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Research article

What affects the use of smartphones by the elderly? A hybrid survey from China

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Abstract: Aging is a growing issue nowadays, and active aging is not only about the health of the elderly but also about social participation. The gap between the elderly and the digital age has to some extent reduced their motivation to participate in social activities. To explore the smartphone use behavior of the elderly, this study developed an extended model based on the technology acceptance model. A hybrid survey was carried out with data collection both online and offline. A total of 271 valid questionnaires were collected through offline field interviews and online distribution of questionnaire links, and hypothesis testing was conducted using path analysis. The results showed that both perceived usefulness and attitude toward using could directly, positively and significantly influence the intention to use. Moreover, perceived playfulness and perceived ease of use showed positive and significant relationships with perceived usefulness and attitude toward using, respectively. Therefore, we suggest that smartphone companies focus on improving perceived playfulness when designing and developing product features or applications for the elderly to increase their competitiveness based on ensuring basic technical features.

Keywords: active aging; population aging; public health; elderly behavior; technology acceptance model; hybrid survey

JEL Codes: C38, D12, I18, L63, J14

Abbreviations: perceived value (PV), perceived playfulness (PP), perceived usefulness (PU), perceived ease of use (PEOU), attitude toward using (ATU), intention to use (ITU).

1. Introduction

The accelerating pace of population aging poses severe challenges to population health and society, while also creating unaffordable costs for governments and individuals as people live longer and longer (Toropoc, 2022). Active aging has become one of the goals of sustainable development. It has been defined as "a process of optimizing opportunities for health, participation, and security in order to enhance quality of life as people age" (Socci et al., 2020). China classifies people over 60 as elderly, which differs from the United Nations' definition of seniors (65 years or above). According to China's seventh national census in 2020, the number of people 60 years and above was 264.02 million, as 18.70% of the total population (National Bureau of Statistics of China (NBS), 2021). In today's digital era, digital technologies are widely used in social and economic life, gradually constructing a new era centered on "Internet Plus." Elders are subject to technological constraints in terms of communication, routing and mobility. The elderly is the leading group of Internet non-users, with a proportion of 41.6% in China (China Internet Network Information Center (CNNIC), 2022). When confronted with new technologies, they may try to evade because of physical impairments or psychological resistance. It is especially more difficult for elders who did not grow up with these types of technologies to accept (Peek et al., 2014). These reduce their social engagement.

China has announced the downgrade management of COVID-19 from 8 Jan 2023, shifting the focus from infection prevention to medical treatment and stepping up its protection for key demographic groups, especially the elderly (The State Council of the People's Republic of China, 2022). Recalling the years of the pandemic, the daily lives of the elderly were extremely difficult because many operations had to be performed via smartphone. Public transportation and health services were once problems because they could not use the health QR code, a personal identification code via smartphone. They needed to show their nucleic acid reports within a certain period and/or scan the place code when entering public places and check their health QR code status frequently in China. While the government has taken measures to address these problems, such as the implementation of "No Health QR Code Access" or linking it to other personal identification, it is more important that the elderly are enabled to tackle the problem by themselves. This also forces them to start using and becoming gradually aware of the convenience of smartphones.

As a result, this study aimed to find which factors influence the smartphone use behavior of the elderly. Distinctive features of smartphones are the increased interactivity between users and it and the interactive communication between users, in which the perceived playfulness of the user may be a key factor influencing user behavior. Therefore, drawn on the theory of technology acceptance, we proposed an extended model based on the technology acceptance model (TAM) by adding perceived playfulness to it and utilizing an empirical study. We illustrated how perceived playfulness influences other factors (perceived usefulness, perceived ease of use attitude toward using) to enhance users' intention to use, and the applicability of TAM was also verified.

2. Theoretical background and literature review

2.1. Technology acceptance model

The technology acceptance model (TAM) is now widely used to study individuals' attitudes and usage behavior toward new products. Many studies have expanded on this model and combined it

with other principles or different contexts. Most of these have explored multiple types of websites and mobile applications. For example, a combined model of TAM and self-determination theory was once used to examine the user acceptance of online games (Linares et al., 2021). It is based on the pathway of "willingness to act on behavior" in the theory of rational behavior, which examines the perceived usefulness and attitudes to use that subjects are influenced by in terms of human psychological perspectives and attitudes (Davis, 1989) (Figure 1). The model was extended by introducing pre-factors to consider the cognitive and social factors influencing individual users' attitudes. Pre-factors refer to preconceptions based on others' evaluations and past experiences before users use a specific concept. When pre-factors are added to the TAM, the user behavior in the TAM is consistent, and the user can reflect the user's behavior, including considerations based on the influence of the surrounding environment. It has been pointed out that the vital roles of perceived usefulness and perceived ease of use of a given technology affect user attitudes and behavioral intention to use the technology (Wang et al., 2022). Later, Venkatesh and Davis (2000) proposed the well-known TAM2 to expand the predicates for perceived usefulness based on the TAM, including subjective norm, image, job relevance, output quality and result demonstrability. After that, Venkatesh and Bala (2008) developed a complete TAM3 based on TAM2 by integrating ease of use into the six antecedent variables, including computer self-efficacy, perceptions of external control, computer playfulness, perceived enjoyment and objective usability.

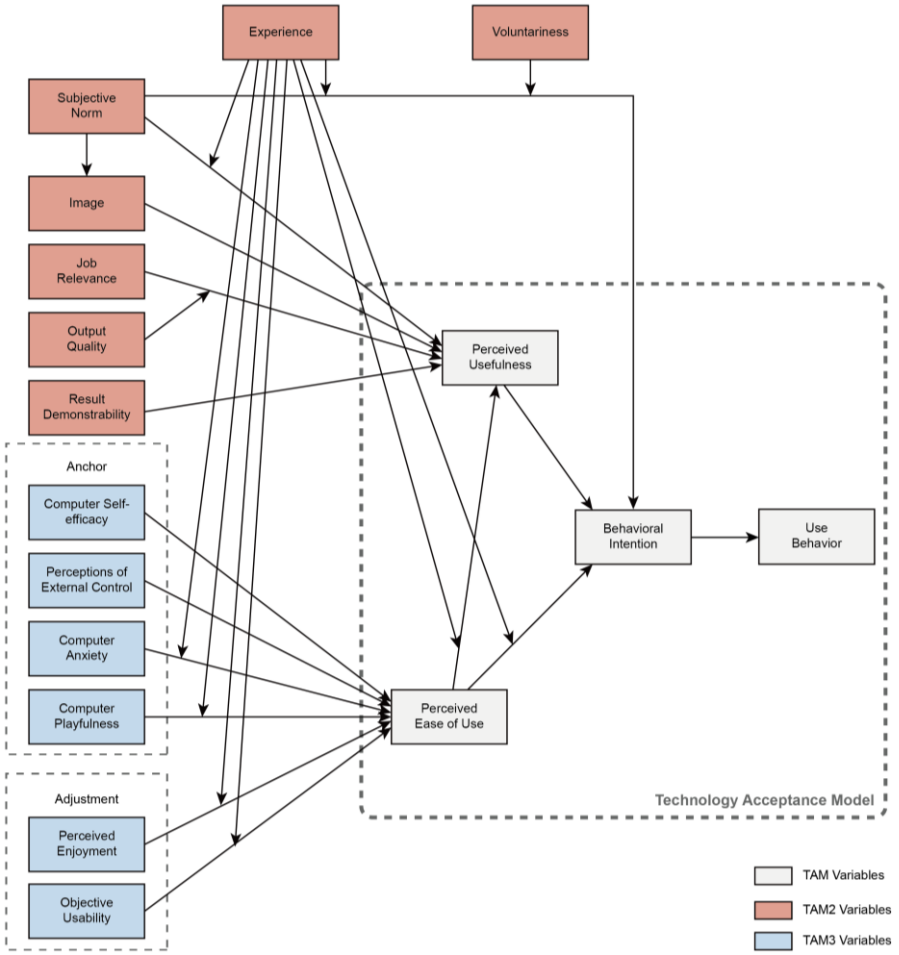

Figure 1. Evolution of TAM series model.

2.2. Usage behavior of elders

Unlike the younger, most elders use smartphones only for basic functions. However, with advances in technology and changes in the social environment, the usage behavior of the elderly may also be influenced. More than a decade ago, e-commerce was already gradually infiltrating people's daily lives. As opposed to shopping at the supermarket, many elders choose to buy what they need from some online shopping sites because it is more convenient (McCloskey, 2006). In parallel, e-commerce has flourished with the support of m-payments. The unified theory for the acceptance and use of technology (UTAUT) has been used to explain the m-payments adoption of customers, with performance expectancy and perceived cyber security risk often being the main determinants (Hanif and Lallie, 2021). In terms of healthcare, due to the COVID-19 pandemic, many patients who are not infected with this coronavirus have been affected to varying degrees in hospital visits (Zhai et al., 2021), and elders are particularly prominent. Mobile medical apps have become an effective measure to address this issue, having important impacts in optimizing the allocation of medical resource and improving the efficiency of medicine (Zhai et al., 2022). However, many factors are also influencing the usage behaviors of the elderly. For example, Askari et al. (2020) used senior technology acceptance model (STAM) found the factor of expect for finance did not influence the intention to use mobile medical apps among the older in the Netherlands, and other factors (i.e., service availability, sense of control, self-perceived effectiveness, facilities, social relationships, etc.) play significant roles. Similarly, in China, many users have become accustomed to obtaining medical advice and consultations from mobile medical apps, but the users' fear and apprehension when using technologies were particularly critical for the older users' acceptance and adoption of them (Li, 2020).

2.3. Perceived playfulness

Perceived playfulness (PP) emphasizes the individual's entertainment characteristics, which are a specific individuality, stability and a certain characteristic sense of fun for the individual. Webster and Martocchio's (1992) study of perceived playfulness showed that if the individual is efficient when using a computer for working and shows great interest in what is being done, then there will be some entertainment. For entertainment, perceived playfulness is based on the interaction between a person and the environment. It is mainly related to emotion-related activities experienced at a given time. Such emotions are unstable and change in some way over time. In the study of usage behavior, Csikszentmihalyi (2000) argued that personal motivation is influenced by both internal and external motivation. Internal motivation refers to the perceived playfulness of an individual's behavior when doing something. External motivation is defined as the predicted change that can be brought about by certain behavior. Then, Moon and Kim (2001) divided perceived playfulness into three dimensions, the extent to which the individual perceives that personal attention is focused on the interaction with the World Wide Web (WWW), the curiosity during the interaction and finding the interaction intrinsically enjoyable or exciting.

3. Research framework and hypotheses

Perceived value (PV) influences users' behavior by affecting their preferences and evaluations of certain products. When using a new good or product, the higher the perceived value experienced is,

the better their attitude will be, influencing their intention to use it (Yu et al., 2019). While the elders experience some barriers to smartphones, some studies showed that smartphones can reduce loneliness and enhance communication with family and friends. When retired, the reduction of paid work activities and the consequent increase in leisure time usually leads to more intensive mobile communication (Petrovčič et al., 2015). Considering that in using smartphones, some mobile applications or websites can offer both functional and hedonic value, their features play a leading role in influencing a user's experience of playfulness, and users will be excited and find it enjoyable (Hur et al., 2017). So, we included perceived playfulness as an external variable in the original TAM. It has been verified to be positively correlated with user satisfaction and usage behavior in websites and mobile applications (Hsu et al., 2011; Liu et al., 2021). At the same time, the relationship between perceived playfulness (PP) and other perceived value variables has been studied, and their relationship tends to show a positive impact and influence usage behavior (Çelik, 2011; Chiu et al., 2010). Therefore, we make the following assumptions:

- H1: The perceived playfulness of smartphones by the elderly has a positive and significant effect on their attitude toward using.
- H2: The perceived playfulness of smartphones by the elderly has a positive and significant effect on the perceived ease of use.

Perceived ease of use (PEOU) is a technology characteristic that refers to "the degree to which a person believes that using a particular system would be free of effort." (Davis, 1989). Users may believe that a new thing requires too much effort to understand and use, and higher perceived ease of use leads to higher perceived usefulness, which ultimately leads to higher usage of technology. Although perceived ease of use does not significantly influence the intention to use in some areas (e.g., car-sharing services) (Wang et al., 2018), it has been proven that it can strongly influence the intention to use mobile applications (Schmidthuber et al., 2020; Talantis et al., 2020). Also, for the elderly, if the technology meets usability principles, making it easy to learn, use and understand, older people want to use it (Hough and Kobylanski, 2009). Therefore, we propose the following hypotheses:

- H3: The perceived ease of use of smartphones by the elderly has a positive and significant effect on perceived usefulness.
- H4: The perceived ease of use of smartphones by the elderly has a positive and significant effect on their attitude toward using.
- H5: The perceived ease of use of smartphones by the elderly has a positive and significant effect on the intention to use.

Perceived usefulness (PU) is defined as the degree to which elders believe using smartphones would enhance performance in this study. It is a predictor of usage behavior, has a significant impact on usage behavior and is compared with other perceived values, and it appears to be more important than other values (Lubua and Semlambo, 2017; Renny et al., 2013). This is because it is more like a starting point for stimulating behavior to occur, and users are more likely to adopt and use a new thing when they perceive it to be valid. In terms of mobile applications, if the elderly think that it is beneficial to use smartphones to register applications at first, they will be more likely to adopt them (Hsu and Peng, 2022). So, we propose the following hypotheses:

- H6: The perceived usefulness of smartphones by the elderly has a positive and significant effect on their attitude toward using.
- H7: The perceived usefulness of smartphones by the elderly has a positive and significant effect on the intention to use.

Among the many empirical studies about TAM, we can find that perceived usefulness and perceived ease of use affect behavioral intentions, and sometimes this influence may be directed or mediated by attitude (Chen and Aklikokou, 2019; Li et al., 2017; Tajudeen Shittu et al., 2011). Attitude can be defined as the psychological tendency of users to evaluate a particular entity with some degree of approval or disapproval. The relationship between attitudes toward using and intention to use has also been shown that as a powerful positive influence (Hwang et al., 2019). Hence, the following is hypothesized:

- H8: The attitude toward using smartphones by the elderly has a positive and significant effect on their intention to use.

The research model is shown in Figure 2.

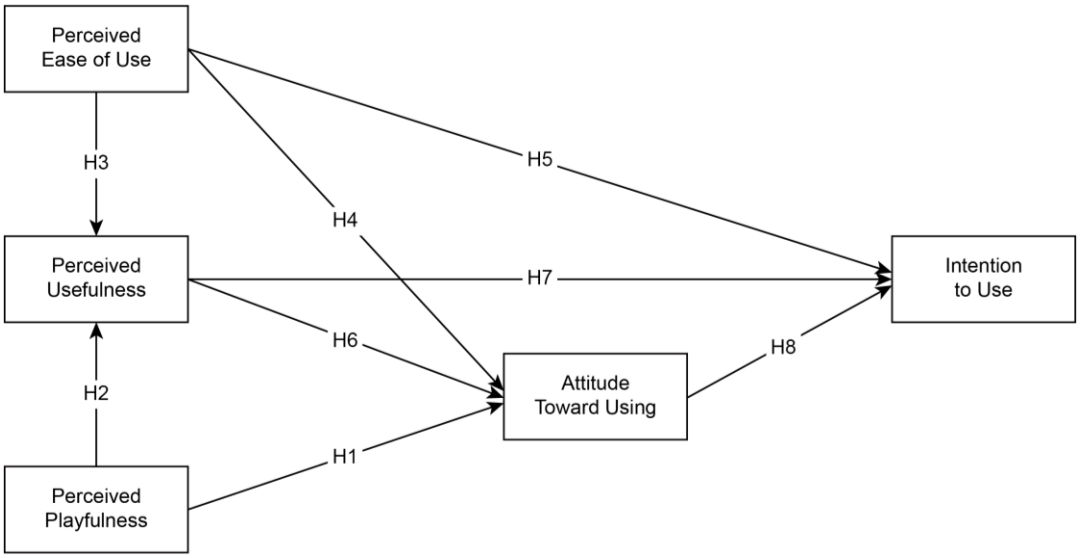

Figure 2. Research model.

4. Methodology

4.1. Survey design

This study took place in Tianjin, one of the four major municipalities directly under the central government of China. It has a population of 3.866 million, of which 21.66% are aged 60 and above. According to the United Nations criteria for classifying an aging population, a country or region with a population aged 60 and above of 10% of the total population or a population aged 65 and above of 7% of the total population marks the region as an aging society. Thus, the severity of aging in Tianjin makes our study more representative.

To gain a comprehensive understanding of factors affecting the elders' usage of smartphones, we conducted a stepwise survey based on our model and hypotheses. In the first step, the questionnaire was designed. Considering that our respondents were all over 60 years old, the questionnaire was conducted simultaneously both online and offline. They may not be able to view smartphone screens for a long time because their eyesight is failing. Also, they may not be able to stay in one position for a long time to fill out the questionnaire or answer our questions, as it requires a high level of physical

fitness. Therefore, we streamlined the questionnaire and simplified the item descriptions to focus on the influencing factors, which are the core of the study. The questionnaire included three parts. It began with a brief introduction of this study with a confidentiality statement. Next was the factoring measurement with a total of 15 items, which refer to Constantinides et al. (2013), Leng et al. (1970), Moon and Kim (2001) and Lu and Xu (2006). It used a 5-point Likert scale response scale ranging from 1 to 5 (1-strongly disagree, 5-strongly agree). The last part was demographic characteristics, including gender, level of education and income.

The second step was a pilot test. Before the formal survey, we invited 25 respondents (age 60+) from different fields to conduct a pilot test to confirm the clarity of the questions and the possible completion time. None of them was an expert in consumer behavioral areas. Based on the pilot test, many of the respondents gave us feedback that a suitable number of questions were set, the description of questions was brief and easy to understand. They could fully concentrate on answering the questions and did not feel any discomfort in the process of answering the questions.

The third step was the adoption of combining online and offline data collection. Since our research aim is to study the usage of smartphones by elders, the online survey alone may create bias in data collection. To provide solid evidence and ensure a balanced sample, we adopted a combination of online and offline questionnaires to collect data. Referring to Creswell (2012), we planned to collect a total of 400 questionnaires (>350), divided into 50% online and 50% offline. For the online side, Wenjuanxing, an online questionnaire platform from China, was applied to distribute the questionnaire link through community sharing and moments on a social app (i.e., WeChat). For the offline side, the questionnaires were distributed by trained interviewers in six central urban districts of Tianjin from February to April in 2023. The target respondents were randomly selected from sites with a large flow of elders, such as supermarkets, hospitals, open food markets, etc. The research team offered a gift as an incentive to encourage participation. Then, we informed the aim of the survey, possible completion time (5-10 minutes) and declaration of confidentiality of personal information orally. With the respondent's consent, trained interviewers asked questions from the questionnaire, and the respondent answered. Meanwhile, another research team member recorded the data manually.

4.2. Sample characteristics

Through the questionnaire distribution, a total of 321 questionnaires were returned. After removing 50 invalid questionnaires, 271 valid questionnaires were reserved (102 online and 169 offline), with an effective rate of 84.42%. The demographic characteristics (Table 1) show that 57.20% (23.99% online, 33.21% offline) of the respondents were male and the remaining 42.80% (13.65% online, 29.15% offline) were female. For the level of education, the largest number of people graduated from junior high school, accounting for 32.47% (7.75% online, 24.72% offline) of the total, followed by below primary, high school, and university, with 25.46% (5.17% online, 20.30% offline), 21.77% (7.38% online, 14.39% offline) and 18.08% (15.13% online, 2.95% offline) of the total, respectively. Last is postgraduate, only accounting for 2.21% of the total and all belonging to online respondents. In terms of income, many respondents earned 5000 CNY and above (56.46%), followed by the 3500 to 5000 group (22.88%), the 2000 and below group (11.44%) and the 2000 to 3500 group (9.23%).

Table 1. Sample Characteristics.

Variable	Classification	Total sample (N = 271)	Online sample (N = 102)	Offline sample (N = 169)
Gender	Male	155 (57.20%)	65 (23.99%)	90 (33.21%)
	Female	116 (42.80%)	37 (13.65%)	79 (29.15%)
Level of education	Below primary	69 (25.46%)	14 (5.17%)	55 (20.30%)
	Junior high school	88 (32.47%)	21 (7.75%)	67 (24.74%)
	High school [a]	59 (21.77%)	20 (7.38%)	39 (14.39%)
	University	49 (18.08%)	41 (15.13%)	8 (2.95%)
	Postgraduate	6 (2.21%)	6 (2.21%)	0 (0.00%)
Income (CNY)	2000 and below	31 (11.44%)	10 (3.69%)	21 (7.75%)
	2000-3500	25 (9.23%)	9 (3.32%)	16 (5.90%)
	3500-5000	62 (22.88%)	25 (9.23%)	37 (13.65%)
	5000 and above	153 (56.46%)	58 (21.40%)	95 (35.06%)

Note: High school [a] includes technical secondary school, vocational school and technical school.

5. Data analysis and results

5.1. Reliability and validity

To check the consistency of the measurements and the degree of fit with what was studied, reliability and validity tests were done. Reliability refers to the stability and consistency of the scale. Cronbach α is often used as an indicator for reliability testing. In this study, Cronbach α coefficients of each construct ranged from 0.774 to 0.963 (Table 2), and Cronbach α coefficients of all constructs is 0.934. According to Hair et al. (2014), Cronbach α should be higher than 0.7, which is considered acceptable, so we considered that the study passed reliability testing. Then, we tested the validity, that is, the extent to which the data are consistent with the questions of interest. The Kaiser-Meyer-Olkin (KMO) and Bartlett's sphere test and exploratory factor analysis (EFA) were used for validity testing. When KMO > 0.9, it indicates an excellent relationship between the variables, and it can be considered that factor analysis is well-suited between the variables (Bhakar et al., 2013; Williams et al., 2010). In this study, the KMO value is 0.911, and the p-value is less than 0.01, which showed that the validity is perfectly suitable for factor analysis. Subsequently, we performed EFA by SPSS 26.0 and used principal component analysis to select common factors with eigenvalues greater than 1.0 (Kaiser, 1960) and orthogonal rotation by the maximum variance method. According to the above method, we extracted a total of three common factors with a cumulative percentage of the variance of 75.565%, and the factor loadings of all the question items were greater than 0.5 (Table 3). Therefore, the structural validity can be considered good.

Table 2. Internal consistency reliability.

Constructs	Item numbers	Cronbach's α	
Perceived usefulness	4	0.865 [a]	0.934 [b]
Perceived ease of use	3	0.963	
Perceived playfulness	4	0.774	
Attitude toward using	2	0.755	
Intention to Use	2	0.934	

Note: [a] Cronbach's α coefficient of each construction; [b] Cronbach's α coefficient of all constructions.

Table 3. Rotated component matrix (Varimax).

Items	Factors		
	1	2	3
Using smartphones makes me feel that life is not so boring.	0.816		
Using smartphones makes my life more convenient.	0.772		
Using smartphones can let me get some useful information.	0.736		
I think it's very interesting to use smartphones.	0.707		
Using smartphones can help me gain more knowledge.	0.704		
Using smartphones makes me feel happy.	0.648		
Using smartphones makes me feel less lonely.	0.621		
I like to use smartphones.		0.806	
I am willing to use smartphones.		0.804	
I will use smartphones for a long time.		0.790	
Using smartphones is a wise choice.		0.761	
Various functions of smartphones are easy for me to understand.			0.915
I think it's easy to learn how to use smartphones.			0.906
I think the operation of smartphones is simple.			0.893
Applications on smartphones are very practical.			0.575

5.2. Hypothesis test

To explore the influence relationship between the factors, we chose path analysis to test the research model and used AMOS 21.0 software for data processing. From the data in Table 4, all the hypotheses passed the test except for H5 and H6, which were not supported. Through the analysis of the path coefficients, the path coefficients between the variables in the hypotheses that passed the significance test are more than 0. Moreover, combined with the results of the significance analysis, it can be seen that H1 ($\beta = 0.421$, $p < 0.01$), H2 ($\beta = 0.94$, $p < 0.001$), H3 ($\beta = 0.187$, $p < 0.001$), H4 ($\beta = 0.077$, $p < 0.05$), H7 ($\beta = 0.199$, $p < 0.05$) and H8 ($\beta = 1.07$, $p<0.001$) are all significantly and positively influenced by each other (Figure 3).

Table 4. Hypothesis test.

Hypothesis	Path	Estimate	Standard Error	Critical Ratio	P	Result
H1	PP→ATU	0.421	0.157	2.684	0.007**	Supported
H2	PP→PU	0.94	0.071	13.271	0.000***	Supported
H3	PEOU→PU	0.187	0.024	7.714	0.000***	Supported
H4	PEOU→ATU	0.077	0.039	1.982	0.047*	Supported
H5	PEOU→ITU	−0.043	0.026	−1.700	0.089	Rejected
H6	PU→ATU	0.223	0.149	1.499	0.134	Rejected
H7	PU→ITU	0.199	0.082	2.420	0.016*	Supported
H8	ATU→ITU	1.07	0.123	8.667	0.000***	Supported

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

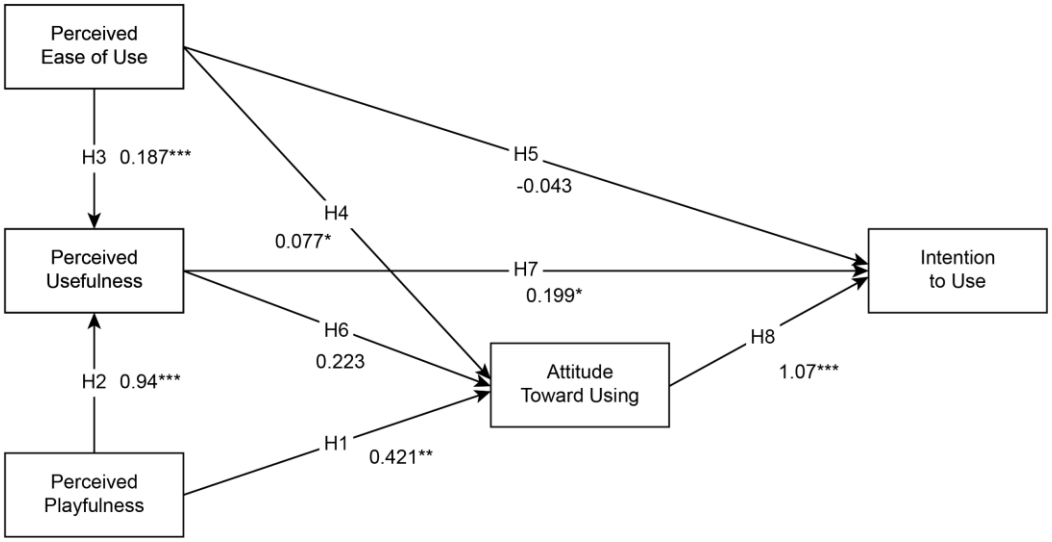

Figure 3. Hypothesis test model.
Note: ***$p < 0.001$, ** $p < 0.05$, * $p < 0.01$.

6. Discussions

6.1. Major findings

The results above show that perceived playfulness has a significantly positive impact on attitude toward using and perceived usefulness. By comparison, the effect for perceived usefulness is more. For this phenomenon, we have a more nuanced discussion. In the past years, with the process of urbanization and industrialization, many young adults worked away from home for long periods, and the number of elderly left behind was increasing, surrounded by higher loneliness and higher levels of mental health problems (Thapa et al., 2018; Zhong et al., 2017). The entertaining applications of smartphones can have some positive impact and add a bit of fun to their lives, which will put them in a happy mood and a more youthful mindset. Our results are in line with the studies of Cota et al. (2015) and Lu et al. (2017).

In terms of perceived usefulness, the effect on intention to use is significant and positive, while the effect on attitude toward using is positive but insignificant. The above show that for the elderly,

perceived usefulness is not effective in influencing their attitudes towards use, which is not in line with previous studies. For this, we argue that it may be influenced by some other factors, such as the price, volume and tutorials of the smartphone. Smartphone prices are often several times higher compared to traditional dumbphones. At the same time, the elderly often have hearing loss, so they need loud volume alert tones to ensure that they can answer their calls, which is also lacking in smartphones. In addition, smartphones have many functions, and the learning ability of the elderly is weak, so they need someone to patiently teach them how to use, but their children often do not have time to take care of them. To a certain extent, these affect the attitude toward using.

Perceived ease of use can positively and significantly influence perceived usefulness and attitude toward using, but there is a negative and non-significant result for intention to use, which is also different from previous studies. As perceived ease of use of smartphones is the primary factor that elderly consumers need to consider when purchasing smartphones, the easier it is to use, the more it will make a difference, such as listening to songs, taking photographs, recording their lives, etc. This will increase their perception of the usefulness, keep them enthusiastic about using it and influence their attitude toward using, with similar conclusions being reached by Arpaci et al. (2015) and Hsieh et al. (2018). Designing easier-to-use smartphones for the elderly has become even more of a call from researchers to production operators, especially in Japan, a country where aging is a particularly serious problem, as illustrated by the research revelations of Han et al. (2020). As for the negative impact of perceived ease of use on the intention to use, we consider that it can be influenced by other factors, such as the privacy and security of personal information, trust, etc. (Featherman et al., 2010; Lai et al., 2013).

6.2. Theoretical implications

Our research has made several academic contributions. First, we investigated the behavioral factors of smartphone use among the elderly under regular epidemic prevention and control through an empirical research approach, which enrich the literature and provide a theoretical basis in this field. Second, unlike most studies on TAM, we observe that perceived ease of use is not a very effective direct predictor of users' intention to use, but rather a predictor of attitude to use, a result that also provides a multi-faceted approach to the TAM. This study confirms that the TAM is indeed effective in studying smartphone use behavior among the elderly and has research applicability. Finally, it has been shown that perceived playfulness as an innovation in this study can effectively enhance the perceived ease of use and attitude toward using in terms of user usage, which also supports the expansion of TAM applications.

6.3. Managerial implications

This research also provides consequential management implications. The whole section focuses on the factors influencing elders' intention to use smartphones, explaining which factors play a strong driving role. The results show that elders' intention to use smartphones is mainly influenced by attitude toward using and perceived usefulness, and attitude toward using is heavily dependent on whether the user finds it easy to use the smartphone and how much fun they experience in the process. Therefore, first and foremost, business practitioners should seek to make smartphone features and applications more interesting, such as interactive games, comment sections or short videos to increase social

interaction between older people and the outside world. An excellent example of this is TikTok, as its use among the elderly has greatly increased during the COVID-19 pandemic, and the elderly have become content creators for short videos. In addition, product designers and operators should continuously optimize the operation path and usage logic throughout the product lifecycle, emphasizing the practical value of the product (i.e., highlighting perceived usefulness and perceived ease of use) and effectively considering the practical needs of the elderly. Finally, although there is a very high proportion of older people in the non-Internet user group who have not yet benefited from the convenience of smartphone usage, they may perceive the benefits of using smartphones for shopping, communication, health care and public payments if product promotions are properly informed about the significant factors affecting smartphone usage.

6.4. Limitations and future research directions

The limitations of this study are as follows. Most important are the sample size and geography. The respondent group in this study was from only one city in China and did not fully cover the characteristics of the Chinese population. Due to geographical differences, there may be differences in smartphone usage behavior, and future studies could increase the sample size to cover more respondent groups. Additionally, our study did not examine smartphone usage behavior from a demographic perspective, such as gender, age, occupation and so on. In consumer behavior research, the study of the attributes of the consumer population is useful for companies to implement product market segmentation strategies better. Therefore, the elderly group can be further split into different categories to analyze the differences in their smartphone usage behavior in the future. Furthermore, this study was cross-sectional, and respondents were not followed up over a period to find out if there was a behavioral change in the use of smartphones by the elderly and whether other factors would influence this change, such as if the degradation management of epidemic prevention and control may reduce the daily use of smartphones or affect the tendencies of existing users. One could attempt to use qualitative research to conduct observational studies of respondents over time to explore the reasons behind the behavior further later. Finally, this study provided further validation of the applicability of TAM, and researchers can also use other variables and theories for model extensions to study the usage behavior of the elderly.

7. Conclusions

Combined with the previous section, the use of smartphones has attracted widespread attention from scholars and industry as technology advances and develops. However, in the face of unavoidable realities, such as the growing problem of aging and the regular epidemic prevention and control, the research into the smartphone use behavior of the elderly has yet to be adequately explained and illustrated. How to frontload thinking about which factors affect their use behavior is one of the critical concerns of the industry in product design and operation. Therefore, this study extended the TAM by adding perceived playfulness and investigated the factors influencing the smartphone use behavior of the elderly through an empirical study. The questionnaires were collected from both online and offline sources to ensure the rigidity of the data collection. Our findings showed that perceived playfulness is significantly and positively correlated with perceived usefulness and attitude toward using and that perceived usefulness and attitude toward using can ramp up elders' intention to use smartphones. Thus,

we recommend that smartphone companies focus on the elderly user group and include them as key consumers of their products, helping them cross the digital divide. When designing and developing product features or applications for them, it is essential to ensure basic technical functionality while focusing on the user's perceived playfulness to improve their competitiveness.

Use of AI tools declaration

All authors declare we have not used artificial intelligence (AI) tools in the creation of this article.

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Conflict of interest

All authors declare no conflicts of interest in this article.

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