The impact mechanism of perceived AI interaction style on citizen experience of innovative smart cities in China

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***Abstract*—China's innovative smart cities face urgent challenges of low citizen experience and participation rates, necessitating a transition from government-led to market-driven development. While existing research predominantly examines macro-level development status and evaluation systems, this study addresses the micro-level gap by investigating how perceived AI interaction styles (task vs. social) influence citizen experience through a structural equation model (SEM) based on first-hand survey data from more than 300 citizens in smart Guangzhou. The results reveal that citizen adjustment fully mediates both interaction styles' impact on citizen experience. Brand involvement amplifies these effects, with higher involvement strengthening the mediation pathways. Theoretically, this research integrates Sociotechnical Systems Theory and Brand Community Theory to propose a novel "Technology – Emotion - Community" framework, advancing scholarly understanding of human-AI synergy in urban governance. Practically, it guides policymakers to resolve citizen experience dilemmas by advocating differentiated AI strategies, thereby accelerating market-oriented smart city transitions through stakeholder collaboration.**

***Keywords*—impact mechanism; perceived AI interaction style; citizen experience; innovative smart cities; smart Guangzhou**

I. INTRODUCTION

As China advances its "Digital China" strategy, innovative smart cities have emerged as a cornerstone for enhancing governance efficiency and urban livability. An innovative smart city is a new form or model of urban development that focuses on improving people's happiness and satisfaction, comprehensively promoting deep integration of the new generation of information technology with urban development and realizing urban smart reform and innovation [1]. As the weight of citizen experience in Innovative Smart City Evaluation Indicators was increased from 20% to 40% in 2022[2], citizen experience has become a decisive factor of citizen participation in innovative smart cities. [1]

However, two critical challenges persist: (1) suboptimal citizen experiences leading to low participation rates—a stark contrast to global counterparts like London and Tokyo[3]; (2) an overreliance on government-led development models that hinder market-driven sustainability of smart cities. Recent advancements in artificial intelligence (AI) offer a promising solution by enabling interactive communication between citizens and smart city systems. Yet how perceived AI interaction styles shape citizen experiences? Addressing this issue is of significant practical importance to address two critical challenges above.

Domestic scholarship has focused on macro-level development[4] and standardized evaluation systems[5] of smart cities, yet overlooks the psychological mechanisms underlying citizen-AI interactions. International studies emphasize service quality[6] and service design[7], yet lack contextual relevance to China's unique sociopolitical landscape. Theoretically, extant frameworks overlook synergies between sociotechnical systems theory (STS) and brand community theory (BCT), leaving unexplored how AI interactions synergize technological functionality with emotional bonding.

To bridge these gaps, this study adopts a mixed-methods approach grounded in structural equation modeling (SEM) to explore the psychological impact mechanism of perceived AI interaction style (task-oriented vs. social-oriented) on citizen experiences of Smart Guangzhou. The reason for sampling Guangzhou is that it has made significant achievements on the development of smart governance through the application program named 'Sui is easy to handle'. Data were collected through a stratified survey of more than 300 Guangzhou residents. Results reveal that citizen adjustment fully mediates perceived AI interaction styles' impact on citizen experience. Brand involvement amplifies these effects, with higher involvement strengthening the mediation pathways.

II. CONCEPTS AND HYPOTHESES

A. Concepts

Perceived interaction refers to the degree to which individuals perceive that communication allows them to feel in control as if they can communicate synchronously and reciprocally with the communicator[8]. As one of the two dimensions of perceived interaction, perceived AI interaction

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style refers to the mode, ritual, and style adopted by buyers and sellers in the interaction process in the context of marketing and is divided into three types – task-oriented interaction, in which the focus is on the efficiency of completing tasks, interaction-oriented interaction, in which personalization and socialization are regarded as essential elements of interaction, and self-directed interaction, in which individuals only pay attention to their interests[9]This classification emphasizes consumers' subjective perceptions of how they interact with the service providers. In multidimensional situations, such as sales and service, perceived AI interaction styles can be divided into active and responsive [10], reflecting the timeliness of the interaction between the service providers and the customers. In the context of online shopping, the interaction between AI shopping assistants and customers can be divided into two types – task-oriented and social-oriented interaction; the former provides task-oriented guidance information, whereas the latter includes informal dialogue in addition to the guidance information related to task completion[11]. Since virtual information technologies, such as AI, are increasingly applied in the interaction between innovative smart cities and citizens, this study defines the perceived AI interaction style as the mode and style perceived by citizens, which can be divided into two styles – task-oriented and social-oriented. Task-oriented interaction refers to the guiding of online information communication between AI assistants and citizens to complete task objectives, such as task issuance and operation instructions, while social-oriented interaction refers to the relational information communication between AI assistants and citizens in addition to completing task objectives, such as encouraging conversation and emotional exchange.

The concept of citizen adjustment originates from newcomer adjustment in organizational behavior research, which refers to the task and social transformation process of new employees acquiring knowledge and skills and understanding the organization's expected behavior patterns [12]. This includes three elements – role clarification (the new employee understands the tasks to be completed and is clear about his/her responsibilities), self-efficacy (the new employee learns to complete the tasks and gains confidence in performing the job role) and social acceptance (the new employee feels appreciated and trusted by his or her colleagues)[13]. Feldman [13] further applies the concept of newcomer adjustment to marketing and believes that the process of consumer adjustment is similar to newcomer adjustment, which includes the three elements – role clarification (customers receive certain services and understand their roles or expectations), self-efficacy (customers acquire the necessary knowledge and skills for consumption) and social acceptance (consumers have a pleasant feeling of being accepted and recognized by peers). In the context of smart city, Wang et al. [14] investigate citizen acceptance of smart city technologies (e.g., real-time navigation, bike-sharing systems) and reveal that privacy concerns and system usability are the primary determinants of adoption. González et al.[15]examines how citizen participation influences adaptive governance in smart cities, focusing on Barcelona's IoT-based environmental sensor network. Like the employees in an organization, citizens in a smart city also need to go through the adjustment process to better complete task participation and social transformation. Therefore, this study applies the concept of newcomer adjustment to the construction of innovative smart cities and proposes the concept of citizen adjustment. This is defined as the social transformation process in which citizens, as participants in innovative smart cities, understand the task of building these cities (i.e., role clarification), acquire the knowledge and skills to complete the task (i.e., self-efficacy) and feel accepted and recognized by stakeholders (i.e., social acceptance).

The concept of experience originated in philosophy and psychology and was later introduced into economics and management. From a psychological perspective, experience is closely related to flow, which can be defined as an individual's internal experience, that is the psychological feeling of an individual immersed in an activity [16]. From an economic perspective, experience is the psychological crystallization of goods and services, which has economic value [17]. From a marketing perspective, experience is a psychological feeling or internal reaction generated by consumers after receiving stimulation from various marketing activities [18]. Scholars have studied similar concepts, such as product, service, and brand experience. However, research on the concept of citizen experience in the field of urban management is limited. For example, Zhu et al. [6] combined the flow experience with a smart city system and concluded that the citizen experience of a smart city is a citizen's psychological feeling concerning the smart city system, including immediate and continuous experience. Abella et al. [7] noted that citizen experience refers to their perceptions of smart city services. Since citizens are the main builders and service targets of innovative smart cities in China [18], this study defines the citizen experience of an innovative smart city as a psychological perception or emotional response generated by citizens' participating in the service process of China's innovative smart city construction..

B. Hypotheses

For online interaction, both technical human-computer interaction and emotional interpersonal interaction can reduce consumers' perceived risks and enhance their emotional value [20]. Moreover, both task- and interaction-oriented activities positively affect consumer experience[21]. In the context of service interaction, service providers, focusing on consumer demand and feedback and trying to establish friendly relationships with consumers, greatly affect consumers' perceptions of cost or utility and elicit a series of value perceptions, such as satisfaction, pleasure, and positive utility[22]. In the context of public crises, the content and credibility of smart city information communication, as perceived by citizens, has a positive impact on their continuous flow experience[6]. Zhao et al., [23] revealed that immersive technologies like VR can result in increased public participation rates by 68% and reduced project delays by 30%. Accordingly, the following hypotheses are proposed:

Hypothesis 1(H1): Perceived AI interaction style positively affects citizen experience with innovative smart cities.

Hypothesis 1a(H1a): Task-oriented interactions positively affect citizen experience with innovative smart cities.

Hypothesis 1b(H1b): Social-oriented interactions positively affect citizen experience with innovative smart cities.

In the context of service marketing, social and functional interactions between online service agents and new customers have a significant positive impact on the adjustment levels of new customers[24]. During service contact, active task-oriented interactions of service providers enhance consumers' knowledge acquisition and sense of control over the process[25]. In the context of online shopping, task- and social-oriented interactions of AI shopping assistants have different impacts on the social and functional perceptions of the elderly[11]. Further, Chen et al.,[26]demonstrates emotion-aware AI systems can significantly improve urban mental health outcomes in urban areas. Based on the above research, both task- and social-oriented interactions perceived by citizens may positively affect their self-adjustment process. Therefore, the following hypotheses are proposed:

Hypothesis 2(H2): Perceived AI interaction style positively affects the level of citizen adjustment.

Hypothesis 2a(H2a): Task-oriented interactions positively affect citizen adjustment.

Hypothesis 2b(H2b): Social-oriented interactions positively affect citizen adjustment.

In the context of organizational behavior, the level of newcomer adjustment has a positive impact on job performance and employee satisfaction[12]. The organizational socialization strategy related to newcomer adjustment positively affects the information acquisition ability of new employees and, thus, positively influences their work attitude[27]. In the marketing context, consumers' adjustment positively affects their functional and emotional value perceptions[28]. Therefore, the higher the citizen's adjustment to an innovative smart city, the easier it is to generate positive emotional experiences and the higher the citizen satisfaction. Based on this, the following hypothesis is proposed:

Hypothesis 3 (H3): The level of citizen adjustment positively affects their experiences of innovative smart cities.

In the context of service marketing, both social and functional interactions between online banking agents and new customers have a positive and significant impact on customers' adjustment processes, thus, affecting their response to marketing[24]. Moreover, the newcomer adjustment process in interactive contact can enhance (or weaken) consumers' positive psychological feelings, thus, affecting their perception of experience value[28]. Studies have pointed out that newcomer adjustment has a partial mediating effect on the relationship between perceived AI interaction styles and experience value[21]. Therefore, task- or social-oriented interactions between innovative smart cities and citizens will enhance the citizen adjustment level to further optimize their experience. Therefore, the following hypotheses are proposed:

Hypothesis 4 (H4): Citizen adjustment mediates the relationship between perceived AI interaction style and citizen experience.

Hypothesis 4a (H4a): Citizen adjustment mediates the relationship between task-oriented interactions and citizen experience.

Hypothesis 4b (H4b): Citizen adjustment mediates the relationship between social-oriented interactions and citizen experience.

Brand involvement is an intentional factor that reflects the relevance and importance of consumer perceptions of a target brand. The higher its value, the more likely the consumers are to generate or maintain interest in a brand[29]. According to the heuristic or systematic information processing model (HSM), individuals with high involvement are more sensitive to functional information and more inclined to systematic information processing, while individuals with low involvement are more sensitive to empirical information and more inclined to heuristic information processing[29][30]. In addition, for consumers with high involvement, social-oriented interactions, focusing on consumer demand and feedback, can meet their information search needs, help them make accurate decisions and enable them to generate stronger, smoother, and happier psychological cognitions and a sense of efficient returns. However, consumers with low involvement have weak motivation and a need to gather information and the experience value produced by task-oriented interactions is not sufficiently strong[21]. Therefore, when the city brand involvement of citizens is higher, the functional information provided by task-oriented interaction is easier to process, resulting in a higher level of citizen adjustment and further citizen experience. However, when the city brand involvement of citizens is lower, the functional information provided by task-oriented interaction is not easily processed, which means that the level of citizen adjustment is lower, thereby weakening the citizen experience. Nonetheless, when citizens' brand involvement is higher, the task and relationship information provided by social-oriented interactions are more likely to be systematically processed so that citizens have a higher level of adjustment, thereby, optimizing their experience. When citizens' brand involvement is lower, the level of citizen adjustment caused by social-oriented interaction is lower and citizens' experience is worse. Therefore, the following hypotheses are proposed:

Hypothesis 5 (H5): Brand involvement moderates the mediating role of citizen adjustment in the relationship between the perceived AI interaction style and citizens' experience, which is a moderated mediating effect in the first stage.

Hypothesis 5a (H5a): Brand involvement positively moderates the mediating effect of citizen adjustment on the relationship between task-oriented interactions and citizens' experience.

Hypothesis 5b (H5b): Brand involvement positively moderates the mediating effect of citizen adjustment on the relationship between social-oriented interaction and citizens' experience.

The conceptual model proposed is presented in Figure 1.

III. METHODS

A. *Variable measurement*

The measurement of the two styles of perceived interaction used the maturity scale developed by Williams and Spiro [31] and each style used three measurement items.

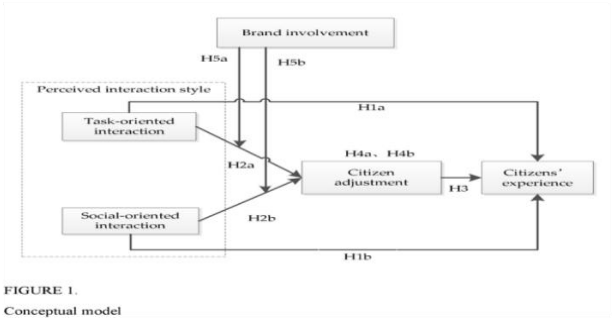

FIGURE 1.
Conceptual model

To measure citizen adjustment, reference was made to the three-dimensional combination scale of social acceptance, role clarification and self-efficacy developed by Bauer et al.[12], with 10 measurement items. Brand involvement was measured with the maturity scale developed by Petty et al., [32], with three measurement items. Based on a maturity scale including four dimensions (sensory, affective, intellectual, and behavioral) developed by Brakus et al.[33], this study developed a citizen experience measurement scale for innovative smart cities by combining the opinions of three experts in the field of smart cities. A small-sample pre-test was used to determine a formal scale with eight measurement items after twelve were initially. All of the questions were evaluated on a Likert scale, with values ranging from 1 to 5, representing completely disagree, strongly disagree, unsure, strongly agree and completely agree, respectively..

B. Small-sample pre-test

The pre-test was conducted using snowball sampling of college students on campus in early November 2023, and 70 valid questionnaires were collected. SPSS 22.0 was used to conduct exploratory factor analysis on perceived AI interaction style, citizen adjustment and citizen experience. The Kaiser-Meyer-Olkin (KMO) test values of all the above three variables were greater than 0.80 and Bartlett's test was significant (α<0.001), indicating that the samples were suitable for exploratory factor analysis. Therefore, principal component analysis was selected, orthogonal rotation was performed using the maximum variance method and the cumulative variance contribution rate was above 60%. Most measurement items had factor loadings greater than 0.70, except for a few items with factor loadings greater than 0.50 but less than 0.70. These results indicate that the scales of the majority variables had good validity. The internal consistency Cronbach's α coefficients of the above three variables are greater than the recommended value of 0.70, indicating that the scales adopted in this study have good reliability. In addition, the reliability and validity indicators of brand involvement reached acceptable standards.

C. Questionnaire design and formal data collection

The research questionnaire consisted of five parts with 34 questions. First is the introduction, including the investigation background and the completion instructions. Second, is a screening question that primarily examined respondents' living period in Smart Guangzhou. The third consists of subjective content, which includes 27 items measuring perceived AI interaction style, citizen adjustment, citizen experience and brand involvement. Fourth contains the sample's demographic characteristic items, including gender, age, monthly income after tax, education, and occupational status. Fifth is the conclusion and acknowledgement.

A formal survey was conducted from November to December 2023. The respondents were randomly invited to complete the questionnaire through the online survey platform with the cash reward of 20 RMB as a fixed reward plus randomized lottery entries (10% chance of 20 RMB) after completing the questionnaire items. All of the study design were approved by the Ethics Committee of survey company. After excluding invalid questionnaires, a total of 400 questionnaires were recovered, with 300 valid questionnaires resulting in 75% effective questionnaire recovery rate. The majority of the respondents were female (58%) with fewer males (42%). The age distribution was relatively average, with more people aged 16-25 years (28.3%) and 26-35 years (30%) and fewer people aged 36-45 years (24%) and above (17.7%). Most respondents (83.3%) had a monthly income of less than 10,000 RMB and only 50 (16.7%) earned more than 10,000 RMB. The majority had a bachelor's degree (38%) or a graduate degree or higher (34%). A small number of the participants had junior college degrees (11.3%) or below (16.7%). People from enterprises (42.7%) and university students (33%) comprised the majority, while people from government or public institutions (19.3%) and retirees or freelancers (5%) were relatively few. The majority had lived in Guangzhou for more than six years (59%) or between six months and six years (36.3%). Few people lived in Guangzhou for less than six months (4.7%).

IV. RESULTS AND DISCUSSION

A. Validity and Reliability Analysis

AMOS 22.0 was used to conduct confirmatory factor analysis on the samples collected in the formal investigation. As shown in Table 1, $\chi 2/df$ of the three variables all met the acceptable criteria. Such indices as NFI, CFI, IFI, and GFI were all greater than 0.90 and RMSEA was less than or close to 0.80, indicating that the model fit well. A second-order confirmatory factor analysis was conducted. Except for the three measurement items of the perceived AI interaction style, the first- and second-order factor loadings of all the other measurement items were greater than 0.7. Moreover, the internal consistency Cronbach's α coefficient of each factor of the four variables – perceived AI interaction style, citizen adjustment, citizen experience and brand involvement – was greater than 0.70 and the composite reliability (CR) was greater than 0.60. The average variance extraction(AVE) values of the variables were greater than 0.50, indicating that the scale used in the study had good convergent validity and high reliability. The discriminant validity of the scale was evaluated by comparing the square root of the AVE values of the variables with the correlation coefficient (see Table 2). The square roots of the AVE values of the four variables (values on the diagonal in the table) are greater than the correlation coefficient in the row and column where they are located, indicating that the scale used in this study has good discriminant validity. Therefore, this model can be used for structural model analysis.

B. Hypothesis Testing

AMOS 22.0 was used to perform model fitting on the sample data. The fit indices of the structural equation model are as follows: $\chi 2/df = 612.918/241 = 2.543<3.00$, CFI = 0.920, IFI = 0.920, GFI = 0.858 and RMSEA = 0.073<0.08. These indices indicated that the structural model in this study had a good fit. According to the structural model(see Figure 2), the test results prove that task-oriented interaction has no significant positive impact on citizen experience ($\beta = 0.13$, $p = 0.299$,Cohen's $f^2 = 0.017$). The positive impact of social-oriented interaction on citizen experience was not significant ($\beta = 0.33$, $p = 0.15$, Cohen's $f^2 = 0.122$). Thus, H1a and H1b are not supported. However, task-oriented interaction has a significant positive effect on citizen adjustment ($\beta = 0.33$, $p = 0.01$, Cohen's $f^2 = 0.36$, VIF=2.078); thus, H2a is supported. Social-oriented interaction has a significant positive effect on citizen adjustment ($\beta = 0.66$, $p = 0.000$, Cohen's $f^2 = 1.169$, VIF =2.078), supporting H2b. In addition, citizen adjustment has a positive effect on citizens' experience, with a significant influence ($\beta = 0.53$, $p = 0.031$, Cohen's $f^2 = 0.713$). Thus, H3 is supported.

Citizen adjustment has a significant mediating effect on the relationship between task-oriented interaction and citizens' experience ($\beta = 0.33 \times 0.53 = 0.18$, $p = 0.024$, Cohen's $f^2 = 0.038$), supporting H4a. The mediating effect of citizen adjustment on the relationship between social-oriented interaction and citizen experience is significant ($\beta = 0.66 \times 0.53 = 0.35$, $p = 0.018$, Cohen's $f^2 = 0.277$), supporting H4b. Using the PROCESS Macro for SPSS (Model 4; Preacher et al. [34]), we conducted 5,000-bootstrap resamples to test the significance of the indirect effects. The result of bootstrapping also shows that the indirect effect of citizen adjustment on the relationship between task-oriented interaction and citizen experience is significant at 95% Confidence Interval ($\beta = 0.18$, $p < 0.001$, CI = [0.12, 0.26]). The indirect effect of citizen adjustment on the relationship between social-oriented interaction and citizen experience is significant at 95% Confidence Interval ($\beta = 0.35$, $p < 0.001$, CI = [0.26, 0.46]). In conclusion, direct paths from perceived AI interaction styles to citizen experience are non-significant, while the mediator (citizen adjustment) fully explains the relationship.

Using the PROCESS Macro for SPSS (Model 7; Preacher et al.[34]), we conducted 5,000-bootstrap resamples to test the significance of the moderated mediating effects of brand involvement at 95% confidence interval. As shown in Table 3, task-oriented interaction and brand involvement had significant interaction effects on citizen adjustment ($\beta = 0.157$, $t = 2.877$, $p < 0.01$) and the structural model fit well ($R2 = 0.510$, $F = 99.723$, $p < 0.001$). Moreover, when the value of brand involvement increased from 2.953 to 4.333, the mediating effect of citizen adjustment was significantly enhanced, increasing from 0.240 (CI = [0.1574, 0.3554]) to 0.361 (CI = [0.2648, 0.4669]). In other words, the higher the level of brand involvement, the task-oriented interaction leads to a higher level of citizen adjustment, which produces a better citizen experience and vice versa; thus, H5a is supported. On the other hand, social-oriented interaction and brand involvement had significant interaction effects on citizen adjustment ($\beta = 0.153$, $t = 2.997$, $p < 0.01$) and the structural model fit well ($R2 = 0.573$, $F = 128.734$, $p < 0.001$). Moreover, when the value of brand involvement increased from 2.953 to 4.333, the mediating effect of citizen adjustment was significantly enhanced, increasing from 0.225 (CI = [0.1488, 0.3346]) to 0.317 (CI=[0.2160, 0.4269]). Hence, the higher the brand involvement, the more social-oriented interaction leads to a higher level of citizen adjustment, which produces a better citizen experience and vice versa. Thus, H5b is supported.

B. Discussion

The analysis results of the structural equation model revealed that task-oriented interactions significantly improve citizen adjustment, while social-oriented interactions exert a stronger effect. And citizen adjustment has a significant positive effect on citizen experience. Furthermore, citizen adjustment fully mediates the impact of the two styles of perceived interaction on citizen experience, while the direct effects from perceived AI interaction styles to citizen experience are non-significant. The possible underlying reason is that most of citizens need to get psychological counseling and guidance to reduce their doubts or worries about innovative smart cities, and complete the psychological adjustment process during each style of AI interaction. In addition, citizens' brand involvement with an innovative smart city positively moderates the mediating effect of citizen adjustment on the relationship between the two styles of perceived AI interaction and citizen experience.

C. Discussion

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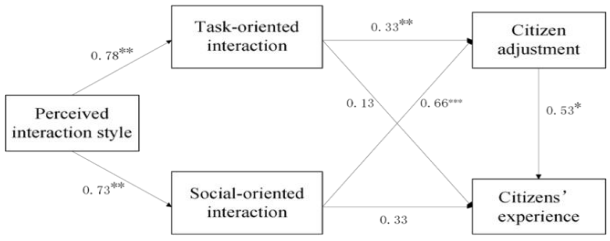

FIGURE 2.
Testing results of structural equation model
Note: ***, ** and * represent p < .001, p < .01, p < .05, respectively.

complete the psychological adjustment process during each style of AI interaction. In addition, citizens' brand involvement with an innovative smart city positively moderates the mediating effect of citizen adjustment on the relationship between the two styles of perceived AI interaction and citizen experience.

Some managerial implications are proposed. From the

policy-level perspective, urban governments should establish a dual-track governance structure to institutionalize AI-driven public services. In terms of task-oriented governance, government should legislate mandatory AI adoption in standardized service delivery, such as welfare distribution, tax filing to ensure procedural fairness. In terms of relational governance, government should embed emotional intelligence requirements into AI ethics guidelines. Besides, urban managers should formulate a local smart city branding strategy which is widely accepted by citizens to unify public perception, with local governments customizing campaigns under central oversight. The ultimate goal of governance is to establish a social collaborative mechanism led by the government and dominated by enterprises and citizens. From the implementation perspective, urban governments and service providers can use AI service assistants to carry out task-oriented information communication, such as deploying government portal chatbots to deliver task-specific guidance on subsidy application via digital citizen profiles, and introducing gamified reward systems to incentivize engagement. In the context of social AI application, they should develop localized interactive mini-programs and emotion-aware interfaces with dialect support, elderly-friendly modes in standard applications, such as voice navigation, simplified menus. Besides, it is necessary to partner with social media influencers to demonstrate AI tools, like TikTok tutorials on subsidy applications, and organize community workshops to showcase AI functionalities, such as senior centers' AI kiosks.

However, we acknowledge the limitations of our study in addressing cross-cultural generalizability and intergroup differences in citizen experience. First, our sample was confined to Guangzhou, which may not capture the diversity of AI interaction styles across China's innovative smart cities. For instance, tech-driven cities like Shenzhen and Shanghai may prioritize efficiency-centric AI tools, whereas culturally heritage-focused cities like Xi'an might favor relational interfaces aligned with local traditions. Second, while our findings on digital communication strategies are context-specific, they may not account for cross-regional variations in digital literacy gradients or institutional trust disparities.

To address these gaps, future research could adopt a multi-group experimental design across five culturally distinct cities (Shenzhen, Beijing, Xi'an, Chengdu, Shanghai) stratified by digital literacy and AI adoption rates. Second, as cultural values significantly shape AI adoption[35], future studies may further replicate our moderated mediation model in individualist cultures to test the generalizability of the brand involvement effect. Employing Hofstede's Cultural Dimensions as a moderating framework, we will analyze how power distance and uncertainty avoidance shape the interplay between AI interaction styles and citizen experience through structural equation modeling. Finally, building on Mahamuni et al.'s[36] vision on machine learning (ML) applications in smart cities, future research could explore how ML-driven smart city solutions can enhance sustainability and efficiency while mitigating privacy risks.

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