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Understanding continuance intention of artificial intelligence (AI)-enabled mobile banking applications: an extension of AI characteristics to an expectation confirmation model

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Artificial intelligence (AI) has been proven to be a disruptive financial technology in the context of mobile banking that can provide more practical value to users and banks. AI is a critical way of facilitating user acceptance and adoption of mobile banking applications (apps). Nevertheless, the ways in which AI features influence users' continuance intention towards AI-enabled mobile banking apps have not been investigated from the perspective of an expectation confirmation model (ECM). To address this research gap, this paper develops a research model by combining two constructs pertaining to AI characteristics, namely, perceived intelligence and perceived anthropomorphism, and by using the ECM to explore users' continuance intentions in this context. We employed a survey research method using a random sampling approach to collect 365 valid responses. A partial least squares approach was used to examine the model. The results show that both intelligence and anthropomorphism can increase user satisfaction via confirmation and perceived usefulness, which in turn fosters users' willingness to continue to engage in mobile banking. This paper offers theoretical advancements, discusses future directions for mobile banking research and provides practical guidance to app developers with respect to designing and developing proper mobile banking apps using AI technology.

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Introduction

As a new technology platform emerging from financial technology, mobile banking can provide users with more convenient services and reduce the impact of physical obstacles in this context (Payne et al., 2018, 2021). Users can easily and quickly complete financial operations such as transactions, investments and other nonfinancial operations anytime and anywhere (Asnakew, 2020; Banerjee and Sreejesh, 2022; Zhou et al., 2021). For banks, mobile banking can reduce operating costs and improve competitiveness (Ali et al., 2022; Nguyen et al., 2022; Purohit and Arora, 2021).

Recently, artificial intelligence (AI) technology has become relevant to mobile banking applications (apps) (Lee and Chen, 2022b; Lin et al., 2023; Payne et al., 2018, 2021; Suhartanto et al., 2021; Yussaivi et al., 2021). AI refers to the use of computer operations by machines to simulate human intellectual activities and to provide services or complete a series of tasks to help users or businesses in different contexts (Huang and Rust, 2020; Prentice et al., 2020). The inclusion of AI transforms traditional mobile banking into intelligent mobile banking, which can meet users' fundamental needs for personalized and intelligent services and enhance user experience (Lee and Chen, 2022b; Lin et al., 2023). For example, the human customer service JD.com instant messaging intelligence included in a JD Finance app uses portraits as avatars, communicates with users by employing human-like language to improve the AI's understanding of users' intentions, collects data and starts operations (Lee and Chen, 2022b).

Users' continuous mobile banking usage intention is critical to the successful development of mobile banking apps (Banerjee and Sreejesh, 2022; Lin et al., 2023). Most scholars have used the technology acceptance model (TAM) (e.g., Albashrawi and Motiwalla, 2019; Asnakew, 2020; Hassan and Wood, 2020; Naruetharadhol et al., 2021) and the unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al., 2012) to study mobile banking users' continued adoption intentions (e.g., Baabdullah et al., 2019; Goularte and Zilber, 2018; Lin et al., 2023; Merhi et al., 2019). However, unlike these technology acceptance and adoption models, the expectation confirmation model (ECM) (Bhattacherjee, 2001) focuses on the effects of user confirmation of expectations (or confirmation), perceived usefulness and satisfaction on users' continuance intention. ECM has been viewed as a robust theoretical model for explaining continuous usage intention in the mobile banking context (e.g., Albashrawi, 2021; Kumar et al., 2018; Rabaa'i and Almaati, 2021).

Research shows that users' adoption decisions of AI-based applications and systems are significantly influenced by AI (Balakrishnan and Dwivedi, 2021; Cabrera-Sánchez et al., 2021; Moussawi et al., 2020, 2022; Pillai and Sivathanu, 2020). Mobile banking apps have used AI to improve their functions. The literature has shown that unlike traditional systems, the main characteristics of AI systems are intelligence and anthropomorphism, which influence users' perceptions when using such systems (Balakrishnan and Dwivedi, 2021; Moussawi et al., 2020, 2022). In mobile banking apps, intelligence reflects AI-enabled mobile banking apps that can exhibit efficient and autonomous behavior to facilitate users in conducting banking services or transactions. Anthropomorphism refers to AI mobile banking apps that behave like humans to help people complete services or tasks (Lin and Lee, 2023). Thus, it is crucial to explore and investigate whether and how AI features affect users' adoption of AI-powered mobile banking apps.

Accordingly, traditional mobile banking apps have evolved into AI-powered intelligent apps, and the ECM can serve as a fundamental theory for studying user continuous usage intention in the mobile banking context. In this situation, the effects of AI characteristics (intelligence and anthropomorphism) on ECM remain unknown and require further investigation and examination. Accordingly, a research question is formed:

> Do intelligence and anthropomorphism affect users' continuous adoption intentions towards mobile banking apps through the function of ECM, and if so, how?

To answer this question, the purpose of this study is to develop a research model by exploring the effects of intelligence and anthropomorphism on users' confirmation, perceived usefulness and satisfaction as well as their subsequent continuance intentions with regard to the adoption of AI-enabled mobile banking apps. We employ a survey research method to collect 365 valid responses with the aim of using a partial least squares (PLS) approach to examine the model. By integrating intelligence and anthropomorphism into the ECM, this study contributes to the literature by revealing the operational mechanisms of AI characteristics on user confirmation of expectations, perceived usefulness, satisfaction and continuance intention. Namely, this study increases the ECM's applicability and explanatory power to predict and explain users' continuous adoption in an AI mobile banking context. The paper is structured as follows, literature review and hypothesis development, research method, results discussion and contributions, limitations and future research, and a conclusion of the study.

Literature review and hypothesis development

The ECM in mobile banking. The ECM originated from Oliver's (1980) expectation confirmation theory (ECT), which includes four variables: confirmation of expectations (or confirmation), perceived usefulness, satisfaction and information system (IS) continuance intention. Specifically, confirmation refers to users' perception of the congruence between the expectation of IS use and its actual performance (Bhattacherjee, 2001). Namely, the confirmation construct implies that users' postconsumption experiences are consistent with or exceed their preconsumption expectations (Sinha and Singh, 2022). Perceived usefulness is a salient construct in TAM to denote users' assessments of the expected benefits of IS use. Drawing from TAM, postconsumption expectation is represented as ex post perceived usefulness in the ECM (Bhattacherjee, 2001, p. 356). Satisfaction signifies users' affect with prior IS use (Bhattacherjee, 2001; Quan et al., 2022). The ECM explains users' behaviors pertaining to continued use after initial adoption in terms of confirmation of expectations, perceived usefulness, and satisfaction (Bhattacherjee, 2001). Compared to the TAM and UTAUT, which emphasize user acceptance of an technology, the ECM serves a more suitable theoretical basis for explaining the factors that affect users' continued willingness to use the technology (Foroughi et al., 2019; Franque et al., 2021; Susanto et al., 2016; Tang et al., 2022; Yuan et al., 2016). Table 1 summarizes the literature related to the application of the ECM and ECT to mobile banking with respect to users' continuance intention.

The ECM and continuance intention towards AI mobile banking apps. The manifest features perceived by users using AI-enabled mobile banking apps are intelligence and anthropomorphism (Lee and Chen, 2022b; Lin et al., 2023). This paper therefore includes the two key factors of intelligence and anthropomorphism as antecedent variables in the ECM to study continuous use intention regarding such apps, as shown in Fig. 1. As ECM is used as a baseline model, we first verified the relationships hypothesized in the ECM in the context of AI-enabled mobile banking.

Table 1 Research pertaining to the application of ECM and ECT in mobile banking.

Authors	Theories	Added variables	Main findings
Yuan et al. (2016)	TAM, ECM, task-technology fit	Perceived task-technology fit, perceived risk, perceived ease of use, gender	1. Perceived usefulness, perceived task-technology fit, and perceived risk are the main factors that affect users continued use intentions. 2. Perceived usefulness is affected by perceived ease of use and perceived task-technology fit. 3. Gender significantly moderates the effect of perceived risk on users' continued use intentions.
Susanto et al. (2016)	ECM	Perceived security and privacy, trust, self-efficacy	1. Perceived usefulness and self-efficacy foster users' continued willingness to use the technology. 2. User confirmation after first use of mobile banking significantly affects perceived security, privacy, and usefulness, trust and satisfaction. 3. Trust increases satisfaction, while perceived security and privacy affect trust to some degree. 4. Perceived usefulness enhances trust and satisfaction.
Kumar et al. (2018)	ECT, Self-determination theory	Quality, trust, intrinsic regulation, identified regulation, introjected regulation, external regulation, integrated regulation	1. Users' continued intention to use mobile banking is affected by introjected regulation, intrinsic regulation, external regulation, identified regulation and integrated regulation. 2. Satisfaction is influenced by confirmation of expectations, trust and quality. 3. Satisfaction significantly affects introjected regulation, intrinsic regulation, external regulation, identified regulation and integrated regulation. 4. Quality increases user confirmation of expectations.
Hidayat-ur-Rehman et al. (2021)	UTAUT2, ECM	Perceived ubiquity, perceived autonomy, facilitating conditions, trust, perceived security concerns, effort expectancy	1. Perceived ubiquity, perceived usefulness, satisfaction, facilitating conditions, perceived security concerns, and trust directly strengthen users' continued use of mobile banking. 2. Confirmation is positively affected by perceived ubiquity, perceived autonomy and effort expectancy, but perceived security concerns reduce users' confirmation in the context of mobile banking. 3. Effort expectancy and trust foster users' continued use intentions via users' perceived usefulness and satisfaction, respectively. 4. Users' perceptions of mobile banking autonomy enhance their perception of usefulness and their satisfaction with mobile banking. 5. Perceived security concerns decrease trust and satisfaction and indirectly affect users' mobile banking continued willingness. 6. Perceived ubiquity and facilitating conditions increase perceived usefulness and user satisfaction, respectively.
Sinha and Singh (2022)	ECT, Hedonic adaptation Theory	Perceived performance, hedonic adaptation	The use of mobile banking services increases customer satisfaction and continued willingness to use the technology by decreasing the speed of hedonic adaptation.

If the use of the apps entails benefits for users, the perceived service experience meets or exceeds the expected value, which produces positive consistency perception, that is, confirmation of expectations (Bhattacherjee, 2001; Kumar et al., 2018). Yuan et al. (2016) indicated that when an individual's expectations match the expected benefit or performance of mobile banking services, the individual realizes confirmation. In addition, when there is a confirmation of expectations, users believe that using the apps can meet their needs for banking services or financial transactions, view it as helpful in solving their problems, and exhibit pleasant use experience and improved contentment with the apps (Sinha and Singh, 2022). Thus, when users' expectations are confirmed, their perceived usefulness and satisfaction with apps will be increased (Bhattacherjee and Barfar, 2011; Tang et al. 2022). The existing research has validated the impact of confirmation on users' perceived usefulness and satisfaction in the mobile banking context (Hidayat-ur-Rehman et al., 2021; Kumar et al., 2018; Yuan et al., 2016). Therefore, we hypothesize that confirmation has a positive effect on both perceived usefulness and satisfaction for users of mobile banking.

H1: Confirmation is positively related to perceived usefulness.

H2: Confirmation is positively related to satisfaction.

The ECM posits that perceived usefulness has a positive impact on user satisfaction (Bhattacherjee, 2001; Franque et al., 2021). In the mobile banking context, if users feel that the apps are helpful and useful in carrying out their banking tasks, they will obtain agreeable experiences. The more users found AI-enabled mobile

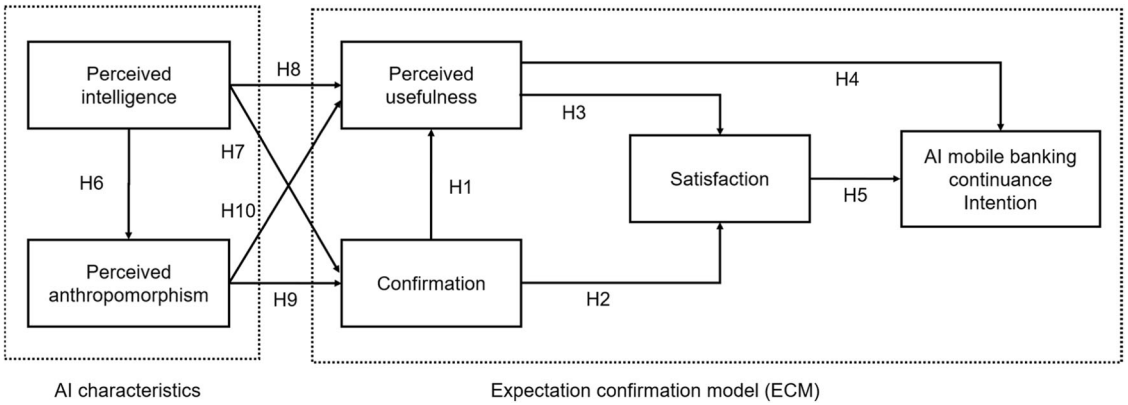

Fig. 1 Research model.

banking apps to have use value, the higher their satisfaction with the apps (Mohammadi, 2015). Scholars have demonstrated that users' perceived usefulness exerts valuable concerns on their satisfaction with mobile banking services (Kumar et al., 2018; Susanto et al., 2016; Yuan et al., 2016). In addition, Bhattacherjee (2001) indicated that when users consider an IS that is useful and valuable, their cognitive dissonance may be reduced by continuing to use the IS. In this sense, if mobile banking apps can help users obtain value and benefits by using apps that meet their financial needs, they will have a tendency to constantly adopt the apps (Hidayat-ur-Rehman et al., 2021; Yuan et al., 2016). In other words, the greater the user's perceived usefulness after using the apps, the higher the possibility that the user will continue to use the apps. In addition, the ECM suggests that satisfaction affects users' continuous usage behaviors regarding technology (Bhattacherjee, 2001; Rahi et al., 2021). When users are satisfied with the services provided by mobile banking apps, they will have inclinations to continually adopt the apps. In the literature, perceived usefulness and satisfaction have been proven to be significant factors that increase user continuance intention with mobile banking (Hidayat-ur-Rehman et al., 2021; Kumar et al., 2018; Susanto et al., 2016; Yuan et al., 2016). Accordingly, we hypothesize the following:

H3: Perceived usefulness is positively related to satisfaction.

H4: Perceived usefulness is positively related to users' continuance intention towards AI-powered mobile banking apps.

H5: Satisfaction is positively related to users' continuance intention towards AI-powered mobile banking apps.

Perceived intelligence, perceived anthropomorphism and the ECM. The success of anthropomorphic implementation lies in the user's perception of the human-like characteristics of non-human actors (Balakrishnan and Dwivedi, 2021; Marikyan et al., 2022) when they use AI technology or systems. Intelligence is another major attribute of AI-powered technologies or systems. Such technologies or systems can improve users' efficiency of online transactions, solve operational problems, and provide personalized financial solutions (Marikyan et al., 2022; Moussawi et al., 2020). Intelligence and anthropomorphism in AI-powered mobile banking apps are complementary (Lin et al., 2023). When users utilize apps, the intelligent features displayed by AI may be regarded by users as a kind of friendly and respectful manifestation, which is the user's perception of the humanization of the apps (Lee and Chen, 2022b; Payne et al., 2021). When AI-powered mobile banking apps demonstrate intelligent attributes, such as by providing personalized financial management plans or banking services derived from AI algorithms and using natural language to communicate, people tend to think that they can understand, communicate with and help them in ways similar to a real person (Lin and Lee, 2023). The existing research on mobile banking shows that the function of intelligence may promote anthropomorphism (Lee and Chen, 2022b; Lin et al., 2023). Therefore, we hypothesize the following:

H6: Perceived intelligence is positively related to perceived anthropomorphism.

AI relies on the ability of the system to combine digital processing algorithms with speech and text recognition functions to communicate with users in an easy-to-understand way to obtain data. This helps to intelligently and quickly understand users' needs and helps users complete tasks efficiently (Marikyan et al., 2022; Moussawi et al., 2022). Perceived intelligence refers to the degree to which users perceive AI technology and its capabilities when interacting with AI (Balakrishnan and Dwivedi, 2021). In the mobile banking context, when users perceive the intelligence of AI in mobile banking apps, they tend to believe that the AI involved in the apps can address problems quickly and effectively, thus facilitating the provision of various financial and banking services (Lee and Chen, 2022b). For example, when a user asks a question via the human–machine interface, the AI can list the multiple useful solutions that the user may want to know based on keywords in the user's question. In addition, when a user wants to purchase wealth management products in mobile banking apps, AI provides a personalized recommended purchase plan after considering the user's levels of risk-taking and income (Lin and Lee, 2023). The intelligence of AI improves service maturity and strengthens users' experience with the human-computer interaction experience by enhancing AI's awakening ability and semantic understanding ability, the accuracy of answered questions, and the efficiency of task completion by enhancing users' inquiries (Sun et al., 2021).

With the help of intelligent ability, AI-powered mobile banking apps can meet users' anticipated financial needs and goals in carrying out mobile banking services (Lin et al., 2023). When users perceive that the intelligence function of the apps meets their expectations regarding the services, their confirmations following the use of the apps are guaranteed. In addition, the utility of intelligence allows users to believe that using apps can solve problems in the operation process and help them complete various tasks quickly, thereby enhancing the overall effect of mobile banking (Lee and Chen, 2022b). That is, the intelligence of AI-powered mobile banking apps can help users use banking services effectively, which allows users to have faith in the apps to help them and increase users' perceived usefulness. Scholars have

demonstrated that intelligence can increase users' perceptions of performance benefits when using AI-powered technology (Moussawi et al., 2020, 2022; Lin et al., 2023). Thus, we hypothesize the following:

H7: Perceived intelligence is positively related to user confirmation.

H8: Perceived intelligence is positively related to perceived usefulness.

Another major feature of AI, anthropomorphism, is also embodied in AI-enabled mobile banking apps (Lee and Chen, 2022b; Lin et al., 2023). AI can reflect emotions in user interactions such that users generate perceptions of anthropomorphism (Moussawi et al., 2020). Anthropomorphic features can instil positive emotions in users, change users' attitudes and cognitions regarding services, and enhance user experiences (Pillai and Sivathanu, 2020; Balakrishnan and Dwivedi, 2021). The AI of mobile banking apps gains the trust of users by communicating with humans and enhancing emotional connections, thereby strengthening the relationship between AI and users (Lee and Chen, 2022b). Specifically, AI can understand the user's pecuniary needs, perceive the user's emotions by way of information provided by the user, and provide care via pleasant text or images (Moussawi et al., 2022). Thus, the user can experience warmth when using AI and become willing to engage in deeper interactions with AI-powered apps (Lee and Chen, 2022b). Due to the support of AI, people believe that the anthropomorphic elements perceived in mobile banking apps can enable them to obtain friendly service, just as they could from real people in a face-to-face environment. Accordingly, their actual use of the apps increases, and they tend to confirm that mobile banking services meet their expectations. In other words, anthropomorphism can help apps meet users' expectations regarding usage and promote a consistent perception of the balance between users' usage expectations and the actual performance of mobile banking.

Moreover, mobile banking app AI can communicate in human-like ways using simple and easy-to-understand language similar to human dialog to prompt and help users complete difficult transactions and tasks. Additionally, by simulating a real person to afford face-to-face service, AI apps can respond effectively to problems during the transactional process and accept users' transaction requests (Lee and Chen, 2022b; Lin et al., 2023). That is, due to the influence of anthropomorphism features, users believe that AI-enabled mobile banking apps can address problems more flexibly from a humane perspective and evaluate their use value more highly, which increases users' perceived usefulness with respect to mobile banking. The literature shows that anthropomorphism enables users to match their financial demands and facilitates their successful accomplishment of financial tasks when using AI mobile banking apps (Lee and Chen, 2022b; Lin et al., 2023). Therefore, we hypothesize the following:

H9: Perceived anthropomorphism is positively related to confirmation.

H10: Perceived anthropomorphism is positively related to perceived usefulness.

Research methods

Data collection and sample. This paper uses a survey to collect data for empirically testing the model. The respondents to the questionnaire were Chinese users who possessed AI-enabled mobile banking app experience. Namely, these users realistically felt and experienced the assistance of AI technology when proceeding with their banking or financial services. Based on the survey of experienced users, we can accurately grasp these users' assessments of AI features (intelligence and anthropomorphism) when using the apps. Since the initial instrument of the variables used in this model was written in English, this study utilizes a back-translation approach to English-to-Chinese translation to develop the preliminary Chinese questionnaire. To ensure face and content validity, the questionnaire was reviewed by three experts in the field of mobile banking and AI to ensure that the content of the questionnaire was valid, clear, meaningful and understandable. According to the suggestions of the experts, several modifications were made to the questionnaire. Then, 30 users of AI mobile banking apps were invited to participate in pretesting. Based on the feedback of the users, the final questionnaire was finally determined after revisions. Moreover, based on the suggestions made by Lee and Chen (2022b), the design for the quality of the questionnaire was intended to control the length and keep it short.

Before distributing the questionnaire, we calculated the minimum sample size requirements needed for the statistical analysis (i.e., in this study, the partial least squares approach) of the proposed model. We adopted G*Power software to estimate the minimum sample size (Faul et al., 2009). As recommended by previous studies (e.g., Campanelli et al., 2018; Lee et al., 2021), the parameters of the software were set to an effect size of 0.15 (average value), a power level of 0.95, and a maximum allowed error of 0.05, which output the minimum sample size required for this study of 119. This study utilized a paid service provided by a professional online questionnaire company (www.sojump.com) to help us collect samples. The advantage of this service is that the company can reach potential respondents quickly, and its large sample bases helped us gather data from a random sample of potential users rather than a convenience sample (Hu et al., 2021; Shen et al., 2018; Lee and Wang, 2022). Moreover, to select appropriate participants effectively, we followed the recommendations of Lee and Chen (2022a) when designing the questionnaire. Specifically, at the beginning of the questionnaire, we first introduced the concept of AI-enabled mobile banking apps, and we then designed a dichotomous question (Yes or No) that asked respondents whether they used such apps to conduct banking and financial tasks. Only respondents who responded "Yes," thus implying that they had AI-enabled mobile banking app experience, were allowed to proceed with the questionnaire. We entrusted the questionnaire company to randomly distribute 400 questionnaires to AI mobile banking users throughout China. A total of 370 questionnaires were obtained; after eliminating 5 incomplete questionnaires, 365 valid questionnaires were used for the data analysis, thus meeting the needs of the minimum sample size. The response rate was 91.25 percent. Table 2 shows the demographic information of the samples. Additionally, we investigated whether the responses were representative of the population; accordingly, we employed the extrapolation method recommended by Armstrong and Overton (1977) to check for nonresponse bias. This approach assumes that participants who respond later are more likely to be nonrespondents (Lee and Chen, 2022b). There were no significant differences between the earliest 25% of the collected samples and the latest 25% of the collected samples, thus indicating that nonresponse bias is not a significant issue and that the samples were representative.

Measurement. In this study, we used the existing validated literature as the basis to measure the variables and their corresponding items and tailor them to match the mobile banking research context (see Supplementary Appendix). A seven-point

Likert scale was used to assess all the items. Specifically, based on the recommendations of Lee and Chen (2022b), we measured intelligence and anthropomorphism using a 5-item scale. Four items adapted from Venkatesh and Davis (2000) and Bhattacherjee (2001) were employed to estimate perceived usefulness. Confirmation was assessed using a 4-item scale adapted from Bhattacherjee (2001). Satisfaction was measured using a 4-item scale adapted from Bhattacherjee (2001). Finally, continuance intention regarding the use of AI-enabled mobile banking apps was measured using two items adapted from Bhattacherjee (2001) and Yuan et al. (2016).

Common method bias. Based on the suggestions of MacKenzie and Podsakoff (2012), this study employed several ex ante means to reduce the occurrence of common method bias (CMB), and we performed three post hoc statistical tests to inspect CMB. With regard to the ex ante means that we used, we specifically considered the questionnaire structure, including varying the scale types and anchor labels, and we explained to the respondents that although the content appeared to be similar, each question was unique in important ways; thus, we encouraged the respondents to read each item carefully. We also concealed the names of constructs and assigned the measurement items randomly (Liang and Shiau, 2018). Concerning the post hoc tests, we first performed Harman's single-factor test to examine CMB (Harman, 1967). The results showed that the first factor accounted for only 35.7% of the total variance. No single factor could explain more than 50% of the total variance, thus implying that CMB is not a substantial issue in this research (Harman, 1967). Then, we conducted the full collinearity test, which is appropriate for PLS analysis as suggested by Lee et al. (2021). The results indicated that none of the variance inflation factors exceeded the recommended threshold of 3.3 (see Table 3). The final method we used was to employ a marker variable approach to check CMB (Simmering et al., 2015). Based on the suggestions of Cao et al. (2021), the average monthly income of the respondents (demographic) was used as a marker variable because it was not theoretically related to the AI features (intelligence and anthropomorphism) and the ECM constructs. The results indicated that average monthly income was not statistically correlated to all the variables included in the proposed model. Overall, CMB did not affect the results of this study.

Table 2 Sample demographic information.

Item		Number	Percentage
Sex	Male	167	45.8%
	Female	198	54.2%
Age	18 to 25 years	85	23.3%
	26 to 40 years	93	25.5%
	41 to 50 years	81	22.2%
	51 to 60 years	57	15.6%
	Over 60 years	49	13.4%
Educational background	Bachelor's degree	195	53.4%
	Master's degree	145	39.7%
	Ph.D.	25	6.8%
Profession	Institutions/ government workers	65	17.8%
	Corporate staff	55	15.1%
	Professional skilled worker	67	18.4%
	Business/service industry	95	26.0%
	Full-time student	50	13.7%
	Retiree	20	5.5%
	Other	13	3.6%
Average monthly income (CNY)	5000 or less	38	10.4%
	5000 to 9999	150	41.1%
	10,000 to 14,999	77	21.1%
	15,000 to 19,999	65	17.8%
	Over 20,000	35	9.6%
Experience using AI-enabled mobile banking	<3 months	29	7.9%
	3–6 months	66	18.1%
	6–12 months	78	21.4%
	>1 year	192	52.6%

Results

This paper employed a partial least squares (PLS) method with confirmatory composite analysis as recommended by Hair et al. (2020) and Cuesta-Valino et al. (2022) to examine the proposed model. The strengths of the PLS are its distribution-free estimation (i.e., the estimation is unaffected by the complexity of the model, small sample size, or nonnormality of the data) and ability to suppress multicollinearity issues (Hair et al., 2013; Lee et al., 2018). Compared to covariance-based structural equation modeling (CB-SEM), we select the PLS statistical technique for data analysis for the following reasons. First, the model is complicated and involves ten hypotheses and possibly numerous mediation paths. PLS can facilitate more complex modeling than CB-SEM (Hair et al., 2017; Ringle et al., 2012). Second, our study is essentially exploratory because to date, no clear knowledge of or indication concerning the underlying effect of AI features (i.e., intelligence and anthropomorphism) on ECM is available in the AI-enabled mobile banking literature (Campanelli et al., 2018; Hair et al., 2017). In contrast, PLS is more suitable for exploratory work than CB-SEM (Hair et al., 2017; Ringle et al., 2012). We adopted SmartPLS 3 software (Ringle et al., 2015) for data analysis. PLS analysis can be divided into two stages (measurement model and structural model) and described as follows.

Measurement model. The aim of the measurement model was to examine internal consistency reliability, convergent validity, and discriminant validity (Hair et al., 2013). We assessed the internal consistency reliability by reference to composite reliability and

Table 3 The collinearity test for CMB.

Dependent variable / Independent variable	PI	PA	PU	CON	SAT	CI
Perceived intelligence (PI)		1.533	1.661	1.678	1.443	1.787
Perceived anthropomorphism (PA)	1.555		2.122	2.662	2.209	2.541
Perceived usefulness (PU)	2.657	2.101		2.122	2.312	2.663
Confirmation (CONF)	1.781	1.567	2.109		2.109	2.728
Satisfaction (SAT)	2.221	1.447	1.456	1.567		1.556
Continuance intention (CI)	1.255	2.018	1.878	2.111	2.135	

Note: The variance inflation factors should not exceed the threshold of 3.3 (Lee et al., 2021).

Table 4 Measurement model results.

Latent variable	Items	Descriptions of the items	Factor loading	Composite reliability	Cronbach's α	Average variance extracted (AVE)
Perceived intelligence (PI) (Lee and Chen, 2022b)	PI1	Mobile banking apps can help me complete banking business quickly.	0.862***	0.886	0.892	0.610
	PI2	Mobile banking apps can understand my instructions.	0.785***			
	PI3	Mobile banking apps can communicate with me in a way that I understand.	0.733***			
	PI4	Mobile banking apps are able to set and pursue tasks by themselves in anticipation of future user needs.	0.751***			
	PI5	Mobile banking apps can adapt their behavior based on prior events.	0.766***			
Perceived anthropomorphism (PA) (Lee and Chen, 2022b)	PA1	Using a mobile banking app to complete a task feels similar to interacting with a real person.	0.772***	0.877	0.885	0.588
	PA2	The mobile banking app feels friendly.	0.731***			
	PA3	I feel that the mobile banking app respects me.	0.717***			
	PA4	The mobile banking app makes me feel interesting.	0.811***			
	PA5	The mobile banking app makes me feel considerate.	0.798***			
Perceived usefulness (PU) (Bhattacherjee, 2001; Venkatesh and Davis, 2000)	PU1	I feel that mobile banking can provide practical services.	0.865***	0.914	0.922	0.727
	PU2	The services provided by the mobile banking app meet my business needs.	0.878***			
	PU3	The various banking service functions provided by the mobile banking app are useful.	0.846***			
	PU4	The functions provided by the mobile banking app are consistent with the banking tasks I need to complete.	0.821***			
Confirmation (CONF) (Bhattacherjee, 2001)	CONF1	I feel that the benefits of using mobile banking are greater than expected.	0.775***	0.874	0.881	0.634
	CONF2	I feel that the service provided by mobile banking is better than expected.	0.767***			
	CONF3	I feel that mobile banking offers more features than expected.	0.810***			
	CONF4	Overall, my expectations for mobile banking have been met after using them.	0.832***			
Satisfaction (SAT) (Bhattacherjee, 2001	SAT1	I am satisfied with the services provided by mobile banking.	0.865***	0.908	0.912	0.711
	SAT2	I think the decision to use mobile banking is wise.	0.822***			
	SAT3	I think the experience of using mobile banking is pleasant.	0.815***			
	SAT4	Overall, I am satisfied with mobile banking.	0.871***			
Continuance intention (CI) (Bhattacherjee, 2001; Yuan et al., 2016)	CI1	I intend to continue using mobile banking and not stop using it.	0.878***	0.858	0.873	0.751
	CI2	If I can, I will use mobile banking as much as possible.	0.855***			

***$p < 0.001$. The average variance extracted (AVE) of each construct should exceed the threshold value of 0.5 (Hair et al., 2013). The acceptable level of factor loading, composite reliability, and Cronbach's α is 0.7 (Hair et al., 2013).

Cronbach's α (Hair et al., 2013, 2020). According to Table 4, all the values of composite reliability (ranging from 0.858 to 0.914) and Cronbach's α (ranging from 0.881 to 0.922) exceed 0.7, thus supporting the reliability of the model (Hair et al., 2013). Moreover, in terms of convergent validity, all the average variance extracted (AVE) values (ranging from 0.588 to 0.751) exceed the threshold of 0.5. In addition, the factor loadings of each variable are greater than the threshold of 0.7 and are all significant ($p < 0.001$) (see Table 4), thus supporting convergent validity (Hair et al., 2013). We adopt a heterotrait-monotrait (HTMT) ratio of correlations approach to conduct a discriminant validity test (Hair et al., 2019). The results indicate that all HTMT values are below the recommended value of 0.85 (see Table 5), thus supporting discriminant validity (Hair et al., 2019). Thus, the variables' reliability and validity criteria were satisfied.

Structural model and mediating effect analysis. Structural model analysis uses the path coefficient (β) and the R^2 value to assess the model (Hair et al., 2013). The path coefficient reflects the strength of the correlation between variables, and the R^2 value can reflect the explanatory power of the model (Hair et al., 2013; Lee et al., 2018). In this paper, a bootstrapping resampling method (10,000 resamples) is used to obtain stable coefficients and R^2 values (Hair et al., 2013). The

results of the model analysis are shown in Fig. 2 and Table 6. We found that all the proposed hypotheses (H1 to H10) are supported. In addition, the R^2 values of anthropomorphism, confirmation, perceived usefulness, satisfaction and AI-enabled mobile banking continuance intention are 0.305, 0.53, 0.571, 0.735 and 0.652, respectively, thus indicating the significant and substantive explanatory power of the model. We also assessed the f^2 value and its effect sizes with regard to the proposed hypotheses. Values of 0.02, 0.15, and 0.35 indicate a small, medium, and large f^2 effect size, respectively (Lee et al., 2021). According to the results, we found at least small f^2 effect sizes for all significant relationships (see Table 6). Moreover, this study used $PLS_{predict}$ to verify the predictive power of the model (Shmueli et al., 2019; Hair et al., 2020). $PLS_{predict}$ with 10 folds and one repetition was employed in line with the suggestions of Shmueli et al. (2019) and Barta et al. (2023). According to the analysis of $PLS_{predict}$, the Q^2 values of the indicators in terms of continuance intention were greater than 0 (see Table 7). In addition, the root mean-squared error (RMSE) and mean absolute error (MAE) of PLS were lower than estimated by the corresponding the linear regression model (LM). This finding implies that compared with LM, the PLS structural model ameliorates the predictive performance (see Table 7), thus highlighting the significant predictive power of the model (Gong and Wang, 2023; Shmueli et al., 2019).

A mediating effect refers to the effect of the independent variable affecting the dependent variable through an additional theoretically relevant variable. According to the results of the structural model analysis, our model may exhibit mediation. We then conducted a mediating examination using Zhao et al.'s (2010) approach. Specifically, when the direct effect and indirect effect are nonsignificant, there is no mediation (Zhao et al., 2010). Complementary mediation (or competitive mediation) occurs when both the direct effect and the indirect effect are significant and the product of the two effects is positive (or negative) (Zhao et al., 2010). In addition, if the direct effect is not significant but the indirect effect is significant, it can also be considered an indirect-only mediation (Zhao et al., 2010). In this study, we focus only on the AI features (i.e., intelligence and anthropomorphism) that produce mediating effects on the ECM. Table 8 shows the mediation effect analysis. The analysis reveals that all mediation paths 1–10 are indirect-only mediations. We will discuss the mediating results in Section "Discussion and contributions".

Table 5 HTMT analysis results.

	CI	CONF	PA	PI	PU	SAT
CI						
CONF	0.654					
PA	0.555	0.665				
PI	0.631	0.679	0.551			
PU	0.768	0.551	0.600	0.722		
SAT	0.810	0.792	0.756	0.659	0.771	

The heterotrait-monotrait (HTMT) ratio of correlations should be lower than the accepted value of 0.85 (Hair et al., 2019).

Discussion and contributions

Discussion of the results. Since AI has been incorporated into mobile banking (Lin et al., 2023; Payne et al., 2018; Payne et al., 2021; Suhartanto et al., 2021), the impact of AI on user adoption behavior

Table 6 Hypothetical relationship test results.

Hypothesis	Path coefficient	*T* value	f^2 value	f^2 effect size	Test result
H1: CONF → PU	0.367	4.559***	0.225	Medium	Supported
H2; CONF → SAT	0.466	7.891***	0.337	Medium	Supported
H3; PU → SAT	0.492	8.963***	0.355	Large	Supported
H4: PU → CI	0.411	5.855***	0.267	Medium	Supported
H5: SAT → CI	0.388	6.121***	0.272	Medium	Supported
H6: PI → PA	0.555	12.548***	0.371	Large	Supported
H7; PI → CONF	0.399	6.897***	0.291	Medium	Supported
H8: PI → PU	0.412	6.532***	0.285	Medium	Supported
H9: PA → CONF	0.487	7.331***	0.326	Medium	Supported
H10: PA → PU	0.198	2.671**	0.193	Medium	Supported

***$p < 0.001$; **$p < 0.01$. Values of 0.02, 0.15, and 0.35 indicate a small, medium, and large f^2 effect size, respectively (Lee et al., 2021).

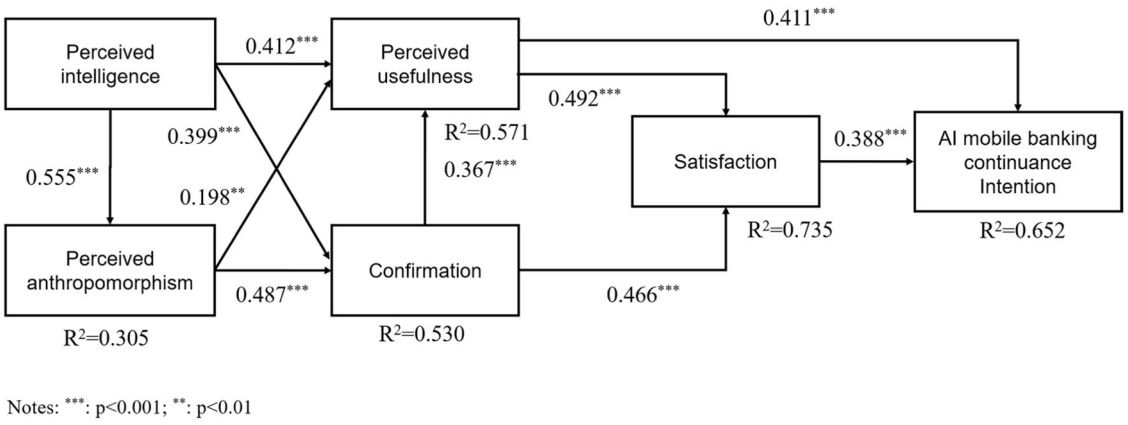

Fig. 2 Results of the model analysis.

of mobile banking apps must be considered (Lee and Chen, 2022b). The main purpose of this study is to combine AI characteristics and ECM to explore users' continuous usage intention of AI-enabled mobile banking apps. According to the empirical results, all the proposed hypotheses are supported. The hypotheses belonging to the ECM that have been extended to the AI-enabled mobile banking context are also established (H1-H5). These findings are consistent with the findings of previous studies (Hidayat-ur-Rehman et al., 2021; Kumar et al., 2018; Rabaa'i and Almaati, 2021; Sinha and Singh, 2022; Susanto et al., 2016; Yuan et al., 2016). In addition, perceived intelligence can enhance perceived anthropomorphism (H6), which is consistent with the results of previous AI adoption studies (e.g., Lee and Chen, 2022b; Lin et al., 2023; Moussawi et al., 2020). When AI can understand user needs and communicate in natural language to explain solutions and solve questions, users tend to believe that AI exhibits human-like characteristics such as friendliness and respect.

Additionally, the results demonstrate that both intelligence and anthropomorphism significantly increase users' continuance intention with regard to the use of AI-powered mobile banking apps (H7 and H9). That is, intelligence and anthropomorphism can promote the user's experience of using mobile banking to reach a consistent perception with their usage expectations and make users believe that the apps possess practical utility. In other words, the intelligent feature of the apps can meet the expectations of users in terms of completing transactions and providing personalized banking services. Anthropomorphic features can make users feel comfortable, such as communicating with a real person, and enhance user experiential anticipation when using apps. In addition, the positive effects of intelligence and anthropomorphism on perceived usefulness are confirmed in the context of AI-powered mobile banking apps (H8 and H10). Users consider that AI can effectively meet their needs for transactions and banking services and solve their problems, and their feelings of use are positive and convincing when they engage in apps. In addition, users believe that AI mobile banking apps are useful, can understand their needs similar to a real person, and can help them complete transactions and various banking services in a friendly manner. These findings are in line with prior AI adoption literature (e.g., Moussawi et al., 2020).

In terms of the mediation analysis, we observe that all the mediations in the model are complementary mediations. In terms of mediation paths 1 and 2, anthropomorphism partially mediates the relationship between intelligence and confirmation. In AI-powered mobile banking apps, intelligence can foster users' confirmation either directly or indirectly by increasing the function of anthropomorphism, which in turn enhances users' confirmation. Concerning mediation paths 3 and 4, confirmation acts as a partial mediator in the relationship between intelligence and perceived usefulness and in that between satisfaction and perceived usefulness, respectively. In terms of mediation paths 5 and 6, confirmation partially mediates the relationship between intelligence and perceived usefulness and that between satisfaction and perceived usefulness, respectively. In other words, both intelligence and anthropomorphism increase users' satisfaction directly; alternatively, intelligence and anthropomorphism can strengthen perceived usefulness, which in turn enhances users' satisfaction in the AI-powered mobile banking context. Regarding mediation paths 7 and 8, perceived usefulness serves as a partial mediator in the relationship between intelligence and satisfaction and in that between continuance intention and satisfaction individually. In terms of mediation paths 9 and 10, perceived usefulness partially mediates the relationship between anthropomorphism and satisfaction and that between continuance intention and satisfaction separately. This finding shows that both intelligence and anthropomorphism straightforwardly foster users' continuous adoption of AI-powered mobile banking apps; otherwise, intelligence and anthropomorphism can strengthen user satisfaction, which eventually encourages users to utilize the apps continuously.

Theoretical contributions. Currently, AI technology has been applied to develop and evolve mobile banking services and apps. Most of the literature considers AI only as a background factor to explore user reaction and usage in the AI mobile banking context (e.g., Payne et al., 2018, 2021; Suhartanto et al., 2021; Yussaivi et al., 2021). Nevertheless, few or no studies have investigated and examined the effects of AI characteristics (intelligence and anthropomorphism) on users' confirmation of expectations and their subsequent adoption behaviors when using AI-powered mobile banking apps. On the other hand, the extant studies have inspected mobile banking user continuous usage by appending some additional factors in the ECM (e.g., Hidayat-ur-Rehman et al., 2021; Susanto et al., 2016; Yuan et al., 2016) (see Table 1). Studies have paid less attention to investigating the role of AI and the joint effect of AI characteristics and the ECM on user continuance intention in the AI-enabled mobile banking context. To

Table 7 Analysis of predictive power.

Items	PLS		LM-RMSE	PLS-SEM – LM-RMSE
	RMSE	Q^2 predict		
CI1	1.665	0.638	1.736	−0.071
CI2	1.738	0.551	1.881	−0.143

CI continuance intention, *RMSE* root mean-squared error, *MAE* mean absolute error, *PLS* partial least squares, *LM* linear regression model.

Table 8 Analysis of the mediating effects.

No.	Path	Direct effect	Indirect effect	Mediating results
1	PI →PA →CONF	0.399***	0.270***	Complementary mediation
2	PI →PA →PU	0.412***	0.110 **	Complementary mediation
3	PI →CONF →PU	0.412***	0.146***	Complementary mediation
4	PI →CONF →SAT	0.605***	0.186***	Complementary mediation
5	PA →CONF →PU	0.198**	0.179***	Complementary mediation
6	PA →CONF →SAT	0.351***	0.227***	Complementary mediation
7	PI →PU →SAT	0.605***	0.203***	Complementary mediation
8	PI →PU →CI	0.511***	0.169***	Complementary mediation
9	PA →PU →SAT	0.351***	0.098*	Complementary mediation
10	PA →PU →CI	0.252***	0.081*	Complementary mediation

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

address these gaps, we employ the ECM as a baseline theory to reconnoitre how intelligence and anthropomorphism affect users' continuous adoption intentions towards AI-powered mobile banking apps through the function of ECM. The empirical results showed that in AI mobile banking apps, the characteristics of intelligence can increase the function of anthropomorphism. Both intelligence and anthropomorphism can strengthen the effects of user confirmation of expectations and perceived usefulness. These effects subsequently promote user satisfaction, eventually increasing the continuous adoption of AI mobile banking apps.

This study offers several theoretical contributions to the literature. First, we discover the operational mechanisms by which intelligence and anthropomorphism enable users to confirm their expectations of demands and increase their benefits from the use of AI mobile banking apps (perceived usefulness) and improve their emotional evaluations of the apps (satisfaction) in the continuous adoption context. Second, in addition to the additional variables that integrate with the ECM provided by the literature (Hidayat-ur-Rehman et al., 2021; Susanto et al., 2016; Yuan et al., 2016) (see Table 1), we contribute to the literature by further recognizing and revealing the significant determinants of the ECM, that is, intelligence and anthropomorphism, which helps magnify the applicability and explanatory power of the ECM by extending it to AI-enabled mobile banking apps. Overall, through the integration of intelligence and anthropomorphism into the ECM, this research can better reflect the development and evolution trend of AI in mobile banking services and apps in academia and industry, which can help us attain a deeper understanding of users' continuance intentions with respect to AI-powered mobile banking apps.

Practical implications. Mobile banking has made groundbreaking contributions to the development of the banking industry, and the application of AI technology to this context has further promoted the development of that industry. However, the continuous utilization rate of mobile banking must still be improved (Merhi et al., 2019). This paper has reference value with respect to the practical application of AI technology in mobile banking apps. First, when designing and developing mobile banking apps, R&D personnel can add proper AI algorithms in AI-powered mobile banking apps to precisely meet and grasp user financial needs. Thus, apps can offer personalized financial solutions or propose suggestions concerning related products in accordance with a user's risk preferences and basic information. This assistance allows users to make better financial decisions and thus promotes usability and user experience, thereby increasing user satisfaction and continuous usage intention with regard to AI-powered mobile banking apps. Second, due to the low error tolerance rate that is necessary for financial transactions via mobile banking, app developers should improve the intelligent performance of AI to help reduce the possibility of calculation errors and user operation errors, enhance reliability, and improve user experience in using apps.

Third, as users' intelligence requirements for AI gradually increase, developers can consider improving the deep learning ability and responsiveness of AI to increase the sensitivity of AI to the needs of users and to allow AI to be able to predict and change aspects of its operation in accordance with user requirements. In terms of anthropomorphism, since anthropomorphism can improve user experience and effectively increase user satisfaction with mobile banking apps, developers can optimize the degree of anthropomorphism exhibited by the interactive interface, update the interactive language, avatar, and voice in real time, and develop additional anthropomorphic elements. Therefore, users can come to believe that AI can help them solve problems effectively in a manner similar to a real person. Finally, when users encounter normal and routine problems with mobile banking, banks should guide and encourage users to seek the help of AI. This immediately helps regulate users' emotions, reduce users' anxiety and impatience, and provide a comfortable and pleasant service experience, thereby maximizing the positive effects of applying AI technology in mobile banking.

Limitations and directions for future research

This paper provides theoretical and practical contributions; however, similar to other studies, it has some limitations that open up possibilities for follow-up research. First, the scope of the survey samples in this paper is limited to China. The findings may not be generalized to other countries and economic regions. In this regard, follow-up studies are recommended to replicate our research design in other areas. Second, our sample (365 responses) for the statistical analysis of the proposed model exceeded the minimum sample size (119 samples) calculated by G*Power software and passed the nonresponse bias test (see section "Data collection and sample"). However, the sample size of this study is relatively small, which may have biased the results since the sample may not exactly reflect the population, which should be noted as a research limitation of this study. Third, a cross-sectional data (i.e., survey) method was utilized to examine the proposed model. Such a method cannot confirm the causal relationships among the proposed variables. Therefore, future work is suggested to conduct long-term investigations (Franque et al., 2021) to explore users' continuous usage intention of AI-enabled mobile banking apps over time. Fourth, this study used the ECM (Bhattacherjee, 2001) as a baseline theory to conduct the investigation. Because the ECM did not contain any moderators, we did not consider moderators in the proposed model. However, according to the empirical results, the R^2 value of AI mobile banking continuance intention is lower than the R^2 value of the preceding satisfaction construct (see Fig. 2). This finding implies that potential moderating variables may exist in the proposed model. Therefore, future investigations should consider several moderators to increase the explanatory power of the model. For example, personal innovativeness and trust have been identified as moderators in technology adoption research. Personal innovativeness and trust may have additional impacts on the proposed model.

Fifth, previous studies have shown that personality affects people's evaluations of technology and their adoption behavior (e.g., Schepman and Rodway, 2022). Hence, subsequent studies can explore the ways in which the joint effects of users' personality traits, such as Big Five personality traits, and AI features (i.e., intelligence and anthropomorphism) impact the continuous use of AI-powered mobile banking apps. Finally, the focus of this study was to combine AI features with the ECM to explore users' continuance intentions regarding the use of mobile banking. In addition to the effects of AI features, scholars have indicated that AI service agents' service quality (AISAQUAL) is critical to AI-powered IS continuous usage intention (Noor et al., 2022). Future research can integrate AISAQUAL and ECM to explore and examine their interactive effects on users' continuance intentions, thereby improving our understanding of AI-enabled mobile banking app adoption behavior.

Conclusion

At present, AI is an important leading-edge technology used to enrich mobile banking services and apps. To understand the impact of AI on user continuous adoption, we employ the ECM as a theoretical basis to develop a research model and

corresponding hypotheses. By extending the ECM through the inclusion of two AI features (i.e., perceived intelligence and perceived anthropomorphism), we can explain the factors that influence users' continuous intentions to adopt AI-powered mobile banking apps more effectively. Based on an empirical investigation of 365 Chinese users with AI mobile banking use experience, the findings of this study are as follows. Perceived intelligence can enhance the utility of perceived anthropomorphism in the AI mobile banking adoption context. Both intelligence and anthropomorphism can strengthen users' satisfaction via perceived usefulness and confirmation, eventually fostering their continuous usage of AI mobile banking apps. This study represents the first attempt to integrate ECM and the technological characteristics of AI into mobile banking research and to recognize intelligence and anthropomorphism as significant factors that affect users' continuous usage decisions. The study also offers practical guidance for managers in the banking industry with regard to strengthening AI capabilities and functions in the context of mobile banking apps, which can help improve user experience and increase continuous adoption of the apps.

Data availability

The datasets generated during and/or analyzed during the current study are not publicly available due the datasets contain the respondents' demographic information and their internet protocol addresses.

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Author contributions

The first author conceived, designed, and wrote the study. The second author collected the sample data. Third author conducted the statistical analysis. All authors contributed to drafting the study and interpretation of results. All authors have read and agreed to the present version of the manuscript.

Competing interests

The author(s) declare no competing interests.

Ethical approval

This manuscript was granted fully ethical standards of the regulations of all the authors' institutions (Beijing Normal University at Zhuhai) and the 1964 Helsinki declaration and its later amendments or comparable standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Additional information

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