Users Adaptation and Infusion of Smart City App

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Abstract. Smart city app is an important link in the process of urban intelligence. However, many users fail to make full use of system functions after adoption. To solve this problem, this paper analyzes the adaptive information behavior of users. It adopts grounded theory-based qualitative research to conduct personal in-depth interviews and focus group interviews with 23 interviewees, and builds a model of influencing factors on the adaptive behavior of smart app users. The research shows that emotional perception, smart environment, users' personal characteristics and non-linear tasks are the main influencing factors on users' adaptive behavior, and technology exploration behavior has a positive effect on technology utilization behavior.

Keywords: Adaptive information behavior · Smart city app · Grounded theory · Process model

1 Introduction

In recent years, with the development of the new generation of information technologies (ITs) such as the IoT, cloud computing and mobile Internet, modern cities are moving forward from digitalization and networking to automation and intelligence. Smart city construction aims to improve the efficiency and transparency of public utilities and services, create a more sustainable urban environment, improve citizens' living standards and quality of life, and promote economic development [1].

The popularity of mobile Internet has impacted the reform of urban management. Smart city apps emerging with mobile Internet have become the main way for citizens to participate in smart city governance. Smart city apps make use of IoT technology devices (such as wireless sensors, GPS, GIS, detector, high-definition camera, etc.) installed on physical infrastructure to realize real-time perception and monitoring of various key data in the city. These IoT data will be transmitted to the cloud backend database in real time, aggregated, processed and analyzed with the data provided by public service departments, and finally delivered to the user. Therefore, compared with the traditional e-government and hospital appointment, the smart city apps take real-time data transmission as the core, and connect the urban IoT and physical infrastructure,

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public service departments and institutions, as well as citizen users, featured with real-time, mobility, integration, etc.

A literature has investigated the smart city apps released by 201 cities with the highest level of smartness in China. The results show that among the 201 cities, local governments of 140 cities have released multiple smart city apps, a total of 333, covering 7 administrative regions in East and South China, with a wide range of distribution. In terms of functions, the apps provide 17 main functions and 52 column settings, covering various areas of civic life such as transportation, medical treatment, payment and appointment. However, the statistics of user ratings of smart city apps show that the average score of 333 apps is 2.99, which is below the median score of 3. In terms of specific scores, 50.5% of the apps are in the low range of 1.0–2.99. The low user ratings means that China's smart city apps currently have low user satisfaction and poor experience. At the same time, the low number of downloads, low loyalty, and the existence of "one-time use" among users are the key to restrict the further development of the apps. "Failed" smart city apps will not only lead to huge waste of hardware infrastructure investment, but also bring negative impact on the life of citizens and the image of local government [2].

As for the smart apps and services in the society, most of the literature focuses on the fields of computer science and artificial intelligence such as system design and algorithm optimization, but rarely discusses the use and participation behavior of users from the perspective of information system (IS). The user behavior of smart city apps has the following two obvious characteristics: First, because of the limitations of usage scenarios, users generally do not use the app again after completing the service or using certain functions, making it a "disposable" app. Therefore, it is necessary for users to expand their use and deeply use system functions, so as to improve the retention rate and utilization rate of smart city apps after adoption. Second, reports have pointed out that smart apps have poor compatibility, link failure, flashback, abnormal data and other prominent problems [3]. These system operation problems are the key factors that lead to negative emotions and negative behaviors of users such as boycott, neglect and quit.

Existing studies on the use behavior of smart technologies and smart apps are mostly focused on adoption and continuous use [3, 4]. However, most studies simply summarize the use behavior in a one-dimensional structure, such as active or inactive, use or not use, and have not subdivide the various use behavior of users in the later stage of adoption.

For this end, this paper tries to use the grounded theory-based qualitative research to analyze the concept of user's adaptive use behavior and explore the development law and formation mechanism of the behavior. This has great theoretical value and practical significance for improving users' usage and participation, realizing the effective connection of residents, government, service providers and resources in the city, and building a truly "intelligent and humanized" service platform for smart cities.

2 Literature Review

2.1 The Concept of User Adaptation and Infusion

Adaptive information behavior refers to that users actively study, explore, adjust, merge and retain the existing system functions according to different task requirements, so as to improve the utilization efficiency of the system [5]. The researchers of user information behavior point out that encouraging users to make full use of the technology already implemented is an important way to realize the value of information system [6]. However, a major problem in the implementation of information system is poor use effect after the implementation of the system. The organizations or users rarely make full use of the information system, so it is difficult to realize the return on investment or the expected impact [7]. The use and information behavior of users are the key factors that determine the successful implementation of IT/IS. Therefore, in order to solve the problem that users do not make full use of the apps, scholars propose to shift the research focus from "building system" to "using system".

The initial stage of IT adoption and use is an important part of the research on the use of information systems [8], which has been extensively discussed in the existing literature on IT/IS use behavior. However, IT/IS adoption is only the beginning of successful implementation of an information system. For the more complex post-adoption stage, user behavior mainly falls into the following two parts. The first part is user continuance behavior, which is also the focus of research on IT/IS user behavior. The Expect-Confirmation Model of IS Continuance (ECM) proposed by Bhattacherjee et al. has become the classical theoretical basis for studying the continuous use of information systems including the application of smart technology [9, 10]. The second part is the habit formation in the use of IT and IS, that is, the tendency of individuals to actively use the information system [11]. This part emphasizes the pre-influencing factors of habitual use and the subsequent influence on the system and environment, as well as the influence of habitual use on users' interaction with the information system (for example, intent of use, innovation, etc.) [12].

Although research on the continuance and habit of IT/IS use is critical, the relevant researches have not adequately addressed the nature of IT use after adoption. The post-adoption active use behavior of users is usually equated with continuous use or habitual use, and is loosely summarized as increased intensity or higher frequency of use [13]. Therefore, some scholars have discussed the specific ways of using IS or IT after adoption.

The researchers point out that users will experience a gradual familiarization process after accepting IT or IS. In the initial stage, users use few system functions to complete the assigned tasks; as users become more familiar with the system, they may not be satisfied with their current usage and explore a wider range of more useful features to achieve task goals, which is adaptive informational behavior [14].

Although the academic circle has put forward many related concepts (such as deep use, extended use, enhanced use, effective use, etc.) from different perspectives, the specific behaviors studied are roughly the same that is, users use more system or technical functions to improve their task performance, which includes existing tasks and broader potential tasks [15]. For example, Schwarz proposed the concept of deep use, which refers to the use of more functions to deepen the use of different technical functions [16]. Burton et al. proposed that deep use means that users' use of IS has reached the extent of making full use of the deep structural features of IS [19]. Wang et al. (2006) embodied deep use as users seeking multiple ways to make full use of IS [18]. Bagayogo et al. defined enhanced use as the use of previously unused functions, the use of IT functions to perform new tasks, and the extension of existing IT/IS functions, etc. [15]. At the individual user level, Burton et al. defined effective use as the use of a system in a way that contributes to the realization of the use goal of the system [19].

2.2 Factors Influencing Adaptive Information Behavior

Most researches around the topic of deep use are about the extended use of IT/IS functions, and the existing researches on the extended use of IS mostly focus on the factors that influence the extended use of users. Hsieh and Wang (2007) combined the technology acceptance model (TAM) with the information system continuance model (ISC) and pointed out that perceived usefulness and perceived ease of use have a positive effect on the deep use behavior. Unlike continuance behavior and adoption behavior, satisfaction does not have a direct impact on the deep use behavior [20]. Hsieh et al. studied the extended use behavior of customer relationship management system in enterprises based on sensemaking theory, and pointed out from the technical level and the working system level that users' perceived technology quality and perceived service quality have a positive effect on the deep use behavior of the system [6]. Tanja and Jurij took the intelligent business system as the research object, and explored the influence of objective system factors (such as system quality, organizational environment, etc.) and behavioral factors (such as perceived effort, social influence, promotion conditions, etc.) on users' deep use. They divided the extended use behavior into three dimensions: use range, use intensity, and use fusion [13]. Hsu et al. improved the IS success model and pointed out that service quality, system quality and information quality had a significant positive effect on user satisfaction, which further influenced the extended use of ERP system by employees, thus determining whether ERP could be successfully implemented [21].

In terms of smart technologies and apps in the context of smart cities, most studies focus on the extended use behavior of smart medical IT/IS. Raymond et al. took the electronic medical record system (EMR) as the research object and affirmed that the extended use of EMR system by doctors can significantly improve the service performance. They also pointed out that the more functions available in the EMR system, the higher the perceived ease of use, and the greater the possibility of extended use of EMR system [22]. From the perspective of social influence theory, Wang et al. took perceived ease of use and perceived usefulness as control variables, and discussed the social influence factors (rewards, punishments, social image and group norms) on doctors' intention of extended use of electronic health record systems (EHR) [23]. For the smart technology of wearable medical devices, some scholars pointed out that user concerns such as users' privacy and health information concerns would affect their coping behaviors, which would affect the extended use behavior of patients in learning and using wearable medical devices [24] (Table 1).

Table 1. Related research on adaptation behaviors

Author	Adaptive behavior	Research object	Main theoretical basis	Research method	Kernel variable
Tanja and Jurij [13]	Extended use	Business intelligence system (BIS)	Technology, Organization and Environment (TOE) framework	Qualitative research	Personal characteristics, quality characteristics, organizational factors, macro-environment characteristics, performance concepts, results demonstration, effective perceptions, social influence, favorable conditions
Bagayogo et al. [15]	Enhanced use	ERP system, Office system		Grounded theory	Innovation track, real-time use range and adaptation
Hsieh et al. [6]	Extended use	ERP system	TAM theory, ISC continuance theory	Questionnaire survey	Expectation confirmation, satisfaction, perceived usefulness, perceived ease of use
Hsieh et al. [20]	Extended use	CRM system	Sensemaking theory	Questionnaire survey	Technical quality, service quality, employee participation, system coordination
Hsu et al. [21]	Extended use	ERP system	IS success model	Questionnaire survey	Service quality, system quality, information quality, satisfaction
Li et al. [16]	Routine use Innovative use	Business intelligence system (BIS)	Intrinsic motivation theory	Questionnaire survey	Intrinsic achievement motivation, intrinsic cognitive motivation, intrinsic stimulus experience motivation, perceived usefulness

(*continued*)

Table 1. (*continued*)

Author	Adaptive behavior	Research object	Main theoretical basis	Research method	Kernel variable
Liang et al. [25]	System exploration and extended use	ERP system	Effective use theory, adaptive structure theory	Questionnaire survey	System complexity, work autonomy, innovation atmosphere, task diversity
Marakhimov and Joo [24]	Extended use	Wearable medical devices	Coping theory, user adaptation coping model	Questionnaire survey	Health concern, health information concern, privacy concern, challenge arousal, threat arousal, emotional coping, problem coping
Reymond et al. [22]	Extended use	Electronic medical record system (EMR)		Questionnaire survey	Perceived ease of use, functional coverage, and satisfaction
Wang et al. [23]	Extended use	Electronic health record system (EHR)	Social influence theory	Questionnaire survey	Reward, punishment, social image, group norms

Previous studies have mostly combined TAM and TPB theories to discuss the influencing factors on users' adaptive behavior. However, the following problems indicate that the existing theories at the adoption stage are not sufficient to explain the adaptive use behavior of smart city app users:

1. The function settings and interface layout of the mobile app tend to be unified and homogenized;
2. The improvement of users' information literacy and the increase of digital native users;
3. After the initial adoption stage, users already have a certain understanding of smart city apps.

Therefore, factors such as perceived usefulness and perceived ease of use do not play an obvious role in the adaptive use stage, and the motivation of the adaptive use stage needs to be further explored. In addition, the influencing factors of the adaptive use stage are mostly about the system characteristics, ignoring the influence of task characteristics and social environment factors on the adaptive use of the system. Specifically, in terms of psychological, emotional and cognitive factors, most studies take satisfaction as the core variable. However, the single variable of satisfaction cannot fully capture the sentimental and emotional experience of users in the post-adoption stage. It is necessary to further analyze the cognitive motivations of users' adaptive use by combining the characteristics of smart city apps.

3 Research Design and Data Analysis

Considering the exploratory nature of this research and the purpose of establishing an adaptive information behavior process model, it is appropriate to adopt the grounded theory-based research method. As a qualitative research method, grounded theory can construct theories from empirical data to explain overall research problems and phenomena [26].

The research firstly collects data through open and semi-structured interviews, and then draws on the open coding, axial coding and selective coding proposed by Strauss et al. to conduct a three-stage analysis. The coding process uses NVivo11 as an auxiliary tool to conduct comparative analysis and coding consistency test on the interview data, and build an adaptive behavior process model of smart city app users after reaching theoretical saturation.

3.1 Data Collection

This paper conducted sampling interviews with 25 users. The interviewees were between 23 and 57 years old, and their occupations involved middle school teachers, college teachers, housewives, civil servants, employees of enterprises, Taobao shopkeepers and on-the-job graduate students. These interviewees were representative.

The research adopted the semi-structured interview, and the main questions of the interview outline included "Will your behavior change in information inquiry and other aspects over time?", "For what reasons will you start using new functions?", "Do you have any emotional or psychological fluctuations or changes at this stage? Will it affect your behaviors such as information acquisition", "What will you do when encountering difficulties or unfamiliar functions?", etc. Further questioning and discussion may be conducted based on the answers of the interviewees. In this stage, one-on-one interviews and focus group interviews were used. The one-to-one interview can get to know the usage characteristics and psychological cognition of the interviewees as deeply as possible, while the focus group interview can make the interviewees' thinking more divergent and enlighten each other, thus making the interview content more comprehensive.

3.2 Coding Analysis

In the open coding stage, the researchers reviewed the interview data word by word, refined the original language of each interviewee and formed a concept. Through several comparisons, the data was preliminarily classified and initial category coding was given. A total of 84 categories have been formed during this coding stage.

In the axial coding stage, with the continuous collection of interview data and the emergence of new concepts, the concepts and categories formed in the open coding stage were further compared, analyzed, classified and adjusted to form the main category according to the internal correlation and logical relationship. At the same time, it summarized the behavior stage and behavior related conditions in terms of time dimension, and initially straightened out the influencing factor model of the adaptive use of smart city apps.

In the selective coding stage, the researchers repeatedly compared the axial coding results with the existing literatures and theories, further sorted out the relationship between the main categories and built a process model for the adaptive behavior of smart city app users (see Fig. 1).

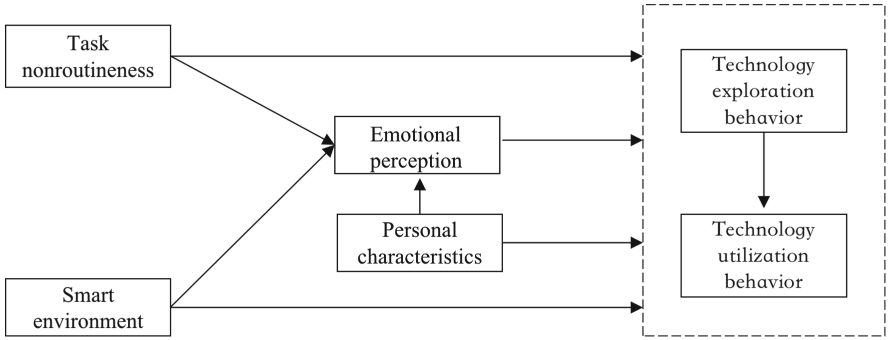

Fig. 1. Influencing factors and process modelfor the adaptive behavior of smart city app users

The research selects the interview data of 6 interviewees for theoretical saturation test, and carries out the same three-stage coding and categorization process for this part of the interview data. The results show that no new concepts, categories and correlation relations emerge. Therefore, it can be considered that the process of research on categorization has good reliability and validity, and the theory has reached saturation.

4 Research Findings

4.1 Model Description

Task nonroutineness smart environment, personal characteristics and emotional perception are the main influencing factors of adaptive use. Among them, emotional perception plays a role of mediating variable, which is jointly affected by task nonroutineness, smart environment and personal traits. If users perceive good operation quality and convenience in the early stage of use, it will prompt users to use more smart city app functions to deal with tasks or query information. In addition, the smart city app is a utilitarian information system, and the characteristics of tasks have an important impact on the activation of new functions. Complex and diverse task nonroutineness prompt users to explore the system more. At the same time, users with high information literacy and strong innovation will have clearer needs for intelligence, and tend to use smart apps in a deeper level. In addition, the intelligence degree of the user's surrounding environment also affects the user's adaptive use. The higher the intelligence degree, the more comprehensive the user's use of smart city apps.

In the adaptive use stage, users will carry out technology exploration behaviors such as learning and exploration, to improve their use experience and system knowledge [27]. As interviewee No. 5 said, “I dare not click at will for fear that I may click the wrong place and the system will fail. My daughter taught me how to operate and I do as she says.” Digital native users will explore the system directly in a more efficient way. As the interviewee No. 3 pointed out, “I skipped the guidance steps at the beginning, which are too troublesome to remember after reading. I like to explore the new functions by myself.” This is because digital native users have higher information literacy and use experience, and tend to interact with the system more efficiently and get real-time feedback when processing information [29]. The exploration behavior will have an impact on extended use. On the one hand, it will expand the scope of use of system functions and enable more new functions; on the other hand, it will increase the frequency of use of new functions and the app.

In addition, if the user perceives that the current use performance cannot match the task requirements, the user will replace the mastered functions with more efficient and simpler ones to improve the system service performance and promote the adaptive use of smart app content [28]. As the interviewee No. 18 pointed out, “I originally made an appointment in the system for local handling when the driver’s license was renewed. But I thought it was too troublesome to go to the vehicle administration office. I then checked other functions in the system and found that I could apply remote renewal directly. So, I applied for remote renewal and received a new license sent from the original license issuing place, saving me a lot of time.”

4.2 Theoretical Elements of Smart City Apps Adaptation and Infusion

Task nonroutineness refer to new, complex, and diverse task forms generated when users use smart city apps. Specifically, it includes the completion level tasks such as living payment (such as paying utility bills), business processing (such as real estate registration), business appointments (such as marriage registration appointments), etc.; information query tasks such as human and social information query, work progress query, cost information query, life information query, etc.; and information acquisition tasks such as local news information, real-time traffic information, public health information, etc. The impact of task nonroutineness on adaptive IT/IS use behavior has been verified in numerous empirical studies. Bagayogo et al. investigated users’ enhanced use behavior of IT and found that the complexity of the user’s task at hand positively affected their enhanced use [15]. Liang et al. investigated the extended use of complex systems by employees in conjunction with the ERP system, and found that the diversity of employees’ tasks at hand ultimately positively affects their extended use [25] (Table 2).

Smart environment refers to the intelligence degree of the surrounding environment in which users use smart city apps, including public environment (such as government publicity, the intelligence degree of the whole society, etc.), family environment (such as the intelligent atmosphere of family, acquaintances’ recommendation, etc.), and technical environment (the intelligence degree of the system environment) (Table 3).

Table 2. Coding paradigm of the core category "Task nonroutineness"

Core category	Sub-categories	Initial concept	Example of quotation
Task nonroutineness	Task completion	Living payment; business handling; business appointment	A02: "For example, when you register for marriage, you have to queue up for a long time if you go to the Civil Affairs Bureau directly, so you need to make an appointment in advance."
	Information query	Human and social information inquiry; work progress inquiry; cost information inquiry; life information query	
	Information acquisition	Local news information; real-time traffic information; public health information	

Table 3. Coding paradigm of the core category "Smart environment"

Core category	Sub-categories	Initial concept	Example of quotation
Smart environment	Public environment	Government publicity; public advertising	A05: "My daughter recommended this app to me and taught me some basic operations."
	Family environment	Acquaintances recommendation; children's influence; follow trends	
	Technical environment	Response speed; stable operation ability; equipment adaptability; information accuracy;	

As a new type of smart app, the user groups are highly differentiated in terms of information literacy and digital savvy, which can be divided into digital immigrants and digital natives. Most digital natives were born in the technological era after the 1980s. They have high digital savvy and information literacy, can actively explore in the information system according to personal information needs, and are keen on new technologies. However, digital immigrants were born earlier and have to go through a difficult learning process for new technologies and information systems. Therefore, the user's personal characteristics have an important influence on the adaptive behavior of smart city apps (Table 4).

Table 4. Coding paradigm of the core category "Smart environment"

Core category	Sub-categories	Initial concept	Example of quotation
Personal characteristic	Personal innovation	Innovation consciousness; innovation ability	A12: "I have used similar apps before, so I am familiar with them quickly."
	Information literacy	App use awareness; App use ability; literacy	
	Knowledge and experience	System cognition; functional knowledge; use experience	

The user's emotional perception mainly includes trust, emotional attachment and perceived convenience. In the process of use, users' emotional perception will be affected by smart environment, personal characteristics and other aspects, which in turn will affect the development of adaptive behavior. Therefore, users' emotional perception is an important mediator variable that affects adaptive behavior (Table 5).

Table 5. Coding paradigm of the core category "Emotional Perception"

Core category	Sub-categories	Initial concept	Example of quotation
Emotional perception	Trust	Authoritative trust; service ability trust; security trust	A16: "I think this app is run by the government, which is quite authoritative. I don't worry about my privacy information being leaked, so I often use the services."
	Emotional attachment	Habit; love; support; involuntarily	
	Perceived convenience	Use convenience; life convenience; service convenience	

When analyzing the adaptive behavior of enterprise information systems, scholars pointed out that technological exploration is manifested by employees' attempts to use new methods or innovative use of existing technologies to complete work, so as to achieve the purpose of improving work performance [5, 30]. In the context of smart apps, technological exploratory adaptive behavior means that users update their existing cognition and knowledge reserves of apps through learning or exploration, and try to use new functions or new technologies to solve task requirements (Table 6).

Table 6. Coding paradigm of the core category "Technology exploration behavior"

Core category	Sub-categories	Initial concept	Example of quotation
Technology exploration behavior	Exploration intention	Explore more new functions; explore function combination; explore efficient alternatives; explore personalized settings	A20: "When I come across a function that I haven't used before, I just click it and see how it works and what the process is."

After users have enough knowledge about the system and new functions, they will use the new system functions to complete personal tasks or meet information needs, that is, technology utilization adaptive behavior [5, 30]. Full utilization and adaptation of new functions can improve the utilization rate of system functions and task performance [19], which mainly includes extended use behavior and integrated use behavior in smart APP. Integrated use behavior is more manifested as the combination of user's personalized settings and functions, such as setting and adding common functions, or combining the "hot news" function and the "local news" function (Table 7).

Table 7. Coding paradigm of the core category "Technology utilization behavior"

<table>
<tr><th>Core category</th><th>Sub-categories</th><th>Initial concept</th><th>Example of quotation</th></tr>
<tr><td rowspan="2">Technology utilization behavior</td><td>Extended use behavior</td><td>Use more functions; enable new functions; increase the frequency of use; alternative use;</td><td rowspan="2">A11: "After I got how to use the function search bar of app, I don't have to search in the menu bar for a long time. I can directly use the search bar to find the function I want to use".</td></tr>
<tr><td>Integrated use behavior</td><td>Combined use; reconstruction use; personalized settings</td></tr>
</table>

5 Conclusion and Suggestion

This paper adopted the grounded theory of procedural school to systematically explore the adaptive behavior process of smart city app users. The research first collected data through questionnaire survey and in-depth interview, followed by three-stage coding, and built a model of influencing factors on adaptive behavior.

In theory, the research broke through the thinking restrictions of research adoption and continuance, and analyzed the information behavior of smart app users from the perspective of post-adoption adaptive behavior. On the one hand, the research explored the internal motivations of adaptive behaviors from four aspects: environment, tasks, emotions, and users; on the other hand, the research identified the main categories of different adaptive behaviors through coding analysis, and clarified the concepts of adaptive behaviors in terms of technological exploration and technological utilization, expounded the mutual influence of adaptive behaviors, and systematically interpreted adaptive behaviors. The research helps to fully understand the complex evolution process of the information behavior, enriches and deconstructs the connotation of adaptive behavior, and provides a theoretical basis for it.

This research is a grounded theory-based qualitative research. Due to the limitations of research methods, there will inevitably be some personal subjective factors of the researcher in the coding process. In addition, the influence intensity of emotional perception, social environment and other factors, as well as the influence of adaptive behaviors on user performance, needs to be analyzed through quantitative research, in order to reveal the process and results of adaptive behaviors of smart city mobile service users more completely and accurately.

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