to those produced by simultaneously including interaction terms in the same step.

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Table 4
Multiple regressions for examining the moderating effects of separation habit and socio-demographic factors ($N = 188$).

	Model 5	6	7	8
	Behavior T2	Self-efficacy	Personal norms	Behavior T2
Behavior T1	0.008	0.059	0.006	−0.097
	(0.139)	(0.081)	(0.067)	(0.132)
Gender	1.294***	0.482**	−0.014	1.000***
	(0.434)	(0.242)	(0.232)	(0.333)
Age	−0.031	−0.087	−0.267*	0.159
	(0.266)	(0.198)	(0.156)	(0.290)
Years of residence	−0.284*	−0.234**	−0.164	−0.087
	(0.148)	(0.117)	(0.116)	(0.191)
Income	0.266	0.144	0.147	0.118
	(0.238)	(0.174)	(0.132)	(0.213)
Household size	0.022	0.013	0.033	0.078
	(0.222)	(0.117)	(0.117)	(0.230)
Education level	−0.290	−0.219	−0.104	−0.023
	(0.282)	(0.177)	(0.155)	(0.216)
Economic incentive (econ.)	2.509***	0.573*	0.381	2.002***
	(0.541)	(0.343)	(0.497)	(0.479)
Social influence (soc.)	1.744***	0.910***	0.321	0.905**
	(0.448)	(0.303)	(0.305)	(0.414)
Self-efficacy (se)				0.823***
				(0.226)
Personal norms (pn)				0.086
				(0.159)
Econ. x behavior T1	0.944**	0.525**	0.403*	0.496
	(0.424)	(0.237)	(0.224)	(0.315)
Econ. x gender	−1.467**	−0.243	0.460	−1.476***
	(0.715)	(0.437)	(0.507)	(0.546)
Econ. x years of residence	0.338	0.523*	0.291	0.103
	(0.483)	(0.298)	(0.393)	(0.494)
Econ. x income	−0.635**	−0.103	−0.244	−0.516**
	(0.296)	(0.212)	(0.223)	(0.249)
Soc. x gender	−0.979*	−0.379	0.195	−0.768*
	(0.524)	(0.318)	(0.320)	(0.408)
Soc. x income	−0.560*	−0.147	−0.177	−0.333
	(0.297)	(0.207)	(0.180)	(0.265)
Income x se				−0.240*
				(0.129)
Constant	−1.494***	−0.664***	−0.339	−0.869***
	(0.352)	(0.212)	(0.217)	(0.291)
R^2	0.298	0.240	0.157	0.585

Notes: B-coefficients are listed on top and *Robust* standard errors are in parentheses below.
In order to save space, interaction terms produced by multiplying control variables with treatment dummies and insignificant in all models are not displayed. In model 8, those produced by multiplying control variables with psychological constructs and insignificant are also omitted for the same reason.
*** $p < .01$.
** $p < .05$.
* $p < .1$.

efficiently at an early stage of promoting waste separation based on the findings of this approximately six-month study.

However, it is important to remember that cost accounting should be taken into account in the policy decision from a practical point of view. Although it is outside the scope of this article, we mention some important aspects for the sake of completion. For the direct economic cost, while recruitment of community volunteers is much cheaper than purchase of public service from private corporations (37.5 RMB/household month paid for "Huge"), the latter provides extra services such as solid waste transposition and disposal, which are not covered by social influence approach and can compensate a considerable share of official fiscal expenditure invested in garbage removal, landfill or incineration. Therefore, deciding which one is more cost-effective also depends on multiple macro factors (e.g., local waste production, population distribution, official capability of garbage disposal, and development of social organizations). On the other hand, it is suggested that monetary incentives probably have a negatively cross-situational spillover effect on other environmentally friendly actions not targeted by behavioral intervention due to inhibiting such generally pro-environmental dispositions as environmental self-identity and/or personal ecological norms (Truelove et al., 2014), indicating the necessary of quantifying and reconsidering this indirect and counterproductive impact. While it seems a complicated task, policy-makers need to account for this and evaluate the *net effect* before implementing an intervention.

5.2. Psychological mechanisms of external interventions

Perhaps the biggest contribution of this study is to examine the underlying factors that were presumed to explain how these external initiatives influenced individual separation performance. For economic incentive, the direct path, or price effect, was found as a main path to promote waste separation ($\beta = .649$; see Model 4). This is consistent with economic logic, which argues that increasing individual marginal payoff could effectively encourage contribution to public goods (Olson, 1965; Yau, 2010). It was also found that this "performance-based points" scheme could increase waste separation by enhancing individual self-efficacy, while the effect size of this indirect path was only up to .265 (=.455 × .583; see Model 2 and 4), which might be because this form of feedback was so implicit that would be easily neglected by actors, as well as being difficult for residents to perceive his or her effort to save the environment. As a result, participants tended to lack the

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self-confidence of their *personal influence* in improving environmental quality. Therefore, economic rewards should be accompanied by providing information that personal efforts are an indispensable part rather than "a drop in the sea" for further improving individual's confidence and disposition to engage in waste separation.

Interestingly, economic incentive was shown to not impair, but strengthen personal norms for waste separation, contrary to previous theorizing. As outlined by Frey and Jegen (2001), external intervention would crowd out intrinsic motivation when self-determination and self-esteem are undermined. Instead, they would crowd in intrinsic motivation if individuals perceive that it is *supportive* or gives them more freedom to act. In this regard, the economic enticement performed in our study in fact provided an extra option for people, rather than tried to deprive of their freedom or even force them to behave in a specific way. Furthermore, since this service provided by company usually occurred in the private space (stores or home), participants did not need to worry that their altruistic disposition to involve in waste separation would be misunderstood by others. Another explanation is provided by Lanzini and Thogersen (2014), who argue that the negative effects of monetary inducement may be exaggerated since individuals' attention might shift from extrinsic rewards to the goal of the pro-environmental behavior when they actually perform this behavior over an extended period. Nevertheless, these two propositions need to be empirically supported by future research.

Regarding social influence approach, it was found to promote waste separation directly or by increasing self-efficacy. The former can be understood as a function of outer social norms, which activated participants' inclination to follow the majority or to avoid the social pressure and potential condemnation from the public opinion. Meanwhile, the information dissemination and social modeling involved in this approach could also help elaborate how to perform and why their participation is important, increasing the knowledge and self-capacity to performing separation activities, as well as prompting the comparison process with a predefined social condition. In line with social cognitive theory, all of them are the important sources of self-efficacy (Bandura, 1986; Thøgersen and Grønhøj, 2010). It was also found that social influence enhanced personal norms, speaking to other research which demonstrates that outer social influence could be effectively introjected by actors and heighten their perception of moral obligation (e.g., Bertoldo and Castro, 2016). Despite of this, it is also an issue that the comparatively aggressive social injunctive norms constructed by block leaders might impair participants' sense of self-determination, or foster perceived controlled behavioral regulations (Huffman et al., 2014), and hence hinder the activation of personal norms. Therefore, psychologically empowering residents and nudging their voluntary actions by a more "Libertarian Paternalism" (Thaler et al., 2008) way may become a potential method to further elevate personal norms in applying social influence strategy.

Within mechanisms of both economic rewards and social mobilization, however, personal norms were insignificantly predictive of waste separation behavior, inconsistent with several previous findings (e.g., Bertoldo and Castro, 2016; Doherty and Webler, 2016; Thøgersen and Grønhøj, 2010; van der Werff et al., 2013). As proposed by Finkel and Muller (1998) and Finkel et al. (1989), an effective transformation from individuals' perceived duty of moral norms into actual participation in the provision of public goods strongly depends on the likelihood of *group success*. Put simply, people of high principles and believing in their responsibility might also act as "calculating Kantians". They would be more likely to contribute voluntarily when they realize that actions of the group as a whole could be successful. Otherwise, they would adhere to the strategy of non-cooperation. For participants in two experimental groups, they were not well informed that whether their seemingly negligibly collective efforts could really contribute to building the virtuous recycling economics and creating a better environment of the whole area. Moreover, some inappropriate actions such as mixing the separated trash again by local governments and companies in waste collection, removal or disposal process may also erode residents' confidence and heighten their uncertainty about the effectiveness of collective action in waste source-separation. As a result, they might underestimate the likelihood of group success and choose less efforts or even inactions irrespective of the extent to which they believe they should participate in waste separation. Therefore, the information feedback about how individuals' efforts can help achieve regional economic and environmental success is indeed an essential part for local promotions of waste source-separation activities.

5.3. Differentiated effects for specific audiences

The current research further investigated the scopes of intervention effects by examining the moderating effects of separation habit and many socio-demographic variables. Female participants were found to be less reactive to both rewards and social influence compared with their male counterpart, which is mainly due to the weaker direct intervention effects. In China and many other areas, women tend to take more responsibility in daily garbage disposal and recycling, thus usually displaying high waste separation performance. Consequently, the outer influences would produce less impact on their behavior. Economic incentive was found to be more attractive to participants with lower income level and make them more active in performing waste separation, in accordance with another survey of residents in Hangzhou (Xu et al., 2017). Besides, the more important role of self-efficacy in predicting waste behavior could also be used for explaining why those people were more susceptive to external influences. In addition, people with more active engagement in the past displayed stronger confidence when rewarded externally and then performed better in waste separation. At the same time, their intrinsic motivation was also "crowded-in". A possible reason is that they usually pay more attention to daily waste recycling, which might help accelerate the transformation process of motivation mentioned above. Taken together, males, those from a poorer economic background or with higher past experience can become the main entry points for initiating domestic waste separation in Hangzhou or even in east China.

5.4. Limitations and future directions

One of the main limitations is the self-reported measure for individual waste separation, which is problematic since it may lead to the measurement error resulting from the socially desirable responding in comparison with actual behavior. Hence, future research might benefit from replicating our study by virtue of observational data. Secondly, we only observed the relatively short-term effects of economic and social approaches, with little being known about their durability over a long-term time-span. Therefore, it is recommended that longitudinal experiments or tracking surveys are needed for uncovering the dynamic evolution of these intervention effects. Thirdly, self-efficacy and personal norms were examined as two potential mediators for exploring the mechanisms of outer influences, which can help delineate a stronger link between intervention-based and determinant-based research within the domain of household waste separation and recycling. However, there are still many underlying factors such as identity, perceived values of public goods, and perception of group success that are suggested as essential parts in predicting individual participation in collective actions and pro-

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environmental behavior (e.g., Abrahamse and Steg, 2013; Finkel et al., 1989; Varotto and Spagnolli, 2017). Therefore, these factors need to be further discussed by future studies to construct a systematical framework, for explaining how effective interventions should be designed to achieve successful collective actions within the realm of household waste separation and other environment protection actions.

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Author Contributions

This article was originally conceived and designed by Lin Xu and Maoliang Ling, with data collection managed by Yiling Wu. An initial draft was prepared by Lin Xu and Maoliang Ling, was later revised by all of the authors. All authors have read and approved the final manuscript.

Conflicts of Interest

None.

Appendix. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.wasman.2018.04.048.

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