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RESEARCH ARTICLE

Shaping e-waste recycling intentions through psychological motivation: An integrated study of the theory of planned behavior and the theory of Value-Belief-Norm

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ABSTRACT

This study analyzes the influencing factors of residents' intention to participate in e-waste recycling behavior with the help of the theory of planned behavior (TPB) and Value-Belief-Norm (VBN) model. On the basis of factor analysis, through correlation analysis and regression analysis, this paper conducts an empirical study on the influencing factors of residents' intention to participate in e-waste recycling behavior, revealing the formation mechanism of residents' intention to participate in e-waste recycling behavior. The results show that Values, Awareness of consequences, Ascription of responsibility, Behavior attitude, Perceived behavior control and Personal norm are the main factors that affect residents' participation in e-waste recycling behavior, and the impact of perceived behavior control is the most significant. The research results can help understand the formation mechanism and implementation process of residents' e-waste recycling behavior intention, predict the possibility of residents' participation in e-waste recycling behavior in the future, and provide some reference and inspiration for the research of residents' participation in e-waste recycling behavior in China. In addition, we can essentially understand the reasons for the low recovery rate of e-waste and the lack of scale, and provide reference for the government and relevant departments to formulate corresponding policies and enterprises to establish a standardized recovery system.

Keywords: electronic waste; theory of planned behavior; Value-Belief-Norm theory; psychological motivation

1. Introduction

With the acceleration of urbanization and economic development, the annual consumption of electric and electronic products and the generation rate of electric and e-waste have been continuously improved. The trend of rapid popularization of electronic products not only brings convenience to people, but also accelerates the generation of e-waste[1].

According to the United Nations' global e-waste monitoring report in 2020, global e-waste is expected to reach 74 million tons (20MT) in 2030, and the amount of e-waste will double during this period[2].This prediction is derived from the record 53.6 million tons of global e-waste in 2019, with an alarming growth rate. The report also predicts the amount1 of e-waste on all continents at that time, 2.9 million tons in Africa, Oceania produced 700,000 tons. 12 million tons in Europe, then 13.1 million tons in America, while the sharply

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increase of Asian e-waste reaches astonishing 24.9 million tones. E-waste become the modern world's most amazing growing major household waste, with the words of Darby and Obara[3], it is mainly because the improvement of people's consumption level and population growth have enabled people to renew their homes.

The frequency of electrical appliances has also increased significantly compared with the past. Some scholars predict that the waste from discarded electronics in China will exceed 27.22 million tons by 2030[4]. Therefore, how to recycle and deal with e-waste scientifically and effectively cannot be ignored, and has gradually become a major livelihood and social problem.

China is a large producer of electronic products, and a large number of electronic products are exported, which means that a large number of energy, steel, precious metals and other materials are consumed in China, and the energy tension trend is not optimistic[5]. Therefore, the recycling of waste household appliances is undoubtedly an effective means to save resources and reduce resource waste. In other words, the renewable utilization of E-waste appliances contains huge business opportunities.

Discarded household appliances usually need to be removed by professionals. Many waste recyclers say that their recycling profits are very small, excluding transportation and labor costs. Waste household appliances occupy space in the home and are disposed at will, which not only hinders the appearance of the city, but also wastes resources. What is more noteworthy is that some small recycling workshops of waste household appliances use backward technology to extract precious metals from waste household appliances in order to make profits, which brings pollution to the ecological environment[6].

The recycling of electronic waste, or e-waste, is a critical global concern due to its rapid accumulation and potential environmental and health hazards. Shittu et al. provide a comprehensive overview of current practices in e-waste management and recycling. They emphasize the importance of sustainable recycling practices and highlight technological advancements that have the potential to improve the industry. The underscores the need for addressing future challenges in e-waste recycling, including the increasing volume of e-waste and the development of innovative recycling methods[7]. Sakhuja et al. explore the multifaceted landscape of e-waste recycling. Delves into economic, environmental, and policy-related challenges and opportunities associated with e-waste recycling. It emphasizes the significance of sustainable and innovative recycling solutions that not only mitigate environmental impacts but also contribute to economic development[8]. Murthy and Ramakrishna provide insights into circular economy strategies for managing e-waste. Circular economy principles, such as product design for recycling, extended producer responsibility, and eco-labeling, are discussed as ways to establish a closed-loop system for e-waste management. The article highlights the potential of circular economy approaches to minimize waste generation and promote sustainable resource use[9]. Li and Achal investigates the environmental and health consequences of e-waste recycling. The study emphasizes the hazards associated with informal recycling practices and underscores the importance of safe and sustainable recycling methods. It serves as a stark reminder of the urgent need to protect both the environment and human health from the negative impacts of e-waste recycling[10]. Cucchiella, D'Adamo, and Koh study evaluates various e-waste recycling technologies from both environmental and economic perspectives. By considering environmental impacts and cost-effectiveness, the article provides valuable insights into the selection of sustainable e-waste recycling methods[11].

Circular economy principles, extended producer responsibility, and eco-labeling are discussed as promising strategies for reducing e-waste and promoting resource efficiency. However, the environmental and health hazards associated with e-waste recycling, especially informal practices, remain a significant concern. Safe and sustainable recycling methods are imperative to protect both the environment and human well-being.

At present, waste from discarded electronics are common, resulting in potential safety hazards, and environmental contamination. With people's increasing voice for environmental protection, Various disadvantages of home appliance recycling have attracted the attention of all sectors of society. Recycling of household appliances is a very policy and technical systematic project, which requires the joint efforts of the state, manufacturers, dealers, consumers, and qualified recycling companies to form a closed loop of household appliance recycling, so as to make the domestic household appliance recycling industry develop healthily.

Recycling of renewable resources involves many aspects. To make waste household appliances become "waste" as treasure, we also need to mobilize all parties to promote the construction of public platforms, constantly improve the recycling business model, and adopt more professional and efficient technical means to improve the commercial value and social benefits of household appliance recycling. The country should also strengthen publicity, improve public awareness of environmental protection, and vigorously create a social atmosphere of "exchanging waste for treasure, protecting the environment and everyone's responsibility".

2. Literature review

2.1. Research related to planning behavior theory

The TPB theory is put forward by Bosnjak et al.[12]. on the basis of rational behavior theory, and it is an extension of rational behavior theory. The theory holds that "human behavior is the consequence of a considered programme", Ajzen and Fishbein put forward the theory of rational behavior by summarizing the existing literature[13].

In rational behavior theory, Behavioral attitude is the positive or negative evaluation of the individual's behavior. The individual's perception of this social pressure is Subjective norm. Behavioral intention is influenced by Behavioral attitude, perceived behavioral control and subjective norm, and it is the most direct factor affecting action, and behavior intention eventually leads to behavior. According to Theory of Reasoned Action (Hereinafter called TRA), if a person believes that an action is positive and family and friends around him support and encourage him to do so, he or she will have a stronger willingness to act and is likely to eventually produce the behavior[14].

However, scholars have found in subsequent studies that behavioral intent does not necessarily lead to an act, because the behavior intention and specific behavior will also be subject to environmental constraints. The final execution of many behaviors in reality often requires the use of opportunities or resources that affect people's ability to control an action. When such non-motivational factors as described above are not achieved, they may impede the execution of the act. An individual can ultimately successfully perform the behavior only if he has a certain level of opportunity or resources, believes that the behavior is positive and receives support from important others, and wants to perform the behavior.

Therefore, Ajzen adds the variable "Perceived behavioral control" to the rational behavior theory, and it holds that all factors which can affect the action indirectly influence the behavior result through the action intention. The intention to behavioral is influenced by 3 associated elements, one of which originate from the individual's own "Behavioral attitude "; 2nd is the "Subjective norm ", which affects an individual's ability to take a particular action, and, finally, from "Perceived behavioral control ". The factors affecting individual behavior add the factor of "Perceived behavioral control "which stems from the original "behavioral attitude" and "subjective norm" to better predict behavior[15]. Ajzen added further supplements the TPB theory, by amending the theory of rational behavior to expand the scope of application of the theory, enhance the theory of individual will and practical behavior of the interpretation, marking the maturity of TPB.

TPB theory holds that behavior is influenced by intent, as well as by the Behavioral attitude and

Subjective norm. The more support there is for behavior There is a positive correlation between Perceived behavioral control and behavioral intention. The three are independent and interrelated. There is a positive correlation among behavior, Perceived behavioral control and behavioral intention as shown in **Figure 1**.

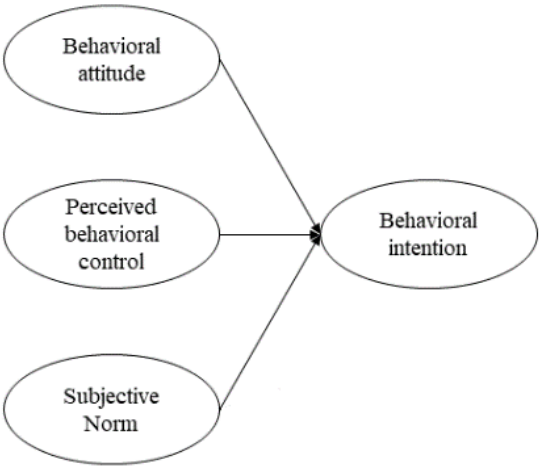

Figure 1. A theoretical model of TPB.

The TPB theory scale contains three elements: Behavior attitude, Subjective norms and Perceived behavior control. Behavior attitude focuses on individual evaluation of the importance and necessity of behavior; Subjective norms mainly emphasize the degree of subjective will when individuals perform behavior. Perceived behavior control emphasizes the perception of normative pressure from family, friends and other outsiders and the ability to match executive behavior. Subjective norms, Perceived behavior control, Behavior attitude and Behavior intention are derived from the TPB scale[16]. In addition, this paper also refers to Wan and Shen[17]. Wan, Shen applied a conceptual model by extending the Theory of Planned Behavior (TPB) for addressing the gap. Their research is also carried out under the theme of garbage collection, based on the TPB, which is very similar to the research theme of this paper.

In research at home and abroad, TPB not only furnishes a theoretical basis for research on recycling behavior[18–20], but also predicts other behaviors well: buying behavior[21] public participation in public decision-making behavior[22]. Although the theory of planned behavior does not fully explain behavior, it has been verified by the introduction of new variables by researchers in recent decades, and the results show the basis and effectiveness of it. Although TPB theory has been extensively applied in many areas of society, some studies have shown that the variables involved in this theory can explain the limited effect of certain behavioral intentions. Therefore, in recent years, in addition to confirming the TPB theoretical standard model, many existing studies have introduced other variables to increase its interpretation following the initial TPB theoretical model[23]. Ajzen also acknowledges that TPB theory is a theory that can be adjusted, and that if other variables can enhance the interpretation of the original model, it can be added to the original TPB theory.

2.2. Value-Belief-Normative theory related research

As illustrated in **Figure 2**, Value-Belief-Norm Theory (VBN) is based on the normative activation theory intermediary model, which is established by incorporating value theory and new environment paradigm theory[24]. As far back as the 1980s, Western scholars launched theoretical research on environmental behavior. For example, the previous research Schwartz reflected the successful application of altruistic normative activation theory to pro-environmental behavior, with some success[25]. The theory holds that if people believe that their actions have corresponding consequences and are willing to take responsibility, people's behavior tends to be consistent with their individual norms, which in turn affect individual norms and, in turn, behavior.

The theory consists mainly of three variables: Awareness of consequences, Ascription of responsibility, and Personal Norm. Subsequently, Stern, Dietz reasoned that environmental behavior was linked to a particular basic type of value based on existing research, introduced value theory and new environmental research paradigm into the normative activation model, and proposed three "Values" related to "egoism ", "altruism" and "Biosphere values"[26].

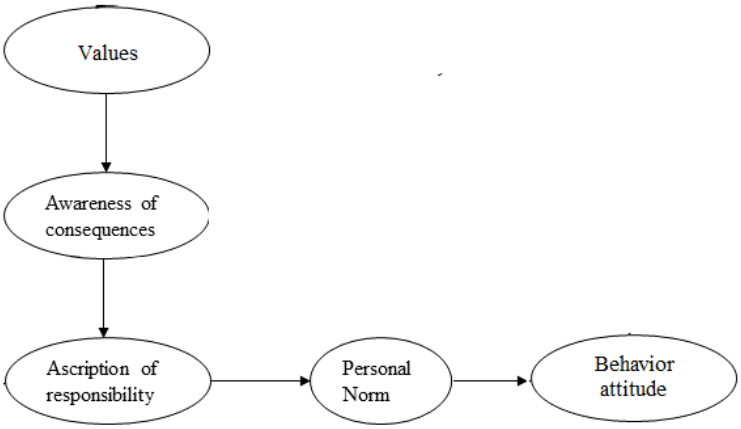

Figure 2. A theoretical model of VBN.

VBN Theory emphasizes enhancing the social subject's risk perception of environmental protection behavior by emphasizing adverse consequences and their personal responsibilities, and to strengthen their positive environmental behavior through psychological intervention. Yue further added that the Values, formed by the actors under different value orientations, will trigger their own different thinking on environmental issues, and trigger the corresponding beliefs, including the sense of behavior results and environmental responsibility, and thus stimulate different degrees of personal norm, thereby making positive or negative environmental behavior[27].

2.3. VBN Theory complements the theory of planned behavior

The TPB has been proved by many scholars in predicting and interpreting rational behavior such as environmental protection behavior[28,29], but the structure of theoretical behavior still lacks the support of personal belief[30].

It is incomplete and restrictive to study according to one of these theories alone. Today, VBN has been discussed together with other major attitude theories, for example Ajzen and Fishbein, which suggest that combining pro-environment and rational selection theory can produce higher predictive power. According to the normative activation theory model, belief is an individual's perception of the harmful consequences of others and a responsibility after feeling the consequences. According to the model, individuals who hold both the beliefs of result perception and attribution of responsibility perform civilized travel behaviors critically by conducting self-regulation to prevent expected harm. Riper and Kyle point out of the individual's sense of results may affect their behavioral attitudes, which in turn may affect the individual's pro-environmental behavior norms[31]. Some researchers have begun to rely on the theory of planned behavior to try to predict and understand people's intention to protect environmental behavior. Han combines VBN and planning behavior theory into a theoretical framework in the study of tourists' environmental behavior in green hotels, and the proposed model is significantly effective in predicting green hotel consumption behavior[32].

Kloeckner and Bloebaum used meta analytical structural equation model to comprehensively analyze a large number of literatures on environmental friendly behavior, and proposed a robust theoretical model[33].

Some Chinese scholars combine the theory of planned behavior with the theory of value belief norms to build a model. Hu, Fu conducted research on pro-environmental behavior, low-carbon tourism behavior, etc. The applicability of VBN theory and TPB theory has been successfully verified by applying this theory to explain an individual's environmental behavior[34].

Therefore, an individual's an individual's Awareness of consequences may affect his or her behavioral attitude and ultimately his or her behavior intention. Even though the theory of planned behavior has been persuasive enough to explain rational behavior, the robustness and explanatory power of the whole model have been greatly improved by adding values, Awareness of consequences, Ascription of responsibility and Personal norm variables.

This paper will refer to this model to integrate TPB theory and VBN theory, and use structural equation model to study influencing elements of residents' desire to recycle e-waste, so as to provide theoretical guidance for promoting residents' energy-saving behavior.

3. Research design

3.1. Participants

The research object of this study is the behavioral intention of residents on e-waste recycling. The study takes Nanning residents as an example. Considering the large number of administrative areas in Nanning and the large and scattered sample of residents and the difficulty of obtaining the survey data, in order to ensure the generality and improve the questionnaire recovery rate and efficiency, the questionnaire was distributed offline through online and offline channels.

3.2. Data collection

Structured surveys were designed to assess participants' behavioral attitude, subjective norms, perceived behavioral control, values, awareness of consequences, ascription of responsibility and personal norm related to e-waste recycling. The survey also included demographic questions.

3.3. Scales

Use standardized scales which were already validated by previous studies to measure the hypotheses.

3.4. Hypothesis formulation

According to the theoretical basis, residents' e-waste recycling behavior intention is a typical environmental protection action. VBN and TPB are often used to explain individuals' Pro environmental behavior. The difference between the two is that the former believes that personal values decisively affect personal environmental beliefs, and then affect Pro environmental behavior[35]. The latter believes that personal Pro environmental behavior attitude, subjective norms and perceived behavior control affect Pro environmental behavior intention together. The causal relationship between the two theoretical influence mechanisms is different. Some scholars have found that the integration model of VBN and TPB has a good predictive effect on the behavior intention of Pro environment. Based on this, this paper constructs an integrated model of residents' e-waste recycling behavior intention based on the value belief norm theory and TPB theory, draws lessons from the existing achievements, and includes the demographic characteristics in the analysis[36]. When investigating the e-waste recycling behavior of residents in Nanning, the influencing factors include personal and family characteristics, behavior attitude, subjective norms, Values, responsibility attribution and perceived behavior control. Among them, the Values of residents' e-waste recycling behavior is the connecting medium between TPB and VBN theory, which may be related to behavior attitude, subjective norms The perceived behavior is related to the motivation, and may have an impact on the responsibility attribution of residents' e-

waste recycling behavior in VBN theory. All variables based on the two theories will ultimately affect residents' e-waste recycling behavior intention.

3.4.1. Relevant assumptions of VBN theory

The main variables involved in the VBN theoretical model are values, result consciousness caused by non recycling of e-waste, responsibility attribution and personal norms will. The stronger the orientation of altruistic values and ecological values, the better It is easy to make self-determination to implement environmental protection behavior[37].

Therefore, to sum up, this paper puts forward the following assumptions:

Hypothesis 1: Values has a positive impact on Awareness of consequences.

Chen and Tung Pointed out that consequence awareness refers to the understanding of the possible harmful consequences of not implementing energy-saving behavior. Responsibility attribution refers to that people think they are responsible for the possible harmful consequences of not implementing Pro environmental behavior.

Then this hypothesis can be expected:

Hypothesis 2: Awareness of consequences has a positive impact on Ascription of responsibility.

Petschnig, Heidenreich added further that individuals realize that failure to adopt energy-saving behavior will have negative consequences, which will promote the formation of responsibility attribution and personal norms related to environmental protection behavior. At the same time, responsibility attribution will affect personal norms, and personal norms will affect behavior intention[38].

Then this hypothesis can be expected:

Hypothesis 3: Ascription of responsibility has a positive impact on Personal Norm.

Personal norms refer to the moral obligation to implement or not implement a certain behavior. Personal norms are informal obligations implemented through internalized awareness of environmental responsibility.

Then this hypothesis can be expected:

Hypothesis 4: Personal norm has a positive impact on Behavior intention.

3.4.2. Relevant assumptions of TPB

The main variables involved in the TPB theoretical model are behavioral attitude, subjective norm, perceived behavior control and behavior intention. Wang, Ma found in the survey that positive recycling attitude will have a actively impact on e-waste recycling action[39]. As Tonglet, Phillips have noted that the actively attitude towards recycling is principal predictor of recycling intention, and the relationship between them is the closest. The more positive the attitude towards recycling, the higher the possibility of recycling behavior. Similarly, perceived behavior control has also been proved to be an important factor affecting behavior intention.

Then this hypothesis can be expected:

Hypothesis 5: Behavioral attitude has a positive impact on Behavioral intention.

Arı and Yılmaz investigated the recycling attitude and behavior of Turkish housewives and perceived behavior control is high weight factor of recycling behavior intention and recycling behavior[40]. Oztekin, Teksöz also found that perceived behavior control is an important predictor of recycling behavior, especially for female groups[41]. Similar research on recycling behavior for student groups, for example, the previous research. Zhang et al. the survey of 239 freshmen and sophomores by reflected that also shows that the best predictor of recycling intention was perceived behavior control[42]. As for Tong and Nikolic both confirmed

that perceived behavior control plays a great role in recycling behavior[43].

Then this hypothesis can be expected:

Hypothesis 6: Perceived behavioral control has a positive impact on Behavioral intention.

Sheppard, Hartwick People's behavior is believed to be determined by their behavior practice, that is, people's subjective will to a certain behavior will be a high weight factor of implementation of the behavior, and people are more likely to put what they are willing to do into practice[44].

Then this hypothesis can be expected:

Hypothesis 7: Subjective norms have a positive impact on Behavior intention.

3.4.3. Theoretical expansion assumptions of TPB theory and VBN

TPB has been verified by many researchers in predicting and explaining rational behavior such as environmental protection behavior[45]. In the meantime, personal attention to the negative consequences of environmental problems has a direct impact on subjective norms and perceived behavior control. Huang et al. used TPB as a prediction model for people's environmental behavior intentions[46]. According to Han, focused on tourists' environmental protection action in green hotels, VBN and TPB were integrated. The model shows stronger prediction ability than the independent VBN framework. As Bamberg and Möser have noted that combining value belief norm theory and TPB theory can produce higher prediction ability[47].

In the words of Riper and Kyle, an individual's awareness of results may affect his Behavior attitude, and ultimately affect a code of conduct.

Then this hypothesis can be expected:

Hypothesis 8: Awareness of consequences has a positive impact on Behavior attitude.

At the end of the 20th century, some scholars questioned the adequacy of TPB to study individual behavior[48]. Stern added further that Results consciousness and responsibility attribution will induce personal obligations of Pro environmental behavior.

Then this hypothesis can be expected:

Hypothesis 9: Awareness of consequences has a positive impact on Perceived behavioral control.

Hypothesis 10: Awareness of consequences has a positive impact on Subjective norms.

Matthies, Selge studied how parents' behavior affects children's Pro environmental behavior, and found that children's personal norms are also significantly affected by subjective norms[49].

Then this hypothesis can be expected:

Hypothesis 11: Subjective norms have a positive impact on Personal Norm.

The conceptual model that shows direct relationship between variables is presented in **Figure 3**.

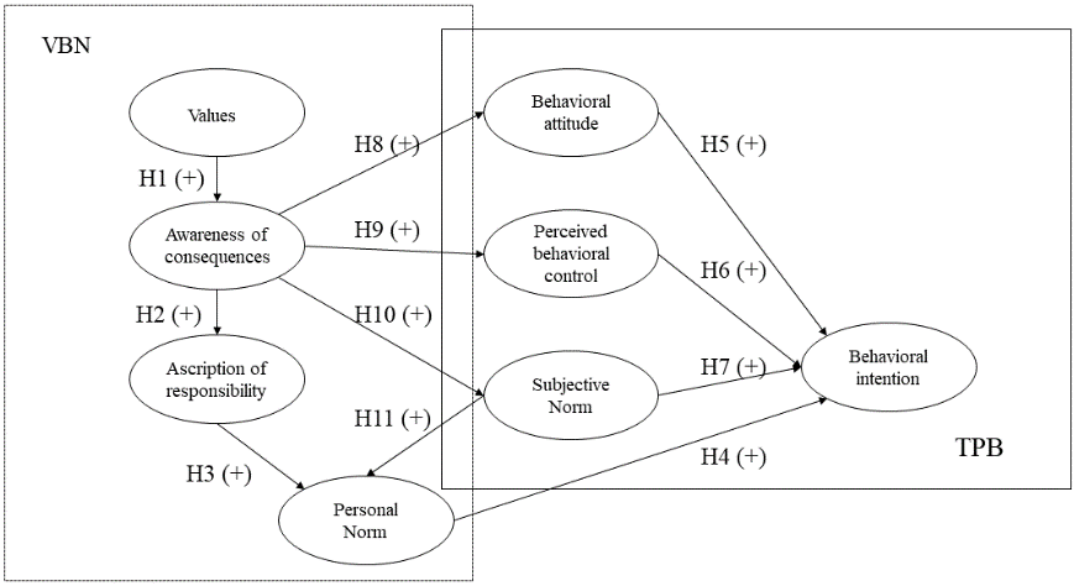

Figure 3. Hypothesis research model.

3.5. Data analysis

Quantitative data analysis techniques, including regression analysis and structural equation modeling (SEM), were employed to test the formulated hypotheses. Statistical software packages were used for data analysis, allowing for a rigorous examination of the relationships between psychological factors and e-waste recycling intentions.

4. Results

4.1. Convergent validity

In this study, the confirmatory Factor Analysis (CFA) for the measurement model was conducted as part of the SEM analysis with variable reduction based on Kline two-stage model modification, and the measurement model was examined before performing the structural model estimation[50]. If the fit of the measurement model is acceptable, the full SEM model report can then be performed.

Hair, Anderson[51] and Fornell and Larcker[52] suggest the criteria as below:
Factor loadings > 0.5,
Composite reliability > 0.6,
Average variance extracted > 0.5.

In this study (shown in **Table 1**), CFA analysis was performed on the 8 constructs, they are as follows, Values (VA), Awareness of consequences (AC), ascription of responsibility (AR), behavior attitude (BA), perceived behavioral control (PBC), subject norm (SN), Personal norm (PN) and behavior intention (BI). All factor loadings of constructs are between 0.581~0.792. composite reliability between 0.73–0.864, average variance extracted between 0.454–0.622.

Table 1. Summary of confirmatory factor analysis.

Construct	Item	Significant test of parameter estimation				Item reliability		Composite reliability	Convergence validity
		Unstd.	S.E.	*Z*-value	*p*-Value	STD.	SMC	CR	AVE
Values	VA1	1.000	-	-	-	0.761	0.579	0.837	0.509
	VA2	0.975	0.055	17.584	0.000	0.745	0.555		
	VA3	1.027	0.057	17.964	0.000	0.779	0.607		
	VA4	0.901	0.065	13.806	0.000	0.610	0.372		
	VA5	0.938	0.063	14.811	0.000	0.656	0.430		
Awareness of consequences	AC1	1.000	-	-	-	0.670	0.449	0.836	0.562
	AC2	1.216	0.074	16.345	0.000	0.790	0.624		
	AC3	1.217	0.080	15.134	0.000	0.776	0.602		
	AC4	1.063	0.071	15.056	0.000	0.757	0.573		
Ascription of responsibility	AR1	1.000	-	-	-	0.761	0.579	0.801	0.503
	AR2	0.902	0.061	14.713	0.000	0.671	0.450		
	AR3	1.009	0.064	15.721	0.000	0.712	0.507		
	AR4	0.884	0.060	14.801	0.000	0.689	0.475		
Behavioral attitude	BA1	1.000	-	-	-	0.792	0.627	0.832	0.622
	BA2	1.035	0.057	18.323	0.000	0.792	0.627		
	BA3	1.045	0.058	17.984	0.000	0.782	0.612		
Perceived behavioral control	PBC1	1.000	-	-	-	0.752	0.566	0.864	0.515
	PBC2	1.055	0.061	17.389	0.000	0.720	0.518		
	PBC3	1.105	0.061	18.177	0.000	0.763	0.582		
	PBC4	0.999	0.057	17.666	0.000	0.742	0.551		
	PBC5	1.041	0.064	16.228	0.000	0.692	0.479		
	PBC6	0.945	0.064	14.721	0.000	0.629	0.396		
subject norm	SN1	1.000	-	-	-	0.686	0.471	0.805	0.454
	SN2	1.058	0.070	15.126	0.000	0.735	0.540		
	SN3	1.029	0.071	14.541	0.000	0.712	0.507		
	SN4	0.900	0.067	13.338	0.000	0.643	0.413		
	SN5	0.807	0.066	12.221	0.000	0.581	0.338		
Personal norm	PN1	1.000	-	-	-	0.727	0.529	0.806	0.510
	PN2	0.928	0.062	14.867	0.000	0.680	0.462		
	PN3	1.013	0.067	15.026	0.000	0.721	0.520		
	PN4	0.967	0.064	15.027	0.000	0.727	0.529		
behavior intention	BI1	1.000	-	-	-	0.699	0.489	0.730	0.474
	BI2	1.054	0.084	12.560	0.000	0.723	0.523		
	BI3	0.868	0.073	11.846	0.000	0.641	0.411		

4.2. Discriminant validity

Fornell and Larcker suggested that the square root of the AVE of each construct needs to be greater than the correlation coefficient of each paired variable to show discriminant validity between the constructs. In this study (shown in **Table 2**), the square root of the AVE of each construct in the diagonal is greater than the

correlation coefficient off the diagonal, so the model has discriminant validity in this studied.

Table 2. Fornell and Larcker criteria.

	AVE	VA	AC	AR	BA	PBC	SN	PN	BI
VA	0.509	**0.713**	-	-	-	-	-	-	-
AC	0.562	0.578	**0.75**	-	-	-	-	-	-
AR	0.503	0.403	0.698	**0.709**	-	-	-	-	-
BA	0.622	0.197	0.341	0.238	**0.789**	-	-	-	-
PBC	0.515	0.275	0.476	0.332	0.162	**0.718**	-	-	-
SN	0.454	0.281	0.486	0.339	0.166	0.231	**0.674**	-	-
PN	0.510	0.294	0.509	0.576	0.174	0.242	0.576	**0.714**	-
BI	0.474	0.248	0.428	0.334	0.245	0.608	0.354	0.378	**0.688**

4.3. Analysis and verification

The model fit of research model are basically acceptable after correction. The overall fitness of research model is good, and it gives a good explanation for residents' e-waste recycling behavior, and can predict residents' future recycling behavior.

Based on VBN-TPB, this research constructs theoretical framework of the influencing factors of the residents' e-waste recycling behavior intention in Nanning. According to the results of 488 valid questionnaires, structural equation model is used to test the theoretical hypothesis of the residents' e-waste recycling behavior intention. The results show that:

The purpose of testing the research hypothesis is to understand the significance of the independent variables on dependent variable in the research model. R^2 is the size of endogenous variable was explained by exogenous variable(s), the greater the R^2 the greater the explanation capability in SEM. If $R^2 > 0.670$ means sustainable, $0.670 > R^2 > 0.330$ means acceptable, $R^2 < 0.190$ means exogenous variable(s) selection are not suitable for research model[53].

In this study (shown in **Table 3** and **Figure 4**), the determination coefficient of Values to Awareness of consequences is 0.334, indicate acceptable explanation capability. The determination coefficient of Awareness of consequences to ascription of responsibility is 0.487, indicate acceptable explanation capability. The determination coefficient of Awareness of consequences to behavior attitude is 0.116, indicate explanation capability not well. The determination coefficient of Awareness of consequences to perceived behavioral control is 0.226, indicated acceptable explanation capability. The determination coefficient of Awareness of consequences to subject norm is 0.236, indicate acceptable explanation capability. The determination coefficient of ascription of responsibility and subject norm to Personal norm is 0.495, indicate acceptable explanation capability. The determination coefficient of behavior attitude, perceived behavioral control, subject norm and Personal norm to behavior intention is 0.449, indicate acceptable explanation capability.

Table 3. Summary of empirical results of research hypothesis.

DV	IV	Unstd.	*p*-value	Standardized	R^2	Hypothesis
AC	VA	0.494	0.000	0.578***	0.334	H1 support
AR	AC	0.865	0.000	0.698***	0.487	H2 support
BA	AC	0.512	0.000	0.341***	0.116	H5 support
PBC	AC	0.568	0.000	0.476***	0.226	H6 support
SN	AC	0.538	0.000	0.486***	0.236	H7 support
PN	AR	0.422	0.000	0.431***	0.495	H3 support
	SN	0.472	0.000	0.429***	-	H11 support
BI	BA	0.071	0.040	0.112*	0.449	H8 support
	PBC	0.419	0.000	0.522***	-	H9 support
	SN	0.105	0.086	0.122	-	H10 reject
	PN	0.127	0.010	0.161*	-	H4 support

Note: VA: Values, AC: Awareness of consequences, AR: Ascription of responsibility, BA: Behavioral attitude, PBC: Perceived behavioral control, SN: subject norm, PN: Personal norm, BI: behavior intention.

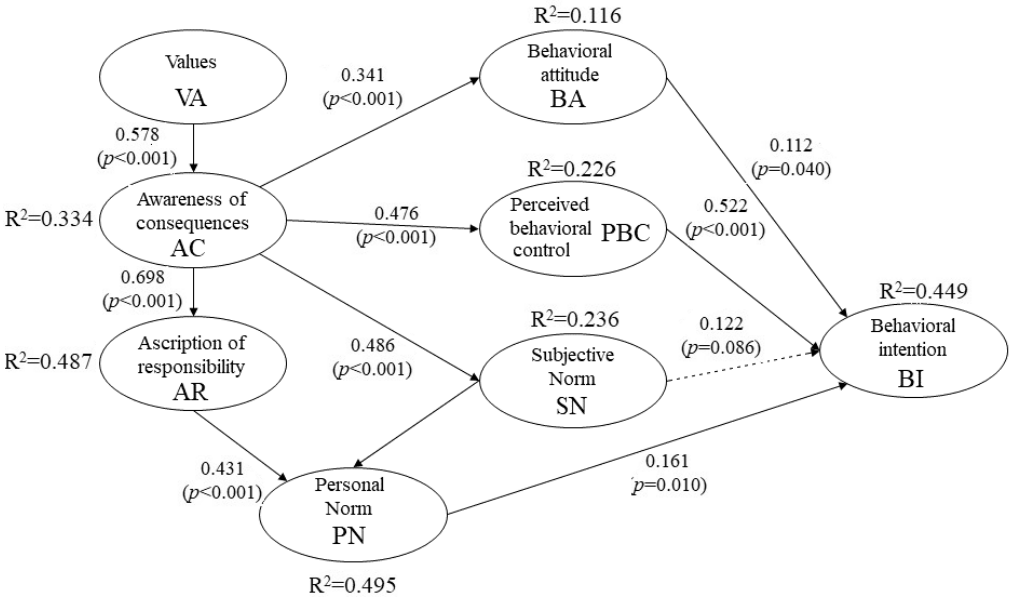

Figure 4. SEM model.

Note: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

H1: The unstandardized coefficient of "Values" to "Awareness of consequences" is 0.494 (The standardized coefficient is 0.578), reach 95% significant level ($z = 7.952$, $p < 0.001$), Therefore, hypothesis 3 of this study, "Values" to "ascription of responsibility" is support.

H2: The unstandardized coefficient of "Awareness of consequences" to "ascription of responsibility" is 0.865 (The standardized coefficient is 0.698), reach 95% significant level ($z = 11.350$, $p < 0.001$), Therefore, hypothesis 2 of this study, "Awareness of consequences" to "ascription of responsibility" is support.

H3: The unstandardized coefficient of "Awareness of consequences" to "Personal norm" is 0.422(The standardized coefficient is 0.431), reach 95% significant level ($z = 11.350$, $p < 0.001$), Therefore, hypothesis 3 of this study, "Awareness of consequences" to "Personal norm" is support.

H4: The unstandardized coefficient of "Personal norm" to "behavior intention" is 0.127 (The standardized coefficient is 0.161), reach 95% significant level ($z = 2.573$, $p < 0.010$), Therefore, hypothesis 4 of this study,

"Personal norm" to "behavior intention" is support.

H5: The unstandardized coefficient of "behavior attitude" to "behavior intention" is 0.071 (The standardized coefficient is 0.112), reach 95% significant level ($z = 2.054$, $p < 0.040$), Therefore, hypothesis 5 of this study, "behavior attitude" to "behavior intention" is support.

H6: The unstandardized coefficient of "perceived behavioral control" to "behavior intention" is 0.419(The standardized coefficient is 0.522), reach 95% significant level ($z = 7.146$, $p < 0.001$), Therefore, hypothesis 6 of this study, "perceived behavioral control" to "behavior intention" is support.

H7: The unstandardized coefficient of "subject norm" to "behavior intention" is 0.105(The standardized coefficient is 0.122), not reach 95% significant level ($z = 1.715$, $p < 0.086$), Therefore, hypothesis 7 of this study, "perceived behavioral control" to "behavior intention" is not support.

H8: The unstandardized coefficient of "Awareness of consequences" to "behavior attitude" is 0.512 (The standardized coefficient is 0.341), reach 95% significant level ($z = 6.713$, $p < 0.001$), Therefore, hypothesis 8 of this study, "perceived behavioral control" to "behavior intention" is support.

H9: The unstandardized coefficient of "Awareness of consequences" to "perceived behavioral control" is 0.568 (The standardized coefficient is 0.476), reach 95% significant level ($z = 8.895$, $p < 0.001$), Therefore, hypothesis 9 of this study, "Awareness of consequences" to "perceived behavioral control" is support.

H10: The unstandardized coefficient of "Awareness of consequences" to "subject norm" is 0.538 (The standardized coefficient is 0.486), reach 95% significant level ($z = 8.425$, $p < 0.001$), Therefore, hypothesis 10 of this study, "Awareness of consequences" to "subject norm" is support.

H11: The unstandardized coefficient of "subject norm" to "Personal norm" is 0.472 (The standardized coefficient is 0.161), reach 95% significant level ($z = 8.302$, $p < 0.001$), Therefore, hypothesis 11 of this study, "subject norm" to "Personal norm" is support.

5. Conclusion

5.1. Research hypothesis verification

Through the empirical analysis of the influencing factor model of urban residents' recycling behavior intention, this article can preliminarily understand the general law of residents' recycling behavior, accurately grasp the influencing factors of residents' e-waste recycling behavior intention, which has certain enlightenment significance for development and construction of e-waste recycling strategies in other cities in China. The research conclusions are as follows:

Values has a positive impact on Awareness of consequences. Especially in China, social altruistic values are mainstream values. Values will have a direct and positive impact on behavior attitude, subject norm, and perceived behavioral control through mediation of Awareness of consequences, and then affect residents' behavior intention of e-waste recycling. Therefore, guiding people to establish positive values plays an important role in the implementation of e-waste recycling by residents.

The Awareness of consequences of residents' e-waste recycling behavior has a direct and positive impact on the ascription of responsibility. The attribution of responsibility is based on an understanding of the consequences of executing a certain action. In order to avoid consequences, taking corresponding actions or assuming corresponding responsibilities when the results occur, residents realize that electronic waste can have many negative consequences. If these negative consequences are caused by not participating in the recycling behavior, residents will feel responsible for it

Ascription of responsibility has a significant positive impact on personal norm. From the survey, we can find that on the one hand, residents may feel responsible for the impact on their living environment due to not participating in recycling activities; On the other hand, if positive guidance on moral awareness is strengthened for residents, they will have a stronger intention to recycle electronic waste. With these two aspects of responsibility, residents will feel proud of their electronic waste recycling behavior, feel guilty for their non recycling behavior, and activate personal norm. Therefore, realizing the consequences of using electronic waste on the environment, a sense of responsibility will make them tend to choose to recycle electronic waste.

Personal norm has a positive impact on behavior intention. Personal norm can explain 12.7% of behavior intention of residents in electronic waste recycling. Individual norms have a strong influence when choosing to execute a certain behavioral intention.

Behavior attribute has a positive impact on behavior intention. Behavior intention is based on individual behavior motivation, but its psychological interaction cannot be separated from behavior attitude, which directly determines the possibility of carrying out a certain behavior.

Perceived behavioral control has a positive impact on behavior intention. people tend to have a strong behavioral intention when they perceive the pressure of persuasion from intimate relationships and the difficulty of implementing a certain behavior. This conclusion is basically the same as that of Huang et al.[46].

Subjective norm has no significant impact on behavior intention. Contrary to the assumption, Subjective norm do not directly affect the intention of recycling electronic waste. On the contrary, the impact of subjective norm on residents' intention to recycle electronic waste is reflected in indirect effects. Although different from TPB proposed by Ajzen, Sheeran and Orbell pointed out that social pressure is difficult to obtain directly by following the wishes of others, which can lead to a weak relationship between subjective norm and behavior[54]. From the research, we can see that subjective norm has an impact on personal norm (with a standardized regression coefficient of 0.429), which indirectly affects residents' intention to recycle, with an impact coefficient of 0.161. It can be seen that the relevant laws and regulations on electronic waste recycling, as well as the attitudes of surrounding people, will significantly affect the moral awareness of individual residents in recycling, thereby affecting their recycling intentions. Therefore, the work on subjective norm needs to focus on our laws and regulations on electronic waste recycling. Only when laws and regulations play their due role, residents will feel pressure from society or others around them, and actively participate in electronic waste recycling.

Awareness of sequences has a positive impact on behavior attitude, perceived behavioral control, and subject norm, respectively. Residents can gradually realize the drawbacks of electronic waste being discarded or left at home, and realize that the informal disposal of electronic waste can bring environmental pollution and seriously affect human health. This stimulates residents' moral subconscious and encourages them to have a positive recycling attitude. In addition, residents' moral subconscious and the government's convenient service measures provide guidance, making them proud of their recycling behavior, and feeling guilty about one's non recycling behavior. This creates a positive environment for electronic waste recycling and forms a virtuous cycle.

Subject norm has a positive impact on personal norm. Personal norms mainly measure residents' recycling awareness from a moral perspective. Based on the active guidance of moral awareness, residents have a stronger intention to recycle electronic waste.

5.2. Analysis of variance

Through analysis of variance, it was found that there were no significant differences in environmental

awareness among the surveyed population in terms of age, gender, income, and education. This is consistent with the study by Kiatkawsin and Han[55]. The reason for this may be that regardless of the group, people's understanding of the environment is consistent, which is inseparable from government departments' promotion and education of environmental protection. Therefore, there is no significant difference in the awareness of electronic waste recycling among different groups of people.

Through the analysis of mediating effects, it was found that individuals' values indirectly influence residents' intention to recycle e-waste through Awareness of consequences and Perceived behavioral control. This suggests that if individuals are aware of the positive consequences of recycling and perceive themselves to have the ability to control their behavior, they are more likely to have the intention to participate in recycling activities. Furthermore, individuals' values can also indirectly influence residents' intention to recycle e-waste through Awareness of consequences, Ascription of responsibility, and Personal norm. Individuals' values indirectly affect their intention by recognizing the importance and positive impact of recycling. If individuals believe that society generally supports and values the recycling of e-waste, they are more likely to be influenced by this social norm, thereby increasing their own recycling intention. Values can also indirectly influence residents' behavior intention to recycle e-waste through Awareness of consequences, Subject norm, and Personal norm. This study demonstrates that individuals' values affect their Awareness of consequences regarding recycling behavior. If individuals perceive recycling e-waste to be of significant importance for environmental and resource protection, they are more likely to recognize the positive consequences of recycling. Additionally, individuals' values also influence their perception of social expectations and norms, specifically the Personal norm. If individuals' values align with societal expectations, they are more likely to be influenced by social norms, thereby increasing their intention to recycle e-waste. However, values cannot indirectly influence behavior intention through Awareness of consequences and Behavioral attitude. Values also cannot indirectly influence behavior intention through Awareness of consequences and Subject norm. This suggests that although Awareness of consequences, Subject norm, and Behavioral attitude cannot explain the relationship between values and behavior intention, there might be other unconsidered mediating factors. These factors could play a more significant role in specific contexts, affecting the relationship between values and behavior intention.

In summary, the study on behavioral intention of electronic waste recycling is a comprehensive decision-making system that considers psychological factors, social norms, and objective situational factors, and is the result of the joint action of Values, Awareness of consequences, Ascription of responsibility, Personal norm, Behavioral attitude, Subjective norm and Perceived behavioral control of residents.

The behavioral intention of residents to recycle electronic waste is the result of the joint action of TPB and VBN. TPB considers the decision-making mechanism of electronic waste recycling behavioral intention of residents from the perspective of rational behavior, while VBN influences behavioral intention of electronic waste recycling from the perspective of Values and Personal norm of residents.

These two theories interact with each other. Awareness of consequences influences TPB through influencing behavioral attitude, subjective norm and perceived behavioral control. Subjective norm affects VBN by influencing personal norm.

This article integrates TPB and VBN, and develops research hypotheses and scales based on literature research and real-life situations. Then, research data is obtained through field research for data analysis and hypothesis testing. The main research conclusions of this article are as follows:

- The first is that personal norm based on VBN theory can be activated by ascription of responsibility and subjective norm, and it affects behavioral intention of residents to recycle electronic waste.

- Secondly, behavioral attitude, perceived behavioral control, and subjective norm based on TPB significantly affect behavioral intention of residents to recycle electronic waste.
- Thirdly, subjective norm cannot directly affect behavioral intention of residents to recycle, but indirectly affects it through personal norms.
- Fourthly, awareness of consequences can indirectly affect recycling behavioral intention through mediating variables behavioral attitude and perceived behavioral control.
- Fifthly, among the influencing factors of behavioral intention of residents to recycle electronic waste, perceived behavioral control played the greatest role, followed closely by behavioral attitude and personal norm, which also had a certain impact.

In conclusion, the analysis of the mediating effects reveals that individuals' values indirectly influence residents' intention to recycle e-waste through four key factors: Awareness of consequences, Ascription of responsibility, Perceived behavioral control, and Personal norm. This indirect influence implies that individuals' values do not directly determine their recycling behavior intention. Instead, it operates through intermediate variables such as recognizing the positive consequences of recycling, feeling responsible for recycling, and perceiving social support and expectations. These intermediaries ultimately shape individuals' behavior intentions. Therefore, to encourage residents to actively participate in e-waste recycling, it is essential not only to raise individuals' Awareness of consequences, making them aware of the significance and positive impacts of recycling but also to emphasize individual responsibility and participation. Additionally, promoting and strengthening social support and expectations are crucial, creating a societal environment that encourages recycling behaviors. This understanding underscores the importance of multifaceted interventions targeting these intermediate variables to foster pro-environmental behaviors among individuals, ultimately contributing to a more sustainable future.

5.3. Research recommendations

With the improvement of economic development level and the rapid progress of science and technology, household waste, especially electronic waste, is increasing every year. The production of electronic waste in China has always been high, and the government has taken a series of measures and made many efforts, including introducing electronic waste management regulations, expanding the electronic waste recycling directory, etc. These policies have achieved certain results, resulting in an increase in the amount of electronic waste recycling, the amount of formal enterprise processing, and the green recycling rate[56]. But in such a severe situation of electronic waste recycling and treatment, we need to consider every factor and every detail that affects electronic waste recycling and treatment. Whether residents can truly and effectively participate in recycling is undoubtedly a key issue for the entire electronic waste recycling and treatment industry.

We should control the generation of electronic waste. Only by controlling electronic waste at the source, we can fundamentally solve the problem. Therefore, the government should attach importance to circular economy, transform traditional development models, and convert resources into products, not into waste, but into renewable resources, committed to green development.

Through the above research results, this article can find that the Values among the influencing factors of residents' behavior intention of e-waste recycling has a direct and positive impact on the Awareness of consequences, while Awareness of consequences has a direct and positive impact on the attribution of responsibility, behavior attitude, subject norm, and perceived behavioral control, which will ultimately affect the residents' behavior intention of e-waste recycling. Therefore, it is necessary to change the concepts of all parties and create a good environment for environmental protection and waste reduction. It is necessary to make residents realize that active participation in e-waste recycling will bring positive impacts on themselves,

others and ecological environment.

The path analysis of the structural equation model in this research shows that the Personal norm has a positive effect on the intention of recycling behavior. It is suggested to add the corresponding environmental protection education content in the compulsory education stage, popularize environmental protection knowledge to the younger generation, improve the overall environmental responsibility awareness of residents, and promote the final formation of good social norms. At the same time, a good information dissemination channel should be established. While publicizing the recycling policy, we should also pay attention to the publicity and introduction of environmental knowledge such as the recycling channels, recycling methods and garbage classification, in order to indirectly improve the residents' ability to classify and recycle e-waste.

The empirical research shows that the impact of perceptual behavior control on recycling behavior is very obvious, indicating that perceptual behavior control has an important role in promoting the transformation of potential behavioral intentions into actual recycling behavior. Similarly, affected by the intermediary effect of perceptual behavior control, convenient collection channels will also have a positive impact on recycling behavior. While improving the management system of e-waste recycling, it is also necessary to establish a convenient and humanized e-waste delivery and investment channel and a recycling network in line with residents' behavior preferences, so as to achieve a higher participation rate of residents in recycling. At the same time, it is also necessary to give dealers, manufacturers, and even streets and communities corresponding recycling responsibilities, and establish a complete e-waste recycling network system.

6. Research limitations and prospects

6.1. Limitations of this research

Due to the data collection method adopted in this research, it is impossible to investigate the real behavior of residents at the destination of e-waste recycling. So this research does not include the actual recycling behavior. Individual behavior intention refers to individual's willingness or preparation for specific behavior. However, this does not mean that the expected action will occur. Therefore, future research can try to expand the conceptual framework proposed by combining the actual e-waste recycling behavior.

6.2. Research prospect

Based on the research status of this paper, future research can be carried out in the following aspects:

In terms of sample selection, this research only selects the sample of Nanning City. In the future, the research can expand the scope of the survey to other cities, select a wider range of sample objects, and enhance the representativeness of the sample. Through a wide and evenly distributed survey, expand the scope of the survey, improve the representativeness of the survey data, and increase the coverage of the survey data, this paper is committed to better identify the key influencing factors of residents' e-waste recycling behavior intention.

In the investigation of recycling behavior, in order to improve the accuracy of the investigation results. Future research can conduct long-term and in-depth follow-up investigation on recycling behavior, or use personnel observation or visit to obtain more detailed information on recycling behavior, and deeply explore the formation mechanism of residents' e-waste recycling behavior.

In terms of research theory, this study integrates TPB and VBN models to construct a research framework. TPB and VBN are based on the level of values and individual psychological constraints and the level of rational behavior, respectively, which can well explain the driving factors of complex behavior. When personal behavior involves not only values but also rational thinking, it is difficult to explain its causes and motives by

a single theory. Therefore, VBN and TPB expand the application field of the model and have strong applicability. There is still much room to study the psychological interpretation of people's behavior, and more in-depth analysis and research can be carried out in related fields in the future.

Author contributions

Conceptualization, AM; methodology, YX; investigation, YX; writing—original draft preparation, YX; writing—review and editing, YX and AM. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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