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Original Research

From Online to Offline: Understanding the Connection between Perceived Interactivity and Pro-environment Behavior

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Abstract

With the exacerbation of environmental pollution, pro-environmental behavior is becoming increasingly imperative. The emergence of mobile mini programs plays a pivotal role in promoting such behavior. However, there remains a dearth of research examining the influence of perceived interactivity on pro-environmental behavior. In line with the Stimulus-Organism-Response (S-O-R) model, this study aims to investigate the impact of perceived interactivity on pro-environmental behavior. Utilizing a questionnaire survey of 336 Ant Forest users, the partial least squares method was employed to analyze the data. The findings reveal that control, responsiveness, and connectivity positively influence user engagement. Moreover, user engagement significantly correlates with brand love and user satisfaction. Additionally, brand love and user satisfaction significantly contribute to user stickiness, thereby fostering pro-environmental behavior. This study represents the first attempt to explore the influence of perceived interactivity on pro-environmental behavior.

Keywords: pro-environment behavior, perceived interactivity, user engagement, S-O-R model, Ant Forest

Introduction

The World Meteorological Organization has asserted that the global average temperature is 1.2°C higher than pre-industrial levels, approaching the lower temperature threshold that the Paris Agreement aims to prevent. Environmental change has threatened human survival and development [1]. Many studies have found a strong link between human activity and climate problems [2-5]. Therefore, it is paramount for individuals to modify their behaviors and conscientiously adopt pro-environmental practices to address climate change [6].

The influencing factors of pro-environment behavior are discussed from different perspectives. The influencing factors of pro-environment behavior are mainly divided into personal and situational factors. Personal factors include demographic variables [7-9], environmental concern [10], value [11], emotion [12], motivation [13], and environmental knowledge [14, 15]. Situational factors include the system [16], the economy [17], and social culture [18, 19]. However, most research has concentrated on offline behaviors rather than online

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ones.

The popularity of Internet technology has made people's lives increasingly embedded in the network, and green mobile phone applications have become a powerful tool to encourage consumers to practice an online green lifestyle [20]. Ant Forest is China's well-known green small program, launched by Alipay. Small programs are generally embedded in the app and do not require users to download. The small program has the advantages of low technical difficulty, short cycle, and low production cost. Ant Forest is a public welfare project that aims to drive the public to reduce carbon emissions. Each person's low-carbon behaviors can be counted as "green energy" in Ant Forest. "Green energy" accumulates to a certain extent, and you can use your mobile phone to apply for a real tree to be planted in an area in urgent need of ecological restoration. By the end of July 2019, Ant Forest had more than 500 million users.

The research on Ant Forest mainly focuses on the user's motivation [21, 22], the user's adoption [23], the user's continuous behavior [24, 25], user retention [26], and the impact of gamification on pro-environmental behavior [27, 28]. Perceived interactivity is a critical mobile internet [29]. Whether perceived interactivity has an impact on users' pro-environmental behavior is unknown. The research objective is to fill the gap by addressing the question:

RQ: How does perceived interactivity foster pro-environmental behavior?

This study is based on the S-O-R model [30] to investigate the impact of perceived interactivity on pro-environmental behavior. The three dimensions of perceived interactivity are control, responsiveness, and connectivity. The validity of the research model was verified with an online survey by the Ant Forest users.

The theoretical contributions of this study are as follows: Firstly, it contributes to the advancement of the theory concerning users' pro-environmental behavior. Secondly, this study provides novel insights into the literature on user engagement.

The research comprises the following components: Firstly, constructing the theoretical model and proposing research hypotheses; secondly, outlining the research methodology; thirdly, presenting and discussing the research findings; and finally, drawing conclusions from the research. Besides advancing our theoretical and empirical understanding of how perceived interactivity may impact users' pro-environmental behavior.

Literature Review

Stimulus-Organism-Response Model

The S-O-R theory posits that external stimuli impact the organism, and following the organism's emotional processing mechanism, these stimuli manifest through the organism's behavior, which encompasses approach and avoidance responses [30]. This theory finds broad application across various domains, including information systems, e-commerce, marketing, tourism, and hospitality [31-34]. Prior research supports the suitability of the S-O-R model for analyzing product attributes and their influence on user behavioral responses [34]. In this study, perceived interactivity serves as the stimuli, while user engagement, user satisfaction, and brand love are considered as cognitive and emotional variables of the organism. Additionally, user stickiness and pro-environmental behavior are treated as intention variables. The theoretical model under investigation is illustrated in Fig. 1.

Pro-Environment Behavior

The global environmental crisis has garnered widespread attention from nations worldwide, emerging as a paramount issue of our time. The investigation

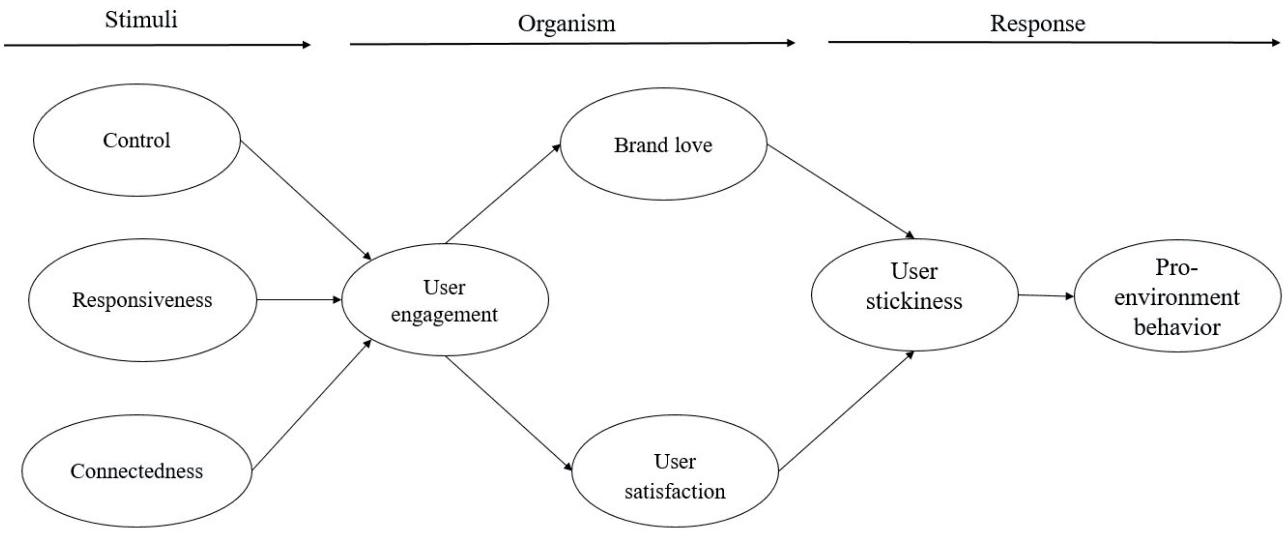

Fig. 1. Theoretical model.

into pro-environmental behavior constitutes a vast and comprehensive field spanning diverse disciplines and viewpoints, with the overarching goal of comprehending and fostering behaviors conducive to environmental well-being. Pro-environmental behavior research encompasses the exploration of concepts, dimensions, and influencing factors, delving into various facets of human interaction with the environment.

Pro-environment behavior is a complex concept. Researchers have defined pro-environment behavior from different angles. Scannell and Gifford [35] believed that pro-environmental behaviors refer to those that can reduce environmental harm and improve environmental conditions. Lee et al. [7] defined pro-environmental behaviors as those that reduce environmental impacts, commit to environmental protection, and conduct activities that do not interfere with ecosystems or the biosphere. Khashe et al. [36] defined pro-environmental behaviors as the behaviors in that individuals participate in green activities to promote sustainable development and reduce or eliminate negative impacts on the environment. Kurisu et al. [37] define pro-environmental behavior as the behavior that actually contributes to environmental protection or is believed to be able to contribute to environmental protection from the perspective of goal orientation and fact orientation. Zhou et al. [27] considered pro-environment behavior to refer to individual actions that benefit the environment, such as low-carbon behavior and environmental conservation.

Debate persists regarding the framework of pro-environmental behavior. Certain researchers view it as unidimensional, focusing on singular behaviors as the subject of study [27]. Conversely, other scholars argue for a multidimensional approach, positing that pro-environmental behavior comprises various facets and dimensions [38].

Various perspectives are explored regarding the factors influencing pro-environmental behavior, which are broadly categorized into personal and situational factors. Personal factors encompass demographic variables [7-9], environmental concern [10], values [11], emotions [12], motivation [13], and environmental knowledge [14, 15]. Situational factors include the system [16], the economy [17], and social culture [18, 19]. Nonetheless, research has predominantly focused on offline behaviors rather than online behaviors.

Hypothesis Development

Perceived Interactivity and User Engagement

From a perception-based perspective, perceived interactivity is defined as a psychological state experienced by users during their interaction with a site [39]. Perceived interactivity is a multidimensional concept, and there are specific differences in its interpretation due to varying research backgrounds. According to Hoffman and Novak, the dimensions of perceived interactivity can be divided into user-to-system and user-to-user [40]. Aligning with the perspective of Hoffman and Novak, this study focuses on exploring the roles of user-to-system (control and responsiveness) and user-to-user (connectivity) [40].

User engagement is an ideal human response to computer-mediated activities [41]. Users are engaged when information systems captivate and hold their attention and interest [42]. Scholars have not reached a consensus on the dimension of user engagement. Some scholars believe user engagement is a single construct [43]. Some scholars believe user engagement is multidimensional [26, 33, 44]. In line with Alzubaidi et al., this study considers user engagement as a unified construct [43].

Control refers to the target behavior that information system users perceive to be easy to execute, reflecting on previous experiences and anticipating obstacles in using the information system [45]. It includes convenient navigation and management of information on mobile through a menu [46]. Complexity will reduce the psychological engagement of users [47]. Therefore, on the contrary, the better the user's control over the information system, the easier it is for them to engage in it. Some scholars found that control can positively impact customer engagement [48]. Hence, we hypothesize that control positively influences user engagement:

H1: Control is positively related to user engagement.

Responsiveness refers to the degree to which users perceive the appropriateness and relevance of the response communication [49]. With high responsiveness, users feel they are emotionally and socially connected on the interactive platform [50]. The previous study found that responsiveness positively impacts customer engagement [48]. Therefore, we propose a hypothesis that responsiveness influences user engagement positively:

H2: Responsiveness is positively related to user engagement.

Connectivity refers to a platform's ability to provide users with a sense of connection to the outside world [51]. With the technological reassessment of Web 2.0, online communities have gained prominence among consumers and marketers alike [34]. Connectivity lets parties find other clients who share their interests, values, and experiences [50]. Social interaction has been identified as a critical driver of customer engagement [52]. Thus, we posit a hypothesis that connectivity impacts user engagement:

H3: Connectivity is positively related to user engagement.

User Engagement, Brand Love, and User Satisfaction

Brand love refers to the passion, attachment, and positive evaluation of a brand [53]. Brand love manifests in consumers' desire to maintain a long-term relationship with the brand [54]. Some scholars thought brand love could be applied to other areas [55]. In our research, brand love is applied in the context of Ant Forest. Consumers have different attitudes towards products/items, shaping their self-concept and fostering attachment through engagement [56]. Batra et al. [57] discovered that active engagement with a brand amplifies brand love, while Loureiro et al. [56] observed that online brand engagement influences brand love. Thus, we propose the following hypothesis:

H4: User engagement is positively related to brand love.

User satisfaction is a widely adopted concept for evaluating the effectiveness of information systems [58]. User satisfaction can be defined as the extent to which users perceive that an information system meets their needs [59]. User satisfaction is defined as the subjective evaluation of various consequences of information systems use [60]. Fang et al. [33] suggested that an engaging experience with a smartphone app may influence user satisfaction. Other scholars have also confirmed the positive impact of engagement on user satisfaction [34, 61, 62]. Consequently, we posit the following hypothesis:

H5: User engagement is positively related to user satisfaction.

Brand Love, User Satisfaction, and User Stickiness

User stickiness refers to the ability to attract and retain users [63]. Stickiness is defined as a user's willingness to use a site more often or to stay longer [29]. Previous studies have confirmed the relationship between brand love and brand loyalty [57, 64], indicating that brand love can trigger customers to consistently use products or services. Some scholars found that users' love of the health and fitness app positively influences stickiness intention [65]. It can be inferred that brand love may lead to users frequently visiting the platform, influencing user stickiness.

Specifically, higher satisfaction can help establish and maintain stickiness and loyalty, while dissatisfaction may lead individuals to discontinue using the product or service [66]. Prior research has also affirmed that satisfaction plays a pivotal role in influencing user stickiness [67-71]. For instance, Wang et al. found that user satisfaction significantly influences the stickiness of users to group-buying websites [67]. Several studies have validated that user satisfaction can influence their stickiness to online communities [68-70]. Some scholars demonstrated that user satisfaction with the app impacts their stickiness [71]. Hence, the following hypotheses are established:

H6: Brand love is positively related to user stickiness.

H7: User satisfaction is positively related to user stickiness.

User Stickiness and Pro-Environment Behavior

Pro-environment behavior refers to individual actions that benefit the environment, such as low-carbon behavior and environmental conservation [27]. Pro-environmental behavior is often introduced to emphasize individuals' positive and beneficial attitudes and behavioral tendencies towards environmental conservation and the entire human ecosystem [72]. Ant Forest is a pro-environmental mini-program that fosters environmental awareness while users play games. Users actively participate in Ant Forest activities, leading to a greater likelihood of exhibiting positive environmental behaviors offline [6]. Therefore, the following hypotheses can be formulated:

H8: User stickiness is positively related to pro-environment behavior.

Experimental Procedures

Data Collection and Procedure

Ant Forest's users are mainly Internet users, so we collect questionnaires through online surveys. We published our questionnaires on Wenjuanxing (www.wjx.cn), which is the largest questionnaire distribution platform in China. Questionnaire links are shared with potential respondents via Wechat (China's largest social networking app). The survey was conducted between January 16 and 24, 2024. Ultimately, we received 406 completed questionnaires, of which 336 met our criteria for validity. The demographic profile of the respondents is detailed in Table 1.

Measurement

Since the respondents were all from China, we translated the scale into Chinese and then adopted the back-translation method. A translator with good language skills was asked to translate the scale back. Each latent variable was measured using a Likert 5 scale, from 1 for "strongly disagree" to 5 for "strongly agree". Perceived interactivity was measured using ten items: three items for control [46], three items for responsiveness [46], and four items for connectivity [73]. Three items were used to measure user engagement [33, 47]. Three items were used to measure brand love [64]. Three items were used to measure user satisfaction [74]. Three items were used to measure user stickiness [75]. Seven items were used to measure Pro-environment behavior [43, 76].

Control Variables

Previous studies have found that demographic variables such as gender, age, education, and income impact pro-environment behavior [77, 78], so these variables were selected as control variables.

Table 1. Sample description.

Feature	Classification	Number	Percentage (%)
Gender	Female	193	57.4
	Male	143	42.6
Age	18-25	39	11.6
	26-35	119	35.4
	36-45	66	34.3
	46-55	66	19.6
	55>	21	6.3
Education	Junior middle school and below	37	11.0
	High school/Technical school	111	33.0
	Undergraduate/Associate Degree	151	44.9
	Postgraduate Degree	37	11.0
Monthly salary	<3000¥	61	18.2
	3000-6000¥	84	25.0
	6001-9000¥	92	27.4
	9001-12000¥	76	22.6
	>12000¥	23	6.8

Data Analysis Technique

Partial Least Squares (PLS) have certain advantages in solving structural equation models and have gained attention from researchers in fields such as marketing and management [79]. In this study, we adopt the Partial Least Squares Structural Equation Modeling (PLS-SEM) method based on principal components and utilize Smart PLS 3.3.3 software to examine the measurement model and test research hypotheses. The primary considerations for this choice are twofold. First, PLS-SEM is suitable for exploratory research and theory building [80]. Second, PLS-SEM, utilizing the Partial Least Squares method based on the principal components of variables, maintains robust computational results even when dealing with complex models, ensuring maximum predictive efficiency [81].

Results

Common Method Variance

As our studies relied on self-reported data, the potential for common method bias exists. We conducted Harman's single-factor test for common method bias to address this concern. All scale items underwent factor analysis without rotation. Results revealed that the largest factor accounted for 37.06% of the variance, which falls below the threshold value of 50% [82]. Hence, it can be inferred that common method bias did not significantly influence the study's results.

Reliability and Validity Analysis

Construct reliability is assessed using Cronbach's alpha and composite reliability (CR) [80]. Cronbach's alpha values for all variables range from 0.812 to 0.915, while CR values range from 0.893 to 0.932, all surpassing the threshold of 0.7 [80]. Detailed results can be found in Table 2.

The convergent validity of constructs is assessed through factor loading and the average variance extracted (AVE). Factor loading values fall within the range of 0.767 to 0.887, while AVE values range from 0.663 to 0.761, all exceeding the threshold of 0.5 [83]. The square root of the AVE surpasses the correlation coefficient between constructs, indicating that discriminant validity is adequately demonstrated [83].

Structural Model Analysis

All path coefficients (H1-H8) were statistically significant, and the study's path coefficients are shown in Table 4 and Fig. 2. The findings indicate that control, responsiveness, and connectivity exhibit positive relationships with user engagement, thereby confirming H1, H2, and H3. Moreover, user engagement demonstrates positive associations with brand love and user satisfaction, thus supporting H4 and H5, respectively. Furthermore, the study reveals that brand

Table 2. Measurement Model Statistics.

Variables	Items	Loadings	AVE	CR	Cronbach coefficients
Control	The menu of Ant Forest is very easy to understand	0.874	0.767	0.908	0.849
	I quickly learned how to operate the Ant Forest	0.887			
	I can manage the information on Ant Forest well	0.867			
Responsiveness	Ant Forest responds quickly to input	0.875	0.738	0.894	0.823
	Ant Forest responds quickly to my needs	0.841			
	Ant Forest has a fasting loading speed	0.860			
Connectedness	Ant Forest encourages interaction among its users	0.828	0.709	0.907	0.864
	Through Ant Forest, I can interact with others	0.851			
	By following Ant Forest, I can keep track of other people or events	0.841			
	Through Ant Forest, I feel like I can be part of a discussion about something	0.847			
User Engagement	When I use Ant Forest, I feel strong and energetic	0.821	0.727	0.889	0.812
	I am passionate about using Ant Forest	0.859			
	The Ant Forest is very attractive and immersive	0.876			
Brand love	Ant Forest means a lot to me	0.830	0.731	0.891	0.820
	The Ant Forest is meaningful to me	0.845			
	I think Ant Forest is a part of my life	0.888			
User satisfaction	I am very satisfied with Ant Forest meeting my needs	0.838	0.741	0.896	0.825
	I am satisfied with the effectiveness of Ant Forest	0.878			
	I am very satisfied with the efficiency of Ant Forest	0.865			
User stickiness	I use Ant Forest more often	0.865	0.747	0.898	0.830
	The frequency of my usage of Ant Forest will increase	0.852			
	I spend more time using Ant Forest	0.875			
Pro-environment behavior	I have a duty to care for the natural environment	0.778	0.663	0.932	0.915
	I intend to buy eco-friendly products in the future.	0.846			
	I will try to buy eco-friendly products in the future.	0.826			
	I plan to buy eco-friendly products in the future.	0.851			
	I intend to buy eco-friendly products in the future.	0.767			
	I will try to buy eco-friendly products in the future.	0.835			
	I plan to buy eco-friendly products in the future.	0.792			

love and user satisfaction positively influence user stickiness, thereby correlating H6 and H7. Lastly, user stickiness is positively associated with pro-environment behavior, thus validating H8.

Discussion

Based on the S-O-R model, this study examines the influence of perceived interactivity on pro-environmental behavior and presents the following findings:

Firstly, the results confirm that the dimensions of perceived interactivity (control, responsiveness, and connectedness) positively impact user engagement, with connectivity exerting the most significant influence. The findings demonstrate that user-to-system and user-to-user interactions contribute to user engagement [26]. Secondly, the study reveals that user engagement correlates positively with brand love and user satisfaction. These results underscore the importance of user engagement as a key determinant of both user satisfaction and brand affection, aligning with prior

Table 3. The Results of Discriminant Validity.

Constructs	1	2	3	4	5	6	7	8
Control	0.876							
Responsiveness	0.294	0.859						
Connectedness	0.411	0.427	0.842					
User Engagement	0.438	0.465	0.545	0.864				
Brand love	0.356	0.335	0.387	0.349	0.855			
User satisfaction	0.302	0.402	0.368	0.399	0.286	0.853		
User stickiness	0.341	0.426	0.368	0.478	0.323	0.454	0.861	
Pro-environment behavior	0.330	0.404	0.457	0.455	0.419	0.452	0.477	0.814

Table 4. The results of the structural model.

Hypotheses	Path	Path coefficients
H1	Control → User engagement	0.221^{***}
H2	Responsiveness → User engagement	0.251^{***}
H3	Connectedness → User engagement	0.347^{***}
H4	User engagement → Brand love	0.399^{***}
H5	User engagement → User satisfaction	0.349^{***}
H6	Brand love → User stickiness	0.211^{***}
H7	User satisfaction → User stickiness	0.394^{***}
H8	User stickiness → Pro-environment behavior	0.479^{***}

Notes: $^{*}P<0.05$; $^{**}P<0.01$; $^{***}P<0.001$

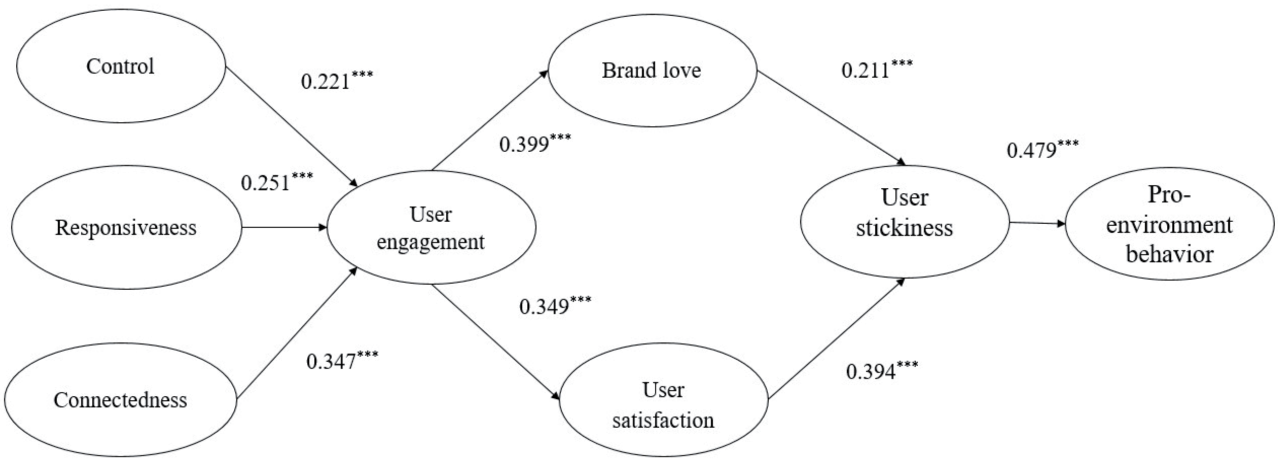

Fig. 2. Path analysis of the structural model.

research [34, 47, 65, 84]. Thirdly, brand love and user satisfaction positively influence user stickiness. The findings suggest that fostering affection for Ant Forest and enhancing user satisfaction can bolster user stickiness, corroborating previous studies [57, 64, 65]. Furthermore, the stronger the user's affinity for Ant Forest, the greater the enhancement in user stickiness, consistent with existing literature [67-71]. Finally, user stickiness demonstrates a positive association with pro-environmental behavior. This outcome empirically supports the notion that online pro-environmental behavior can catalyze offline pro-environmental actions, suggesting that long-term users of Ant Forest are motivated by its environmental consciousness, leading them to partake in offline pro-environmental behaviors. The result provides empirical support for his point of view that online pro-environment behaviors have spillover effects, stimulating offline pro-environment behaviors [85].

For the first time, this study explores the impact of perceived interactivity on Ant Forest user stickiness and pro-environment behavior and finds that it has important theoretical contributions.

First, it adds to the growth of the theory of users' pro-environmental behavior. Most recent environmental research has focused on offline pro-environment behaviors, such as energy saving behaviors [86] and buying green products [87]. Some studies have started to get involved in the pro-environment behavior of users on online platforms [27, 28]. Ant Forest is a new small green program that innovatively combines online and offline environmental activities to propose a new environmental paradigm. This study explores how the perceived interactivity of online platforms affects users' offline environmental behaviors.

Second, this study adds new insights into user engagement literature. Previous research focused on the user's adoption [23], the user's continuous behavior [24], and user retention [26], and research has placed an insufficient emphasis on user engagement. This study reveals the antecedents and consequences of user engagement from the perspective of perceived interactivity.

Some measures can promote users' pro-environmental behavior. Firstly, to enhance control, consider the following aspects: On the one hand, optimize the user interface, ensuring a clear and straightforward layout while avoiding intricate designs. On the other hand, simplify the operational processes, making them easily understandable and user-friendly. Guide new users through simple tutorials or tips, aiding them in grasping the application's basic functions and operational methods, thereby minimizing confusion during initial use. Secondly, to improve responsiveness, operators can start by optimizing the performance of their systems. Refine application code and server performance to reduce load and response times. This involves code streamlining, minimizing unnecessary resource loads, and utilizing appropriate database indexes. Thirdly, the cooperative tree planting function was launched. Allow users to invite friends, family, or other users to collaborate on planting trees. Cooperative planting of trees can increase communication and cooperation between users and allow users to have more fun and a sense of achievement in planting trees.

There are still some shortcomings in this study, which provide a blank for future exploration. First, the sample mainly consists of Chinese users and lacks user groups from other countries, affecting the research results' validity. Future research samples will increase the number of users in their national population. Second, the research data comes from a questionnaire survey with a single data type. In the future, multiple data types will be added to the research design. Third, the cross-section data obtained by the questionnaire survey can't effectively verify the causal relationship between variables. When conditions permit, longitudinal studies can be carried out.

Conclusions

This study addresses the increasingly crucial need for pro-environmental behavior amidst worsening environmental pollution. It highlights the significant role of mobile mini-programs in promoting such behavior yet underscores the scarcity of research investigating the impact of perceived interactivity on pro-environmental behavior. Following the Stimulus-Organism-Response (S-O-R) model, the study probes into this relationship. Several key findings emerge from a questionnaire survey involving 336 Ant Forest users and employing the partial least squares method for data analysis.

Firstly, control, responsiveness, and connectivity positively impact user engagement. Secondly, user engagement is found to be significantly associated with both brand love and user satisfaction. Lastly, brand love and user satisfaction notably contribute to user stickiness, consequently fostering pro-environmental behavior. This research marks a pioneering effort to explore the nexus between perceived interactivity and pro-environmental behavior, shedding light on crucial insights for environmental advocacy and digital interface design.

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Conflict of Interest

The authors declare no conflict of interest.

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