Effect of Comparative Feedback on Consumers' Energy-Saving Behavior: A College Dormitory Example

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Abstract—Comparative feedback is a focus on existing research, while studies on the psychological mechanisms of its effect on consumers' energy-saving behavior remain lacking. This article considers that the social comparison orientation of feedback has a significant impact on consumers' energy-saving behavior and intention through a mediated moderation mechanism. A field experiment of 2 (comparison orientation: upward comparison, downward comparison) $\times 2$ (self-construal: independent self-construal, interdependent self-construal) between-subjects design with taking college student dormitories as the sample shows that consumers can experience higher psychological reactance when they receive energy consumption information through upward comparison than when they do so through downward comparison. The partly negative mediating role of psychological reactance is moderated by self-construal. In the context of independent self-construal, comparative feedback stimulates individual's psychological reactance to the intention to reduce energy-saving, while in the context of interdependent self-construal, it does not. This article has reference value for developing accurate feedback strategies for different types of energy consumers.

Index Terms—Comparative feedback, energy-saving behavior, psychological reactance, self-construal, upward comparison.

I. INTRODUCTION

F EEDBACK as one of consequence intervention measures (influencing one or more determinants after the occurrence of behavior) is more significant than antecedent intervention measures (influencing one or more determinants prior to the performance of behavior, e.g., commitment, goal setting, information, and modeling) in leading to the changes in consumer

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behavior and the achievement of energy-saving behavior [1]-[4]. Providing consumers with feedback on their energy consumption or energy-saving information influences their subsequent behavior through self-evaluation [2], [5]. The behaviors of others greatly affect our own [6]. Social comparison is an interpersonal influence factor that has an effect on consumer behavior [7]. Feedback (i.e., descriptive norm) intervention was found to significantly increase the frequency of participation and the total amount of recycled material from the baseline level [8]. In terms of energy-saving behavior, social comparative feedback (i.e., feedback information that is compared with others' information) can facilitate the reduction of consumers' energy consumption [5], [9]–[11]. The social comparison orientation indicates an upward (e.g., people compare themselves to other people that do better) or downward (e.g., people compare themselves to other people that do worse) comparison, which may not only produce a contrast effect [12] or an assimilation effect [13] on individual self-evaluation, but also produce two completely opposite effects simultaneously [14]. The upward comparison had overall effects on ability assessments and performance satisfaction, consistently showing contrast effect [15]. The unknown or novel dimensions exhibited greater contrast effect subsequent to comparison; for familiar attributes, the comparison had no influence on affections [15]. Thus, the possibility that the comparative feedback orientation has an assimilative effect (same direction as that of the comparative one) or a contrast effect (opposite direction to the comparative one) on individual self-evaluation should be analyzed. In fact, people are unfamiliar with their level of energy-saving behavior without providing comparative feedback information. So the present study aims to probe the impact of comparison orientation on energy-saving behaviors.

Understanding the influence mechanism of feedback can facilitate the development of intervention strategies [5], [9]. Feedback intervention theory [16] proposes that feedback influences behavior by establishing a connection between results and behavioral changes to gain insight into certain outcomes. Social comparison research focused on two issues: the choice of a comparison target (selection) and the effects of comparisons on self-evaluations, affection, and so forth (reaction) [15]. That is to say, self-evaluations and affection may be the mediator roles for the effect of comparison on behaviors. While comparative feedback is treated as potential freedom restrictions, discomfort from limited freedom can trigger negative emotions, such as consumer's psychological reactance [34], [37], [38]. The

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information processing model of psychological reactance holds that psychological reactance caused by adverse cognition and negative emotion leads to a high possibility of consumers' refusal and reduced willingness for participation [17]–[19]. Therefore, social comparative feedback may stimulate participants' psychological reactance and lead participants to ignore or belittle the information. Whether psychological reactance plays a mediating role in the process of influencing comparison orientation on consumers' energy-saving intentions should be explored.

The assimilation effect or contrast effect of social comparison depends on the orientation of social comparison and the specific social context in which social comparison occurs [20], [21]. Schultz et al. [22] argued that a descriptive normative message detailing average neighborhood usage produced either the (constructive) desirable energy savings or the (destructive) boomerang effect, and they pointed out that the normative messages have had mixed success in changing behavior in field contexts. Social behaviors may depend on the kind of self (private, public, collective) that operates in a particular culture (individualism/collectivism) [23]. Self-construal refers to how an individual views the relationship between himself and others [6]. Different types of self-construal embody different social distances between the self and others [24]. Self-construal can influence or determine an individual's cognition, emotion, and motivation, and independent (versus interdependent) selfconstrual is separate from social context (versus be connected with social context) in his ability to express himself (versus adjust) and sensitivity (versus insensitivity) to the context [6]. Thus, facing information feedback comparing oneself to others, whether different types of individuals' self-construal will lead to different psychological reactance and thereby lead to different energy-saving behaviors is worth studying. The main difference between this article and many other energy-saving behavior papers is that this article explores the mediating mechanism of psychological reactance and moderating mechanism of self-construal in the process of comparative feedback affecting energy-saving behavior from the perspectives of the information processing process and the perspective of individual psychological characteristics. This article focuses on the following questions.

- Does feedback with different orientations lead to different directions and degrees of consumers' energy-saving behaviors and behavioral intentions?
- 2) What is the mediating mechanism?
- Can self-construal serve as a moderating variable? What are the boundary effects? We conducted a field experiment to achieve our goals.

II. THEORETICAL BASIS AND RESEARCH HYPOTHESIS

A. Comparative Feedback Orientation and Energy-Saving Behavior

From the perspectives of evolution theory and prospect theory, people who ignore negative information are more likely to be threatened than people who ignore positive information. Negative information is an important signal indicating that "change is a must." Moreover, negative information can change people's behaviors and lead them to considerably adapt to the environment or avoid negative experiences [25]. From the perspective of social comparison theory, the people's ideas of "almost as good as the very good ones" [26] and the better-than-average effect (BTAE) will inspire "automatic tendency to assimilate positively evaluated social objects toward ideal trait conceptions" [27] that they will be able to assimilate themselves to a higher level. The effects of comparison intervention on energy conservation are heterogeneous: households in the highest decile of pretreatment consumption decrease energy usage more than households in the lowest decile [28], which indicates the assimilation effect of comparison orientation. That means there is a "boomerang effect" in energy studies, in which some individuals who learn that they outperform the norm will consume more energy [22], [29]. Chatelain et al. [30] noted that negative information has a negative direct effect on persistent proenvironmental behavior. Negative information is generated when individuals receive the upward feedback (e.g., compared with those who use less energy), thereby results in driving forces that change people's behavior and enhances their energy-saving behavioral intention. Individuals may have a strong sense of self-identity when they receive the downward feedback (e.g., compared with those who use more energy), and thereby have lower energy-saving behavioral intention, which presents the assimilation effect of comparison orientation. Considering that consumer behavioral intention is the basis of consumer behavior and can be used to predict consumer behavior [31], we introduce the following hypotheses:

- H1a: Compared with downward social comparison, upward social comparison leads to an individual's higher energy-saving behavior.
- H1b: Compared with downward social comparison, upward social comparison leads to an individual's higher energy-saving behavioral intention.

B. Mediation Mechanism of Psychological Reactance

The great conundrum of social comparison is why people choose to compare upward when the most likely result is a self-deflating contrast [15]. People presume they are good, but this coexists with "a congenital uncertainty" [32], so they look upward to confirm their closeness to the "better ones," which often leads, alas, to self-deflation [15], [33]. Psychological reactance is a motivational state directed toward reattaining the restricted freedom [34]. Psychological reactance theory assumes that people seek to rebuild their freedom when their perceived freedom is threatened. Therefore, people will choose to resist external decision-making and suggest a "counterproductive" act in response to the information of coercion. The psychological reactance information processing model argues that adverse cognition and negative emotion caused by psychological reactance will lead to a high possibility of refusal which, in turn, reduces consumers' willingness to participate [17]-[19], [35]. Psychological reactance has a negative impact on consumers' purchase intention of energy-saving products [36]. While comparative feedback be treated as potential freedom restrictions and discomfort from limited freedom can trigger negative emotions,

such as consumer's psychological reactance [34], [37], [38]. Dealing with upward feedback as the negative information, individuals' psychological reactance will be increased to reduce their energy-saving behavioral intention. When dealing with downward feedback, individuals will reduce psychological reactance under the self-identity motive, thereby increasing energy-saving behavioral intention. Thus, we formulate the following hypotheses:

- H2: Comparison orientation influences psychological reactance. That is, upward comparison provokes more psychological reactance than downward comparison does.
- H3: Psychological reactance negatively influences energysaving behavioral intention. Together with H_2 , we consider that psychological reactance plays a mediating role in the impact of comparative feedback on energy-saving behavioral intention.

C. Moderation Mechanism of Self-Construal

Self-construal is a key psychological construct that refers to individuals' culturally contingent thoughts, feelings, and actions that are concerned with one's understanding of the self as connected to others, especially to members of in-groups (interdependence) or distinct from others (independence) [6], Markus and Kitayama [6] classified self-construal into independent self-construal and interdependent self-construal. Arnocky et al. [40] proposed that people's environmental concern and behavior stem partly from self-construal, that is, the independent (versus interdependent) self-construal uniquely predicts egoistic environmental concern and competitiveness (versus cooperation) in sharing resources. Stapel and Koomen [41] argued that different levels of self-construal affect individuals' social information processing. When an individual's identity is activated, he will adopt a "heterogeneous" pattern of social information processing to seek differences between himself and others, in what is called the contrast effect. When social identity is activated, an individual will adopt a social information processing model of "seeking commonality or integrating" to make himself belong to a social unit, in what is called the assimilation effect. Compared with an interdependent self-construal individual, upward comparative feedback can activate an independent self-construal individual and have a stronger contrast effect, increasing psychological reactance and, thereby reducing energysaving behavioral intention. By contrast, downward comparison will allow individuals with independent self-construal to maintain their self-esteem and produce less psychological reactance. Upward comparison will allow the individuals with interdependent self-construal to narrow the gap with others and achieve the assimilation effect of self-improvement, thereby producing lower psychological reactance [42]. Hence, we formulated the following hypothesis:

H4: The mediating effect of psychological reactance on the relationship between comparison orientation and energy-saving behavioral intention is moderated by self-construal. That is, upward (versus downward) comparison will arouse more psychological reactance in the context of independent selfconstrual, thereby reducing energy-saving behavioral intention. By contrast, upward (versus downward) comparison will arouse less psychological reactance in the context of interdependent self-construal, thereby increasing energy-saving behavioral intention.

D. Conceptual Model

We propose a conceptual framework model that can be explained as follows in Fig. 1. Hypothesis 1a is excluded in Fig. 1 because it wants to test the main effect of comparison orientation on energy-saving behavior by field experiment, not to test the mediator of psychological reactance and the moderator of self-construal. Consumer behavioral intention is the basis of consumer behavior and can be used to predict consumer behavior [31]. Thus, energy-saving behavioral intention is adopted as a dependent variable in Fig. 1. The impact paths of comparative feedback on energy-saving behavioral intention include one direct path (H1b) and one indirect path, including the mediating role of psychological reactance (H2, H3). In addition, the mediator of psychological reactance is moderated by self-construal (H4).

III. METHODS AND RESULT ANALYSIS

A. First Phase: The Dynamic Influence of Comparative Feedback on Energy-Saving Behavior

This article designed a two-phase field experiment to study the impact of comparative feedback on consumers' energysaving behavior. The first phase of the field experiment has two purposes. First, the pretest experiment was to investigate the similarities of participants' energy consumption behavior and intention before field experiments to exclude the influence of participants' other factors. Second, the pretest experiment aimed to identify the dynamic impact of comparative feedback on the electricity consumption in the dormitories for six consecutive weeks to mainly verify the hypothesis 1a.

1) Experimental Design: In this experiment, college students with similar personal characteristics were selected as participants to control the objective characteristic variables and other variables. The pretest experiment and the six weeks dynamic field experiment were designed to verify the impact of comparative feedback orientation (upward versus downward) on consumers' energy-saving behavior.

We selected the college dormitories in northern China for field experiments because we consider that electricity is dominant in energy consumption in college students' dormitories, and collective feedback can be applied to households or groups without requiring individuals' own electricity meters [5]. When we selected sampling design to divide recruited dormitories into two groups (downward comparison and upward comparison), judgment sampling and systematic sampling were used to make adjacent dormitories in the same building or one floor being divided into the same group as far as possible to reduce the interaction influence between dormitories of different intervention measures. In order to test the effect of grouping, we conducted



Fig. 1. Conceptual framework model.

a questionnaire survey and power consumption survey before the experiment. Using independent sample t-tests, we found that there were no significant differences in power consumption, power-saving behavior, and power-saving intention between the two groups (see Table I for details). We selected the students in charge of the dormitory as experimental participants from each of the dormitory samples (eight students per dormitory), who should fill in the questionnaires and receive dormitory electricity consumption feedback information from the experimenters through the widely used mobile social platform software of WeChat (which is the social media tool owning over 1 billion monthly active users). We considered that the dormitory administrator exerts some influence on the dormitory's collective behavior [5], [43]. The pretest experiment was designed to ensure that the participants have similar energy consumption behavior and energy-saving behavioral intention before the trial experiment to control other factors affecting energy-saving behavior and divide participants into individuals with independent self-construal and interdependent self-construal.

Because the main energy type consumed by college students is electricity, the measurement scale of energy consumption behavior was adapted from the energy-saving behavior measurement scale (seven-point Likert scale) developed by János [44], which mainly tests the electricity consumption behavior of undergraduate students. This scale includes four measurement questions. The energy-saving behavioral intention of the participants involved two methods to verify and improve the validity of the measurement. The first method was based on the research results of Taylor and Todd [45] and János [44], in which a habitual energy-saving behavioral intention measurement scale (seven-point Likert scale) was developed. This scale includes three items. The second method is to directly investigate the participants' behavioral intentions: How much do you plan to reduce your dormitory's electricity consumption next month? The self-construal scale was adopted from the scale developed by Singelis [46] and Zampetakis et al. [47] to measure individual idiosyncratic self-construal levels. The self-construal scale contained 24 items. The median in the mean value of the independent self-construal dimension subtracting from the mean value of the interdependent self-construal dimension, which was taken as the standard to divide into two types of self-construals; specifically, the one larger than the median was independent construal, and the one smaller than the median was interdependent construal.

Measurement scales of the variables in protest are shown in part A of appendix.

After the pretest, a continuous six-week dynamic field experiment was performed. In this experiment, first, the weekly electricity consumption amount (from every Sunday to Saturday) of every participant's dormitory was collected from the service department of the school that owns the dormitory electricity every Sunday; second, manipulated social comparative feedback information was sent to the every participating dormitory leader every Sunday by the social medium tool of WeChat. The experiment adopted a 2 (social comparison orientation: upward comparison, downward comparison) \times 2 (self-construal: independent selfconstrual, interdependent self-construal) between-subjects design, and the participants' next-door dormitories were chosen as the comparative reference objects in the feedback information, because the greater the similarity is, the greater the influence on the participants [5]. In the feedback content, the quantity of electricity used per week was the actual electricity consumption data of the participant's dormitory, while the level of comparison was the control content. In this article, the quantity of electricity used by the participant's dormitory was set to 5% more/less than that of the next-door dormitory.

In particular, the comparative feedback content of the upward/downward comparison is as follows: Electricity consumption quantity in your dormitory was [**] KWh last week, which was 5% more/less than that of your next-door dormitory." The experimental materials are shown in part B of appendix. The medium chosen to provide feedback information was the commonly used social medium WeChat, and the receiver of the feedback information was the leader of the experimental dorm, who had certain authority and influence in the dorm and could affect the behavior of his or her roommates after accessing the comparative power consumption information [5], [43]. Manipulation checks were carried out weekly to determine whether the dorm leader passed on the information to the actual participants through the random investigation of one of the other seven roommates by a measurement scale including the question, "Does your dorm leader tell you energy consumption feedback information? (Yes or no)."

We recruited 88 college dormitory leaders in a university in northern China as participants. Each of the chosen college dormitories has eight students living together in a large room. The experimental dormitories were divided into four groups: group
 TABLE I

 Egnery-Saving Behavior and Energy-Saving Behavioral Intention of Two Groups of Participants Before the Experiment 1

Measurement variable	Group type	Number of subjects (N)	Mean (M)	Standard deviation (SD)	Statistics (t)	Significance (p)	Lower limit of 95% confidence interval (<i>LLCI</i>)	Upper limit of the 95% confidence interval <i>(ULCI</i>)
Week 01*	Upward comparison	38	21.262	7.974	0.316	0.753	-4 427	6 092
	Downward comparison	35	20.430	13.983	0.010			
Week 02*	Upward comparison	38	27.097	10.009	0.025	0.080	6 501	6 428
Week 02	Downward comparison	35	27.178	17.219	-0.025	0.980	-0.391	0.428
W 1.02*	Upward comparison	38	29.156	13.504	1 120	0 808	0.721	7 (74
week 05*	Downward comparison	35	29.684	21.103	-1.128	0.898	-8.751	7.074
W1-04*	Upward comparison	38	25.842	10.374	0.251	0.504	2.945	7 746
week 04*	Downward comparison	35	23.891	14.294	0.351	0.304	-3.843	/./40
Energy-saving	Upward comparison	38	5.441	1.244	0.470	0.(22	0.749	0.459
behavior	Downward comparison	35	5.586	1.340	-0.479	0.633	-0.748	0.458
Energy-saving behavioral	Upward comparison	38	5.763	1.090				
intention 1 (Likert scale method)	Downward comparison	35	5.943	1.071	-0.710	0.480	-0.685	0.325
Energy-saving behavioral	Upward comparison	32	6.775	4.436				
intention 2 (energy- saving %) **	Downward comparison	30	7.850	-0.676		0.502	-4.256	2.106

Note. * Week 01 to week 04 means the average weekly electricity consumption of participants' dormitories in different groups before the experiment. ** This measurement scale of energy-saving behavioral intention (e.g., how much do you plan to reduce your electricity consumption next month compared to this month?) is an open-ended response question. For this question 11, questionnaires were not completed, so they were excluded from the calculation.

A (upward comparison, independent self-construal), group B (upward comparison, interdependent self-construal), group C (downward comparison, interdependent self-construal), and group D (downward comparison, interdependent self-construal). The experiment was conducted with each group simultaneously without disturbing the others. Weekly feedback on electricity consumption was provided to the dormitory leaders of groups A and B, the upward comparison groups, and groups C and D, the downward comparison groups. The experiment lasted for 6 weeks, from April 2 to May 13, 2017. After evaluation and assessment, we eliminated six questionnaires that were incomplete and had insufficient validity and finally obtained 82 valid questionnaires. To remain consistent with the effective samples in the field experiment, we further eliminated the singular values of excessive electricity consumption and obtained valid information for 73 dormitories. Groups A, B, C, and D had 20, 18, 17, and 18 valid questionnaires, respectively. By considering the similarities of the participants to control the impact of demographic variables on the experimental results as much as possible, this experiment mainly selected male dormitories, with 68 male and 5 female dormitories.

2) Results and Analysis: First, we analyzed the results of the pretest study. In terms of reliability, the Cronbach's α coefficient and combination reliability (CR) of the energy-saving behavioral intention scale used in this article were 0.805 and 0.825, respectively, while the Cronbach's α coefficient and CR of the energy-saving behavior scale were 0.652 and 0.666, respectively. Thus, the reliability of measurement scales for the two variables reached an acceptable level [48]. We considered the mean of every item of each variable as its value [36], [49].

The measurement results of the pretest (see Table I) showed that no significant difference was observed between the two experimental groups in terms of the energy-saving behavior and energy-saving behavioral intention before the experiment ($p_{\text{behavior}} = 0.633$, $p_{\text{behavioral intention 1}} = 0.480$, $p_{\text{behavioral intention 2}} = 0.502$). No significant difference was observed in the weekly electricity consumption in the prestudy period ($p_{\text{week 01}} = 0.753$, $p_{\text{week 02}} = 0.980$, $p_{\text{week 03}} = 0.212$, $p_{\text{week 04}} = 0.504$). Meanwhile, no significant difference was observed between the independent and interdependent selfconstrual groups. These results indicate that the participants had high similarity before the experiment ($p_{\text{behavior}} = 0.377$, $p_{\text{behavioral intention 1}} = 0.092, p_{\text{behavioral intention 2}} = 0.433),$ thereby providing a good experimental environment for controlling the upward and downward feedback information. The successful results of manipulation checks showed that the participants received energy consumption feedback.

The sample sizes of the upward comparison and downward comparison groups were 38 and 35 dormitories, respectively. Fig. 2 shows the average weekly electricity consumption and their rate of change (the change rate of this week relative to the last week's electricity consumption) for the two groups from the first week to the sixth week of the experiment.

From the perspective of the average quantity of electricity consumed weekly by the participants' dormitories (see Fig. 2), based on the inertia that the power consumption of the upward comparison group is higher than that of the downward



Fig. 2. Relationship between the social comparison orientations of feedback and dormitories' electricity consumption and its change rate.

comparison group, the average amount of electricity consumed by the upward comparison group is higher than consumed by the downward comparison group from the first week to the third week in experiment 1 (the electricity consumption in week 04 of prestudy period showing: M Upward = 25.842, M Downward = 23.891, p = 0.504). The results of the independent sample t-test during the comparison period showed a significant difference between the two groups in electricity consumption (pweek 1) = 0.059, pweek 2 = 0.093, pweek 3 = 0.030). From the fourth week to the fifth week, the electricity consumption of the upward comparison group began to be lower than that of the downward comparison group, but the independent sample t-test showed no significant difference between the two groups (pweek 4 =0.576, pweek 5 = 0.485). In the sixth week, the gap between the electricity consumption of the upward comparison group and that of the downward comparison group began to widen, and the independent sample t-test showed the marginally significant difference between the two groups (pweek 6 = 0.065). From the second week to the sixth week, the electricity consumption growth rate of the upward comparison group was slightly lower than that of the downward comparison group in all but the third week. From the perspective of change in electricity consumption during 6 weeks' intervention period, there was a significant difference between the two groups at weeks 4 and 6 (p week 2 =0.737, pweek 3 = 0.314, p week 4 = 0.034, p week 5 = 0.799, pweek 6 = 0.009). This result further proves that the upward feedback is more conducive to energy saving than the downward feedback. During the 6 weeks of intervention, the average growth rate of electricity consumption for the upward comparison group was 4.94% lower than that for the downward comparison one, especially in the last three weeks of the experimental period, the average weekly power consumption of the upward comparison group is 10.508% less than that of the downward comparison group. This result implies that we can use upward comparative feedback intervention tools to guide people to conserve energy.

After 6 weeks of intervention, the data of the electricity consumption in the experimental two groups were collected from May 14 to June 17 for five consecutive weeks. The independent sample t-test showed that within five weeks after the intervention strategy was stopped, the average electricity consumption of the upward comparison group was slightly higher than that of the downward comparison group. However, no significant difference was observed in the weekly electricity consumption $(p_{\text{week }7} = 0.419; p_{\text{week }8} = 0.172; p_{\text{week }9} = 0.557; p_{\text{week }10}$ $= 0.117; M_{\text{Upward week } 11} = 66.530, M_{\text{Downward week } 11} =$ 60.941, $p_{\text{week }11} = 0.436$). The correlation coefficient between the average weekly temperature of the experiment site and the average weekly electricity consumption of the dormitory within 15 weeks is 0.460 (p = 0.000). Thus, the average weekly power consumption of the two groups' dormitories increased from 23.638 kWh in experiment period to 60.433 kWh in the post-experiment period as the temperature increased. This finding indicates that the electricity consumption of the upward comparison group rebounded 5 weeks after the intervention stopped. Chatelain et al. [30] pointed out that negative affection reduced the likelihood of showing subsequent similar behaviors as compared to positive affection. This finding means that the feedback intervention was effective in the intervention period and its effect disappeared after the intervention stopped.

The experimental results verified H1a that the orientation of social comparative feedback had a significant impact on the actual energy-saving behavior of consumers. However, two questions still need to be addressed: 1) Is there a mediation mechanism in the impact of comparison orientation on consumers' energy-saving behavior? 2) What factor can moderate the mediation effect? In the second phase of the experiment, these two questions were explored through scale measurement.

B. Second Phase: Mediated Moderation Mechanism

1) Research Design: The second phase of the experiment mainly tested H1b–H4. One month after the first phase of the experiment, the participants were asked to fill in the measurement scales of the variables of psychological reactance and energy-saving behavioral intention. The scale of psychological reactance was adapted from previous studies [36], [50] and consisted of seven items, including two dimensions of compulsive feelings and manipulating intention deduction, which used the seven-point Likert consent scale. The scale of energy-saving behavior intention adapted from the research results of János [44] consisted of three items. The measurement scales of the two variables are shown in part C of appendix.

2) Results and Analysis: In terms of reliability, Cronbach's α and CR of psychological reactance were 0.839 and 0.727, respectively, and Cronbach's α and CR of energy-saving behavioral intention were 0.855 and 0.856, respectively. Therefore, the reliabilities of the measurement scales for the two variables reached an acceptable level [48]. We took the average score of each variable as the value of the corresponding variable [36], [49].

a) Influence of comparative feedback on energy-saving behavioral intention: A double factor variance analysis was performed to check the main effect and interaction effect of the comparison orientation and self-construal on energy-saving



Fig. 3. Effect of social comparison orientation and self-construal on psychological reactance.

behavioral intention. The results demonstrated that the main effect of comparison orientation on energy-saving behavioral intention was significant [F(1, 69) = 25.572, p = 0.000], the main effect of self-construal was not significant [F(1, 69) = 0.007, p = 0.933], and the interaction effect of comparison orientation and self-construal was not significant [F(1, 69) = 1.087, p = 0.301]. The independent sample *t*-test results showed that the energy-saving behavioral intention caused by the upward social comparative feedback was higher than caused by the downward social comparative feedback ($M_{\text{Upward}} = 5.561$, $M_{\text{Downward}} = 4.352$, p = 0.000). Therefore, the orientation of social comparative feedback has a discernable effect on energy-saving behavioral intention, particularly upward comparison, which causes higher energy-saving behavioral intention than does the downward comparison. Thus, H1b is verified.

b) Influence of comparative feedback and self-construal on psychological reactance: The Double Factort ANOVA revealed that the main effects of comparison orientation [F(1, 69) =5.503, p = 0.024] and self-construal [F (1, 69) = 4.709, p =0.033] were significant, while their interaction effect was also significant [F(1, 69) = 9.885, p = 0.002]. The independent sample *t*-test results showed that the psychological reactance level affected by upward comparison was higher than that affected by downward comparison ($M_{\text{Upward}} = 4.128, M_{\text{Downward}} =$ 3.555, p = 0.029). The results of the simple effect test by the Monovariant analysis method demonstrated that a significant main effect of social comparison orientation occurred only in the context of independent self-construal (p = 0.000). That is, in the context of independent self-construal, upward comparison induces higher psychological reactance than downward comparison does, while in the interdependent self-construal situation, the main effect of social comparison orientation is not significant (p = 0.566). Fig. 3 shows that participants with independent self-construal under the context of upward comparison produced the highest psychological reactance (M Independent-upward = 4.721), whereas participants with independent self-construal under the context of upward comparison produced the lowest psychological reactance (M Interdependent-upward = 3.437). Therefore, H2 and part of H4 are verified.

TABLE II MODERATION EFFECT OF SELF-CONSTRUAL ON THE MEDIATION EFFECT OF PSYCHOLOGICAL REACTANCE

					G		95% confidence interval CI				
Mediation variable	Category	Self- construal	Effect size	error (SE)	Statistic s T	Significant	Lower	Upper limit			
					51	P	limit of CI	of CI			
							(LLCI)	(ULCI)			
	Direct	Direct		0.102	6 200	0.000	1.504	0.020			
	effect		-1.211	0.192	-0.309	0.000	-1.394	-0.828			
Psychological		Independent	0.415	0.170*		1 1 0	0.111*	0 70 4*			
reactance	Mediation	type	0.415	0.1/2*	_	excluding 0	0.111*	0.784*			
	effect	Interdependent	0.064	0.002*		. 1 1 0	0.055*	0.120*			
		type	-0.064	0.093*	-	including 0	-0.255*	0.130*			

Note: Feedback (upward and downward coded as 0 and 1, respectively), self-construal (independent type and interdependent type coded as 0 and 1 respectively), and psychological reactance and energy-saving behavioral intention were standardized data; * denotes "Boot."



Fig. 4. Mediation effect of psychological reactance. Note: *** and ** indicate significance at <0.01 and <0.05, respectively; upward and downward feedback coded as 0 and 1, respectively; psychological reactance and energy-saving behavioral intention were standardized data.

c) Mediation effect test: The results of regression analysis showed that the negative impact of psychological reactance on energy-saving behavioral intention was marginally significant [F(1, 69) = 3.199, p = 0.078], and the standardized regression coefficient was -0.208 (t = -1.788, p = 0.078). Thus, the first half of H3 is effectively supported. The mediation effect of psychological reactance was tested by the mediation effect analysis program proposed by Zhao et al. [51] and the bootstrap method proposed by Preacher et al. [52] and Hayes [53]. Consequently, model 4 was selected with a sample size of 5000. The indirect effect of the independent variable on the dependent variable and its standard deviation were estimated using a bias-corrected bootstrap method with a 95% confidence interval [52]. Fig. 4 shows that the indirect effect of comparative feedback on energy-saving behavioral intention mediated by psychological reactance was significant (95% CI: LLCI = 0.019, ULCI = 0.407, excluding 0), with an effect size of 0.185. The negative effect of comparative feedback on psychological reactance was significant (95% CI: LLCI = -0.964, ULCI = -0.054, excluding 0), with an effect size of -0.509. In addition, the negative effect of psychological reactance on energy-saving behavioral intention was significant (95% CI: LLCI = -0.556, ULCI = -0.171, excluding 0), with an effect size of -0.364. The direct effect of comparative feedback on energy-saving behavioral intention was significant (95% CI: LLCI = -1.594, ULCI = -0.828, excluding 0), with an effect size of -1.211. Thus, H3 was verified.

d) Moderation role of self-construal on mediation effect: The bootstrap method for the mediated moderation effect was adopted with model 7 and a sample size of 5000. The indirect effect of the independent variable on the dependent variable and its standard deviation were estimated through a bias-corrected bootstrap method with a 95% confidence interval [52]. Table II demonstrates the moderation effects of self-construal on the individual mediation effects of psychological reactance. The mediation effect of psychological reactance in the context of independent self-construal was significant (95% CI: LLCI = 0.111, ULCI = 0.784, excluding 0), with an effect size of 0.415. In the interdependent self-construal situation, the mediation effect of psychological reactance was not significant (95% CI: LLCI = -0.255, ULCI = 0.130, containing 0), with an effect size of -0.064. This shows that the upward feedback made individuals with independent self-construal experience a certain psychological reactance to reduce their energy-saving behavioral intention.

The direct effect of the independent variable of comparative feedback on energy-saving behavioral intention was also significant by controlling psychological reactance (95% CI: LLCI = -1.594, ULCI = -0.828, excluding 0), with an effect size of -1.211. Hence, psychological reactance plays the partial mediating role in the influence of comparative feedback on energy-saving behavioral intention. Therefore, the partial mediation effect of psychological reactance in the influence of comparative feedback on energy-saving behavioral intention. Therefore, the partial mediation effect of psychological reactance in the influence of comparative feedback on energy-saving behavioral intention is moderated by self-construal. Thus, H4 is verified.

IV. DISCUSSION

The effect of comparative feedback on energy-saving behavior is increasingly valued by theorists, the government, and the business community, yet research on the conduction mechanism from comparative feedback to energy-saving behavior and its effect boundary needs to be improved [5], [9]. This article reveals that social comparative feedback has a significant impact on energy-saving behavior and intention, and proposes its influence path model and relevant moderation variable, thus enriching and improving the existing research results.

First, this research explores the effect of social comparative feedback orientations (upward comparison versus downward comparison) on consumers' energy-saving behavior and energy-saving behavioral intention. When upward (versus downward) comparative feedback was presented to the consumers, they had a higher energy-saving behavioral intention and energy-saving behavior. Other studies consider that some individuals who learn that they outperform the norm will consume more energy [22], [29]. Positive information has a negative direct effect on persistent proenvironmental behavior [30]. This article shows that in the field of energy-saving, the orientation of social comparative feedback has a significant direct assimilative impact on energy-saving behavioral intention and energy-saving behavior.

Second, this article reveals the influencing mechanism of the orientation of social comparative feedback on the consumers' energy-saving behavioral intention. When upward (versus downward) comparative feedback is presented as negative information to consumers, the consumers will experience higher psychological reactance, and the higher psychological reactance will reduce the consumers' energy-saving behavioral intention. Previous studies have noted that manipulative advertising, unavailable products, and government regulations are regarded as potential freedom restrictions [38]. As one of the manipulated advertising situations, social comparative feedback limits the freedom for people to choose, and this uncomfortable feeling of limited freedom will lead to negative emotions, such as psychological reactance [37]. In addition, psychological reactance negatively influences energy-saving behavioral intention [36]. Psychological reactance plays a partial mediating role, while social comparative feedback orientation still has a significant direct effect on energy-saving behavior.

Last, this article reveals that the mediator of psychological reactance is moderated by self-construal. Social behaviors may depend on the kind of self (private, public, collective) that operates in the particular culture [23]. One's environmental concern and behaviors stem partly from self-construal [40]. This article indicates that in the independent self-construal situation, the partial mediating effect of psychological reactance is significant, as upward comparison produces higher psychological reactance than does the downward comparison, thereby reducing energy-saving behavioral intention, while conversely, in the interdependent self-construal situation, the effect is not significant. Li et al. [19] confirmed that psychological reactance is a moderated mediator. In the previous studies, social demographic characteristics are considered as moderation variables influencing behavioral intention [54]-[56]. Independent self-construal moderates the relationships between attitudes and entrepreneurial intentions; participants primed with an independent self-construal had more favorable entrepreneurial attitudes but not intentions than participants primed with an interdependent focus [47]. This article reveals the boundary of self-construal as an individual psychological characteristic that acts as a moderator in the influence mechanism of comparative orientation on energy-saving behavioral intention. This means

that upward comparative feedback improves the psychological reactance of individuals with independent self-construal and, thus, reduces their energy-saving behavioral intention, while individuals with interdependent self-construal do not experience psychological reactance to comparative feedback.

V. CONCLUSION AND MANAGEMENT IMPLICATIONS

A. Conclusion

The direct effects of comparative feedback on energy-saving behavior and intention were significant. Thus, upward comparison can arouse a stronger energy-saving behavioral intention than downward comparison. That means negative information can change people's behaviors and lead them to considerably adapt to the environment or avoid negative experiences [25].

Psychological reactance played a partial mediating role in the impact of comparative feedback information on energy-saving behavioral intention. Compared with downward social comparison, upward comparison information feedback produced higher psychological reactance. In addition, psychological reactance negatively influenced behavioral intention. It means that in the field of energy-saving, psychological reactance played a negative mediating role in the impact of information intervention on energy-saving behavior [17]–[19], [35].

Self-construal moderated the mediating effect of psychological reactance. That is, in the context of independent selfconstrual, compared with downward comparative feedback, upward comparative feedback can lead to higher psychological reactance so as to reduce energy-saving behavioral intention. In contrast, in the interdependent self-construal situation, the partly mediating effect of psychological reactance was not significant. This shows that upward comparative feedback improved the psychological reactance of individual with independent selfconstrual and, thus, reduced his energy-saving behavioral intention [42].

B. Management Implications

The government vigorously conducts actions such as the creation of energy-saving institutions, green homes, green schools, green communities, and green travel to induce consumers' energy conservation and promote green development in China [57]. The government can implement the study results to promote the construction of green schools to advance the green development in China. First, the government may require energy supply enterprises or organizations to provide consumers' feedback on their energy consumption information through upward social comparison with others to guide the consumers to achieve energy-saving behavior. Compared with downward social comparative feedback, upward social comparative feedback can promote more energy-saving behavioral intention and energy-saving behavior.

Second, the government should consider reducing consumers' psychological reactance when providing feedback on comparative energy consumption. Upward comparative feedback requires the authority of the government to reduce consumers' psychological reactance and improve their energy-saving behavioral intention. Finally, customized feedback strategies for different consumers are more effective in energy saving than general feedback strategies [54], [55], [58]. This article confirms that for consumers with independent self-construal, the upward comparison will stimulate significant psychological reactance, but this is not the case for consumers with interdependent self-construal. Therefore, we should adopt soft upward comparative feedback for consumers with independent self-construal to reduce their psychological reactance.

C. Research Limitations and Future Research Prospects

First, the feedback intervention is effective in the intervention period, but the effect disappears after the intervention stops. This may be because the intervention was only 6 weeks long, and the duration is too short to form energy-saving habits. Therefore, lengthening the study time limit and further measuring the effect during and after intervention are necessary.

Second, this article reveals the mediating effect of psychological reactance in the process of social comparative feedback influencing energy-saving behavioral intention. Moreover, it verifies the moderating effect of self-construal on the mediator of psychological reactance. The other benefits or the BTAE may come along with the self-deflating comparisons [15]. To further explore the psychological mechanism of the effect of comparative feedback on energy-saving behavioral intention, other potential mediation variables must be assessed, such as motivation, emotion, behavioral attitude, and subjective norms. Other possible moderators must be explored including energy usage, income, and other objective characteristics of consumers, as well as self-esteem, visual focus, and other subjective variables.

Finally, for the college students' dormitory, the experiment was conducted by field experiment and scale measurement. The current research used the actual power usage to measure energy-saving behavior and the "self-reporting" method to measure energy-saving behavioral intention. Hence, the real energysaving behaviors of the subjects were not directly observed. The sample size can also be expanded if resources allow. In this article, comparative feedback was provided to the dormitory leaders who might influence the energy-saving behavior of all members of the dormitory, which involves the impact of group norms, so subsequent studies could further control other variables to increase the research validity. And the samples of other citizens such as people in households, work settings, and office context should be selected into energy-saving behavior field studies in the future to expand research external validity.

APPENDIX EXPERIMENTAL MATERIALS

Part A: Pretest Questionnaire

Questionnaire number: Pretest questionnaire of college students' electricity usage Dear Fellow Students:

Hello, we are college students from the School of Management of *** University, and we are currently conducting a study on the daily consumption behavior of college students. We would like to know your electrical consumption behavior in the dormitory. The results are only used for scientific research, and we will not disclose the personal information you provide. Please feel free to fill in this questionnaire. Thank you for your support and cooperation.

A. Please select a rating in the scale according to your previous electricity usage. 1 denotes "never" and 7 signifies "always." The level is gradually increased from 1 to 7 for a given frequency behavior.

ltem		/er		Always			
		2	3	4	5	6	7
EB1 In the past two months, how often do you turn off the lights when you leave your dormitory for more than half an hour? (Assume that no roommates are in.)							
EB2 In the past two months, how many times did you turn your computer off when not using it?							
EB3 In the past two months, how many times did you turn off the light when you leave the dorm? (Assume that no roommates are in.)							
EB4 In the past two months, how many times did you have to turn your computer off when you are not expected to use it within three hours?							

I Energy-saving intention measurement

ESI What's your plan on next month's decreased percentage of electric consumption from this month's usage: ______%

I2 The following statements are about energy-saving behavioral intention, ranked from 1 to 7 with respective responses indicating "strongly disagree" to "strongly agree." Please tick the box according to your level of agreement with the statement.

Item		ngly	disag	ree	Strongly agree			
		2	3	4	5	6	7	
ESI1 If I had never noticed the daily energy saving before, I would like to start now to								
change the my daily habits for energy saving.								
ESI 2 If I had taken energy-saving measures before, I am willing to pay more attention to								
such details in my daily life.								
ESI 3 I am willing to reduce comfort for energy saving.								
ESI 4 I don't want to change my daily habits for energy saving.								

J The following statements are about social interaction, ranked from 1 to 7 with respective responses indicating "strongly disagree" to "strongly agree." Please tick the box according to your level of agreement with the statement.

Item		Strongly disagree Strongly agree								
	1	2	3	4	5	6	7			
SC1 I respect the authority figures I associate with.										
SC 2 Rather than being misunderstood, I would like to express my mind directly.										
SC 3 The joy of the people around me is my joy.										
SC 4 I will offer my seat to my teacher when I take the bus.										
SC 5 I respect those who are modest.										
SC 6 I feel comfortable when I am praised and awarded separately.										
SC 7 I have been consistent in school and at home.										
SC 8 I am willing to sacrifice my own interests for the benefit of the collective.										
SC 9 I often feel that maintaining good relationships is more important than my own achievements.										
SC10 When I meet people I have known only recently, I naturally call them by their										
names, even though they are much older than me.										
SC11 I think health is the most important priority.										
SC12 The collective decision is of utmost importance for me.										
SC13 If my group needs me, I'll stay despite being unhappy.										
SC14 Even if I disagree with the group members, I will avoid arguments.										
SC15 For me, it is important to maintain good rapport with others.										
SC16 Speaking in class is no problem for me.										
SC17 For me, it is very important to maintain an active imagination.										
SC18 For me, my main concern is to take care of myself.										
SC19 No matter who I am with, my performance is consistent.										
SC20 If my friend encounter setbacks, I feel I have a duty to help him.										
SC21 I like to be straightforward with people I just met.										
SC22 I enjoy being different in many ways.										
SC23 It is very important for me to be independent.										
SC24 When making educational plans, I should consider my parents' advice.										

K Personal information s	ection			
K1 Gender: Male / Femal	le.			
K2 Age:				
K3 Grade level: Grade 1	Grade 2	Grade 3	Grade 4	Grad-
uate students				
K4 Major:				
K5 WeChat number:				
K6 Dormitory:				
K7 Average consumption	level per	month		
\Box Less than ¥1000	□¥1001	-¥1500	□¥1501-	-¥2000
\Box More than ¥2000				

Part B: Intervention Content of Comparative Electricity Consumption Information Feedback (Downward vs. Upward)

- Dear student, your electricity consumption this week is degree, using ¥_____, which is 5% more than the other dormitory. This power can light a lamp in the dorm for days. (Upward comparison in controlled group)
- Dear student, your electricity consumption this week is degree, using ¥_____, which is 5% less than the other dormitory. This power can light a lamp in the dorm for _____ days. (Downward comparison in controlled group)

Note: Bittle, Valesano, & Thaler (1979) conducted an experiment and determined that the feedback group consumed 4% less electricity than the control group. Graffeo *et al.* (2015) set the goal of saving energy to 10% of the subjects in his experiment. In our pretest experiment, approximately 40% of our participants answered 5% (ranking first) when asked about the planned power-saving the following month. Thus, 5% energy saving was feasible and universal in most participants' cognition, and 5% energy saving also ruled out defensive negative evaluation produced by the upward comparison. Therefore, we set the level of upward or downward comparison to 5%.

Part C: Questionnaire for the Second Phase of Experiment

Questionnaire number: Survey of electricity usage of college students

Dear Fellow Students:

Hello, we are students from *** university, and we are conducting research on psychological traits and daily electricitysaving behavior. We hope to understand your psychological traits and such behavior through this questionnaire. The research results are only used for scientific research, and we will not disclose the information you provide. Please feel free to fill in this survey. Thank you for your support and cooperation.

A. The following statements are about your view of electricity usage provided before, ranked from 1 to 7 with respective responses indicating "strongly disagree" to "strongly agree." Please tick the box according to your level of agreement with the statement.

Item		ngly (disagı	ee	Strongly agree			
		2	3	4	5	6	7	
PR1 I think the information provided is forcing me to compare with the other dormitory.								
PR21 don't think the information provided can make me concentrate c making decisions when dealing with other electricity information								
PR3 The information provided will induce me to give up the most appropriate decision of electricity usage.								
PR4 The information provided will cause interference for me in electricity decision.								
PR5 I think the information provided attempt to influence my electricity decision.								
PR6 I think the information provided is trying to control my electricity behavior.								
PR7 I think the logistics group provides information to achieve its own purpose, instead of helping me make the best decision.								

B. Please rank the following statements according to your own situation from 1 to 7, with respective responses indicating "very unlikely" to "very likely." Please tick the box which corresponds to your anticipated results.

Item		unlik	1	Very likely			
		2	3	4	5	6	7
ESI1 In the next two months, what is the possibility that you will turn off							
the lights when you leave the dormitory for more than half an hour?							
(Assume that no roommates are in.)							
ESI2 In the next two months, what is the possibility that you will turn the							
computer off when you are not using it?							
ESI3 In the next two months, what is the possibility that you will turn off							
the lights when you leave the dormitory? (Assume that no roommates are							
in.)							

C. Personal information	on (written by e	experimental executive)
WeChat ID:	Gender:	Age:
Grade and Majors:		Dormitory:

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